Queensland Farmers' Federation Ltd

NuWater Project Feasibility Study

Volume 2 – Appendices

March 2018

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

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Appendices

1. Introduction

This document forms Volume 2 Appendices for the NuWater Project Feasibility Study. Appendices contained in this volume are referenced in Volume 1 Preliminary Business Case.

Appendices

Appendix A – GHD Stakeholder Engagement Plan

GHD'S CONSULTATION AND ENGAGEMENT ROADMAP FOR THE NUWATER PROJECT

COMMUNICATION GOAL

Identify community and stakeholder concerns and opportunities and develop mitigation strategies to inform the development of a successful Preliminary Business Case

KEY OBJECTIVES

Key communication objectives:

1. Elicit stakeholder input to inform the development of a successful Preliminary Business Case
2. Identify potential stakeholder issues and project risks
3. Develop and implement mitigation strategies
4. Increase community understanding to improve broad based support within the community for future stages of project

PROJECT STAKEHOLDERS

Project team
GHD Project Team
Synergies
Badu Advisory

Community
Directly impacted landholders
Local landholders, farmers and irrigators
Central Downs Irrigation Limited
Lockyer Valley Growers
Gowrie-Oakey Creek Irrigators/McVeigh Partnership Trust
Clapham Farming
Sleba Enterprises
Koala Farms
Lockyer Valley Irrigators Group

Industry
QFF
Cotton Australia
Central Downs Irrigators Limited
Growcom
Queensland Chicken Meat Council
Agforce
Toowoomba and Surat Basin Enterprise
Seqwater
QUU

Environment
QLD Murray Darling Committee
Darling Downs Environment Council
Landcare
Toowoomba & Region Environment Council Inc.

Council
Lockyer Valley Regional Council - Cr Tanya Milligan, CEO Mr Ian Church
Toowoomba Regional Council
Councillors & Council employees

Government & Agencies
State Member for LV –
Federal Member for LV – Ken O'Dowd (Nats)
State Member for TRC -
Federal Member for TRC –
Dept Agriculture & Fisheries
DEWS
DNRM
NPMC
Building Queensland

Media
Gatton Star
Ipswich Queensland Times
Queensland Times
Toowoomba Chronicle
Toowoomba's Mail
ABC radio southern QLD
State and national radio and television (Ch 7, Ch 9, Ch. Ten, ABC, SBS, Sky News)

KEY ROLES

QFF
Approval of consultation materials
Attendance at stakeholder meetings where appropriate
Main point of contact

GHD
Develop & distribute communication materials
Facilitate stakeholder meetings
Contractor management in relation to community consultation
Reporting and evaluation, including prompt reporting of emerging issues

Contractor – Synergies
Attends all relevant meetings between GHD and QFF
Carry out irrigator and other stakeholder surveys and analysis
Participates in stakeholder meetings as required
Coordination of all technical inputs by Synergies
Reviews and signs off all technical reporting by the team

TOP 4 ISSUES & MITIGATIONS

1.	Existing expectations with regard to the availability and use of treated wastewater	Identify stakeholder issues early in the process and tailor approaches to ensure expectations align with project objectives
2.	Project needs to demonstrate 'social licence' among key stakeholders	Ensure stakeholders understand qualitative social impacts and benefits, and that stakeholder issues are identified in consultation phase
3.	Political interest in the project	Ensure that accurate and timely information is provided to QFF and key stakeholders
4.	Downstream stakeholder interest	Complete a high-level issues identification assessment in collaboration with QFF and identified stakeholders

COMMUNICATION AND ENGAGEMENT APPROACH

STRATEGIC APPROACHES

We are prepared – clearly define roles and responsibilities, and processes and timeframes, for communication and consultation activities.
We inform early – ensure relevant stakeholders and end water users are provided with timely and accurate information appropriate to their needs.
We communicate directly – using relevant tools to target appropriate stakeholders, with clear communication protocols for two way feedback
We respond quickly – ensure effective and prompt issues resolution within nominated timeframes.

IMPLEMENTATION

Task 1
Project inception
Project Plan (Project Options Identification Plan & Risk Management Plan)

Task 2
Investment Logic Map
MCA criteria development

Task 3
Document review
Gap analysis

Task 4
Review of past studies and other documentation
Consultation with key stakeholders and producers
Web-based survey
Focus group session with producers
Assessment of other potential sources of demand
Farm-level modelling
Review of water market activity

Task 5
Water availability analysis

Task 6
Options identification
Water distribution concept development
Options Workshop Report and Presentation
Draft Options Identification Report

Task 7
Options analysis – multi criteria assessment

Task 8
Economic Assessment and Cost Benefit Analysis
Financial/Commercial Considerations
Economic Analysis
Affordability Analysis and Funding Options

Task 9
Environmental assessment

Task 10
Social impact evaluation
Public Interest Consideration
Social impact assessment

Task 11
Delivery assessment
Market Consideration
Delivery Analysis

Task 12
Preparation of Preliminary Business Case

Task 13
Agency consultation

Task 14
Final Feasibility Study
Preliminary Business Case

Appendix B – Options Identification Workshop Report

Queensland Farmers' Federation Ltd

NuWater Project Feasibility Study

Options Identification Workshop Report

December 2017

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

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Abbreviations

AWTP	Advanced Water Treatment Plant
CDIL	Central Downs Irrigators Limited
DAF	Department of Agriculture and Fisheries
DD	Darling Downs
DN	Nominal Diameter
DNRM	Department of Natural Resources and Mines
DTMR	Department of Transport and Main Roads
IPR	Indirect potable reuse
LV	Lockyer Valley
LVRC	Lockyer Valley Regional Council
MCA	Multi-criteria assessment
MF	Micro-filtration
ML	Mega-litre
NWIDF	National Water Initiative Development Fund
QCGA	Queensland Chicken Growers Association
QCMC	Queensland Chicken Meat Council
QFF	Queensland Farmers' Federation
QUU	Queensland Urban Utilities
PRW	Purified Recycled Water
PS	Pump Station
RDA	Regional Development Australia
RO	Reverse Osmosis
ROC	Reverse Osmosis Concentrate
SEQ	South East Queensland
STP	Sewage Treatment Plant
TSBE	Toowoomba and Surat Basin Enterprise
UF	Ultra-filtration
WCRWS	Western Corridor Recycled Water Scheme

1. Introduction

1.1 Background

The Queensland Farmers' Federation (QFF) – on behalf of an unofficial consortium including QFF industry members Cotton Australia, Central Downs Irrigators Limited (CDIL), Growcom and the Queensland Chicken Meat Council (QCMC), Agforce, Lockyer Valley Growers, Toowoomba and Surat Basin Enterprise (TSBE) and Queensland Urban Utilities (QUU) – were successful in applying for funding under the National Water Infrastructure Development Fund (NWIDF) to undertake a feasibility study to test the viability of using recycled water from the South-East Queensland Western Corridor Recycled Water Scheme (WCRWS). This is referred to as the "NuWater Project".

GHD was engaged to deliver the NuWater Project – Feasibility Study in June 2017. The project scope included a workshop to identify options to be considered as part of the study, as well as a report identifying these potential options (this report).

An Options Identification Workshop, involving key stakeholders and project personnel, was held at the Lockyer Valley Cultural Centre on Tuesday 18th July 2017. A list of attendees is included in Appendix A.

This workshop had the purpose of identifying potential options to deliver recycled water from Brisbane to the Lockyer Valley and Darling Downs agricultural areas. Options for consideration were required to address the project's Problem Statement, which has been reproduced below.

"The Project aims to examine the potential for synergistic solutions arising from the nexus of two separate problems:

- *Costs of managing environmental impacts associated with treating South-East Queensland's wastewater and disposing the effluent to sea are expected to continue to increase driven by growing SEQ population and increasingly more stringent environmental standards that are in response to the communities' expectations for maintaining the environmental health of Moreton Bay.*
- *Growth in agricultural and industrial production and associated regional economic benefits (particularly as measured in regional jobs) in the Lockyer Valley and the Darling Downs is being significantly constrained by the lack of opportunities and access to traditional water source supplies and need to develop alternate supplies for the region."*

1.2 Purpose of this report

This report identifies potential options for delivering recycled water to the Lockyer Valley and Darling Downs agriculture areas and covers the following items:

- The process undertaken in conducting the Options Identification Workshop, including reference material
- A description of option elements, including available recycled water sources, water quality of potential water products, the location of demand, water conveyance infrastructure and additional option elements such as power supply
- Options Identification Workshop outputs, including a summary of interactive session outcomes
- Long-list of options to be considered as part of the NuWater Project

- Multi-criteria assessment categories and criteria proposed for assessing the relative merits of identified options.

1.3 Assumptions

The following assumptions have been made in order to conduct this options identification exercise:

- No site investigations have been conducted. This study was purely of a desktop nature using the available information and stakeholder inputs
- The size, capacity and suitability of existing infrastructure, including QUU Sewage Treatment Plants (STPs), Seqwater Advanced Water Treatment Plants (AWTPs), the WCRWS, etc. have not been validated by the respective infrastructure owners at this stage of the project. Therefore the production and delivery quantities indicated in this report are indicative only and will be subject to further investigation
- It is assumed that Seqwater's advanced water treatment plants can be modified to produce alternative water quality products. This will be the subject of further investigation at future project phases
- The size/scale of water supply (and/or treatment) options will ultimately be tailored to site conditions and a wide range of other factors. These and other aspects may be the subject of further studies
- It has been assumed that Lockyer Valley growers are unlikely to be able to accept low quality (e.g. Class B, C) recycled water due to limitations upon appropriate uses for such application. This has not been formally verified and will be the subject of further investigation and consultation with relevant stakeholders and regulatory bodies
- It has been assumed that release of lower quality water products (e.g. Class B, C) to watercourses may not be environmentally acceptable given the substantial increase in waterway volumes this is likely to represent. Conversely, it has been assumed that the release of higher quality water products (e.g. PRW, Class A+) to watercourses will be suitable. Both assumptions will be subject to further investigation and consultation with relevant stakeholders and regulatory bodies
- Potential areas able to be served with recycled water have not been defined beyond broad areas at this stage and would be subject to further investigations.
- The identification and initial development of options has been restricted to bulk transportation of recycled water only and does not currently include recycled water distribution infrastructure. This will be undertaken subject to the outcomes of the demand analysis process and further assessment of existing water distribution infrastructure (channels, storages, etc.) as part of the options development phase.

1.4 Scope and limitations

This report: has been prepared by GHD for Queensland Farmers' Federation Ltd and may only be used and relied on by Queensland Farmers' Federation Ltd for the purpose agreed between GHD and the Queensland Farmers' Federation Ltd as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Queensland Farmers' Federation Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Queensland Farmers' Federation Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Options Identification Workshop

2.1 Workshop Attendees (Representative Organisations)

Organisations represented at the workshop included:

- Queensland Farmers' Federation
- Cotton Australia
- Gowrie-Oakey Creek Irrigators
- Central Downs Irrigators Limited
- Growcom
- Queensland Chicken Meat Council/Queensland Chicken Growers Association
- Agforce
- Lockyer Valley Growers
- Toowoomba and Surat Basin Enterprise
- Lockyer Valley Regional Council
- Queensland Urban Utilities
- Seqwater
- Department of Natural Resources and Mines
- Department of Agriculture and Fisheries
- Regional Development Australia - Darling Downs and South West
- Cardno (representing the Lockyer Valley Aquifer Recharge for Agriculture Productivity and Sustainability NWIDF project)
- Badu Advisory (NuWater Project Manager)
- GHD and Synergies Economic Consultants (Project Team)

A full list of attendees including apologies has been included in Appendix A.

2.2 Workshop Format

The Options Identification Workshop was conducted on Tuesday 18 July 2017. An agenda was issued prior to the workshop, and has been included in Appendix A for reference. The workshop format was as follows:

- Welcome and introductions
- Workshop Objectives
- Project Background and Intent
- Session 1: Open Discussion/brainstorming on individual ideas, issues
- Session 2: Source options
- Session 3: Water product alternatives
- Session 4: Demand options
- Identification of long list of supply options
- High-level assessment of options

In addition to general discussion during each of the above sessions, a number of interactive sessions were held where stakeholder input was specifically sought.

Session 1: Open Discussion/brainstorming on individual ideas, issues

During this session, workshop attendees were invited to write down statements representing an idea, option or issue relating to the NuWater project and assign the statements to one of a number of categories, being:

- Opportunities
- Constraints/limitations
- Benefits
- Risks.

The statements were then grouped into a number of key themes. Those themes have in turn been aligned with the multi-criteria analysis (MCA) criteria proposed to be used to assess options as a means to capture issues of importance derived from the stakeholder group in respect of the project objectives. The outputs from this session have been included in Appendix C.

Session 4: High-level assessment of options

During this session, workshop attendees were given a number of “votes” to assign to a range of options being considered as part of the NuWater Project. Instructions were to vote for the option that best met the objectives of the organisation each attendee represented or best met the objectives of the project. The outputs from this session have been included in Appendix C.

2.3 Workshop Presentation

To support the workshop outcomes, a presentation was prepared in Microsoft Powerpoint format and used during the workshop. The presentation content has been included in Appendix A.

2.4 Workshop Notes

Notes taken during the workshop to capture comments and discussions that took place have been included in Appendix B.

3. Description of Option Elements

In identifying options to address the NuWater Project problem statements and objectives, the individual elements that in combination will form the recycled water scheme have been considered. This section outlines the alternatives for each project element that, in combination, will be used to form discrete options.

3.1 Recycled Water Product Alternatives

3.1.1 Appropriate use of recycled water

Attendees at the workshop identified a broad difference in irrigation water quality needs between the Lockyer Valley and the Darling Downs. This appears to be largely driven by market requirements i.e. broad acre crops such as cotton, grains in the Darling Downs versus horticulture crops, etc. in the Lockyer Valley. The degree to which recycled water undergoes further treatment has a broad range of implications for existing infrastructure, potential modifications and ongoing operational costs, and if the WCRWS is part of the solution, the duration the system may be unavailable due to potable water supply requirements for South East Queensland.

There are regulatory requirements applying to the use of recycled water for some crop types, specifically minimally processed food crops. The Queensland Public Health Regulation 2005 provides an indication of 'fit for purpose' uses in addition to providing definition both of the crop types and the technical definition of recycled water classes; refer to Table 3-1.

Table 3-1 Standards for quality of recycled water for irrigating minimally processed food crops[1]

Crop type	Example	Spray	Drip	Flood/ furrow	Sub-surface
Root crops	Onion, carrot	A	A	A	A
Crops with produce grown on or near the ground – skin typically removed	Pumpkin	B	C	C	C
Rockmelon	-	A+	A+	A+	A+
Crops with produce grown on or near the ground – skin typically retained	Tomato, broccoli, cabbage	A+	A	A+	C
Crops with produce grown away from the ground – skin typically removed	Mango, avocado, banana	B	C	C	C
Crops with produce grown away from the ground– skin typically retained	Apple, olive, peach	A+	B	B	C
Crops for produce grown in hydroponic conditions	Lettuce, herb	A+	A+	A+	A+

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[1] Section 18AG Schedule 3E; page 83 of Public Health Regulations 2005 as at 1 February 2017

The Regulation also recognises a lesser standard for irrigation use on other than minimally processed food crops, which may include:

- Irrigation of non-food crops such as cotton
- Irrigation of heavily processed food crops such as cereal crops grown for flour production (e.g. wheat, rice and corn) and crops grown for oil production (e.g. sunflower, canola and flax seed).

A number of other minimally processed food crops are grown on the Darling Downs, including mung beans, feed corn, chickpeas, sunflowers (for uses other than oil production), barley and sorghum. For many of these crops, irrigation is not applied once flowering has commenced, thereby minimising risk of contamination from recycled water. The appropriate level of treatment required for individual applications would be subject to risk assessment relevant to the water quality and confirmation of irrigation practices.

For lesser quality treated water streams irrigators may be required to produce Customer Site Management Plans. Landholders will generally be required to describe how they will manage the application of recycled water and what measures they have implemented to monitor potential impacts on their property. In the majority of cases, these will be prepared by the supplier of the recycled water in conjunction with the landholder[2].

A further consideration in supplying recycled water from STPs is the concentration of salt retained following the treatment process. Indicative salt concentrations for each of the STPs currently supplying the WCRWS have been included in Table 3-2.

Table 3-2 Salt content of STP effluent

Sewage Treatment Plant	Total Dissolved Solids (mg/L)	Salinity (µS/m)
Luggage Point	1,500	2,340
Gibson Island	1,000	1,560
Oxley Creek, Wacol, Bundamba, Goodna	500	780

It is noted that historical salt concentration records, in particular for Luggage Point STP (the largest STP in South East Queensland (SEQ)), have been found to vary considerably, aligned with Brisbane River flushing, tidal and lunar variations and sewerage catchment rainfall.

During the workshop, it was identified that a salt concentration of around 1100-1300 mg/L may be acceptable for most irrigation applications. It was also noted that there was potential to mix supplied water with other water sources within farm operation, which could dilute the concentration of salt prior to application.

There are potential options to treat all or part of water sourced from STPs with higher salt content through treatment processes included in the AWTPs to create a composite water product with a lower salt concentration, which will be considered as part of the study if consultation with irrigators reveals this to be a significant issue requiring a solution.

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[2] http://www.recycledwater.com.au/uploads/File/Pasture%20and%20Fodder%20Manual.pdf P5 (Accessed 2/8/17)

3.1.2 Proposed water product qualities

The WCRWS is designed to produce potable-level water quality nominally called purified recycled water (PRW), with the scheme delivering indirect potable reuse (IPR) via discharge to Wivenhoe Dam. The scheme currently sources water from six STPs.

In terms of water product alternatives, we have devised three applicable products that would meet the project objectives, to varying degrees, which also have some specific opportunities and limitations. It is planned to assess the relative merits of each in conjunction with associated infrastructure requirements and costs to deliver each water quality product to relevant demand locations consistent with appropriate use of the water. Table 3-3 provides some commentary around each product and a number of key considerations associated with each.

Table 3-3 Water product alternatives

Water Product	Description	Key considerations
Purified Recycled Water (PRW)	Recycled water produced from Seqwater AWTPs (source water supplied from STPs)	Potential to release to environment (e.g. channels, watercourses) Water quality (potable water standard) suitable for use by all customers Requires further treatment of reject stream to remove nutrients (broadly nutrients continue to be discharged to Moreton Bay if the scheme is commissioned as is) Nutrients (N, P) removed from product water and not available to offset agricultural nutrient demand Limited modifications to existing WCRWS infrastructure Limited rectification works to return WCRWS to IPR water supply
Class A+	Recycled water produced from STPs is treated to Class A+ standard; this nominally could involve some treatment processes in place at AWTPs	Potential to release to environment (e.g. channels, watercourses), although subject to more stringent controls than PRW Water quality suitable for use by almost all customers Potential issues with salt content Potentially significant modifications to existing WCRWS (AWTP) infrastructure Potentially significant rectification works to return WCRWS to IPR water supply
Untreated Effluent (Class B/C)	Recycled water produced from STPs	Potential for significant controls placed on release to environment (e.g. channels, watercourses) Water quality may not be suitable for many uses in the Lockyer Valley Potential issues with salt content

Water Product	Description	Key considerations
		Limited modifications to existing WCRWS infrastructure (bypass works only) Potentially significant rectification works to return WCRWS to IPR water supply
Combination of Untreated Effluent (Class B/C) and Class A+ (end of pipe treatment)	Product water treated depending on end use.	Potential for significant controls to be placed on release to environment (e.g. channels, watercourses) Water quality suitable for use by all customers Potential requirement for further treatment of reject stream Limited modifications to existing WCRWS infrastructure (bypass works only) Limited rectification works to return WCRWS to IPR water supply
Wivenhoe water (offset by PRW)	Recycled water produced from Seqwater AWTPs (source water supplied from STPs) used to offset release of Wivenhoe Dam water.	Potential to release to environment (e.g. channels, watercourses.) Water quality (dam water) suitable for use by all customers Requires further treatment of reject stream to remove nutrients (broadly nutrients continue to be discharged to Moreton Bay if the scheme is commissioned as is) Elevated nutrients (N, P) not in product water and not available to offset agricultural nutrient demand Limited modifications to existing WCRWS infrastructure Nil rectification works to return WCRWS to IPR water supply

It is understood that there will be extended periods when a scheme involving the use of WCRWS assets will be unavailable for irrigation supply as the WCRWS is required to be used to supplement the drinking water supply. The recommissioning process for the WCRWS is commenced when key SEQ bulk water supplies reach 60%, with the scheme commencing operation once supplies drop to 40%. Key to the assessment of options and determining the viability and commercial attractiveness of options will be understanding the limitations of options in terms of availability and variability, including:

- The time and cost to recommission the WCRWS back to PRW supply if a lower quality product is required
- The predicted frequency and duration of use of PRW to supplement drinking water supply in SEQ

- Whether regulators will accept the use of the WCRWS pipelines to transport water at a quality other than PRW and what limitations that may present. This may include consideration of public perceptions associated with this aspect.

Engagement with Seqwater and relevant regulatory bodies will enhance understanding of these issues and inform the assessment of options.

3.2 Recycled Water Source Alternatives

3.2.1 Sewage Treatment Plants (STPs)

Options need to deliver a reduction of nutrients discharged to Moreton Bay, which can be achieved by taking treated wastewater (effluent) from municipal STPs that would ordinarily be discharging either directly into Moreton Bay, or waterways connected to Moreton Bay. This does not exclude the use of other recycled water sources to supplement supply volumes, however reducing nutrients from point source discharges is a fundamental requirement of the project (refer to the problem statements in Section 1.1) .

Nutrient load point sources associated with STPs that ordinarily discharge to Moreton Bay and relevant to the project include:

- STPs operated by QUU predominantly located in the Brisbane City Council, Ipswich City Council, Lockyer Valley Regional Council and Scenic Rim Regional Council areas
- STPs operated by Unitywater located in Moreton Bay Regional Council area
- STPs operated by Logan City Council
- When the WCRWS is operating, AWTP Reverse Osmosis Concentrate (ROC) from Luggage Point AWTP and Gibson Island AWTP (Bundamba AWTP is further treated to remove nutrients).

With respect to QUU-operated STPs, the following STPs are part of the WCRWS:

- Luggage Point STP
- Oxley Creek STP
- Goodna STP
- Gibson Island STP
- Wacol STP
- Bundamba STP.

As these are already connected to the WCRWS, these present a relatively efficient means to collect and transfer effluent west towards the demand areas of the Lockyer Valley and Darling Downs. These plants also present the potential for blending with other sources including PRW, other surface water sources and groundwater.

In addition to the abovementioned STPs, a number of other plants are part of QUU’s “bubble licence”, which is an Environmental Authority to undertake environmentally relevant activities (sewage treatment) with an aggregate discharge limit across the relevant STPs. STPs operated by Unitywater, Logan City Council and City of Gold Coast have also been considered as potential supplementary supplies.

A full list of STPs to be considered in the study, along with the approximate effluent produced from each, is included in Table 3-4 below. The locations of potential sources is provided in Figure 3-2.

Table 3-4 Potential sources of STP effluent that discharge (directly or indirectly) to Moreton Bay

Sewage Treatment Plant	Operating Authority	Average Annual Volume (ML/a)	Daily flow (ML/day)
Luggage Point STP	QUU	45,625	125
Gibson Island STP	QUU	14,600	40
Oxley Creek STP	QUU	18,250	50
Wacol STP	QUU	1,825	5
Goodna STP	QUU	4,745	13
Bundamba STP	QUU	5,110	14
Wynnum STP	QUU	1,095	3
Sandgate STP	QUU	6,570	18
Carole Park STP	QUU	1,278	3.5
Karana Downs STP	QUU	110	0.3
Fairfield STP	QUU	548	1.5
Brendale STP	Unitywater	3,103	8.5
Murrumba Downs STP	Unitywater	7,300	20
Redcliffe STP	Unitywater	6,935	19
Loganholme STP	Logan City Council	16,060	44
Beenleigh STP	Logan City Council	TBC	TBC

It is noted that some of the treatment plants identified have existing recycled water supply agreements already in place (e.g. Fairfield, Wynnum, Murrumba Downs). Such agreements will be confirmed as the project progresses and any constraints included in the assessment of options.

3.2.2 Advanced Water Treatment Plants (AWTPs)

The AWTPs (part of the WCRWS) are a potential source of recycled water. It is noted that to fully achieve the objectives of the project, it would be necessary to introduce treatment of the reject stream at both Luggage Point AWTP and Gibson Island AWTP to produce a reduction in nutrients discharging to Moreton Bay; Bundamba AWTP already includes such treatment. The maximum production rate for each of the three AWTPs is included in Table 3-5.

Table 3-5 Potential sources of recycled water

Advanced Water Treatment Plant	Operating Authority	Average Annual Volume (ML/a)	Daily flow (ML/day)
Luggage Point AWTP	Seqwater	24,090	66

Advanced Water Treatment Plant	Operating Authority	Average Annual Volume (ML/a)	Daily flow (ML/day)
Gibson Island AWTP	Seqwater	36,500[1]	100[1]
Bundamba AWTP	Seqwater	22,995	63

[1] Membranes were only installed and commissioned to achieve half the nominal 100 ML/d capacity; it must also be noted that effluent source water is currently limited to a maximum of 80 ML/d

The general process design across the three AWTPs relevant to this project involves the following processes, as illustrated in Figure 3-1:

- Coagulation
- Membrane filtration (MF/UF)
- Reverse osmosis
- Advanced oxidation (UV/peroxide)
- Stabilisation
- Residual disinfection

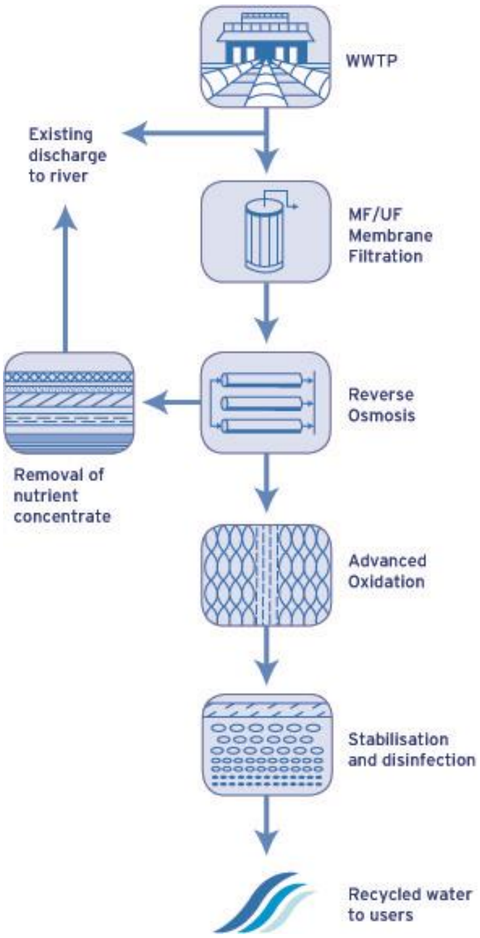


Figure 3-1 AWTP treatment process

It is anticipated that to effect Class A+ level treatment of STP effluent currently produced at the majority of STPs being considered by the project, membrane filtration (MF/UF) and residual disinfection only would be required. It is also noted that the potential to use part of the AWTP process stream requires a thorough understanding of process and issues, e.g. recommissioning; this will be subject to more detailed evaluation as part of the feasibility study.

3.2.3 Other sources

There are a number of other direct and diffuse sources of nutrients that discharge into Moreton Bay, including urban and rural surface water runoff, licenced discharges from industrial and commercial facilities and bank erosion in contributing waterways. To address another of the project problem statements, options are to provide an additional water supply to the Lockyer Valley and Darling Downs along with improved associated water security. As such, the project is focused on being able to efficiently capture, treat (if required) and transport water to the subject areas.

Capture of a diffuse source such as stormwater presents the following issues:

- Typically infrastructure-intensive
- Limited impact on reducing nutrient load
- Significant investment required in diversion and storage at constrained locations to enable capture and pumped transfer
- Subject to weather events (potentially providing water at a time when demand is low).

There are very few stormwater harvesting schemes currently in operation due in part to the constraints identified above. Given the opportunities presented by recycled water from STPs to address the project problem statements, this project will focus on STP point sources at relevant locations. It is noted that there may be opportunities in the future to supplement this supply with additional sources should this present a beneficial outcome in meeting the project objectives.

Paper Size A4

NuWater Project feasibility Study
Options Identification Report

Job Number	41-30968
Revision	0
Date	25 Aug 2017

Locations of potential
recycled water sources

Figure 3-2

G:\41\30968\GIS\Maps\Graphics\41_30968_100_rev_a.indd

145 Ann Street Brisbane QLD 4000 | T 61 7 3316 3000 | F 61 7 3316 3333 | E bnemail@ghd.com | W www.ghd.com

Data Source: Google Earth Pro: Data extracted 28072017.

3.3 Recycled Water Delivery Alternatives

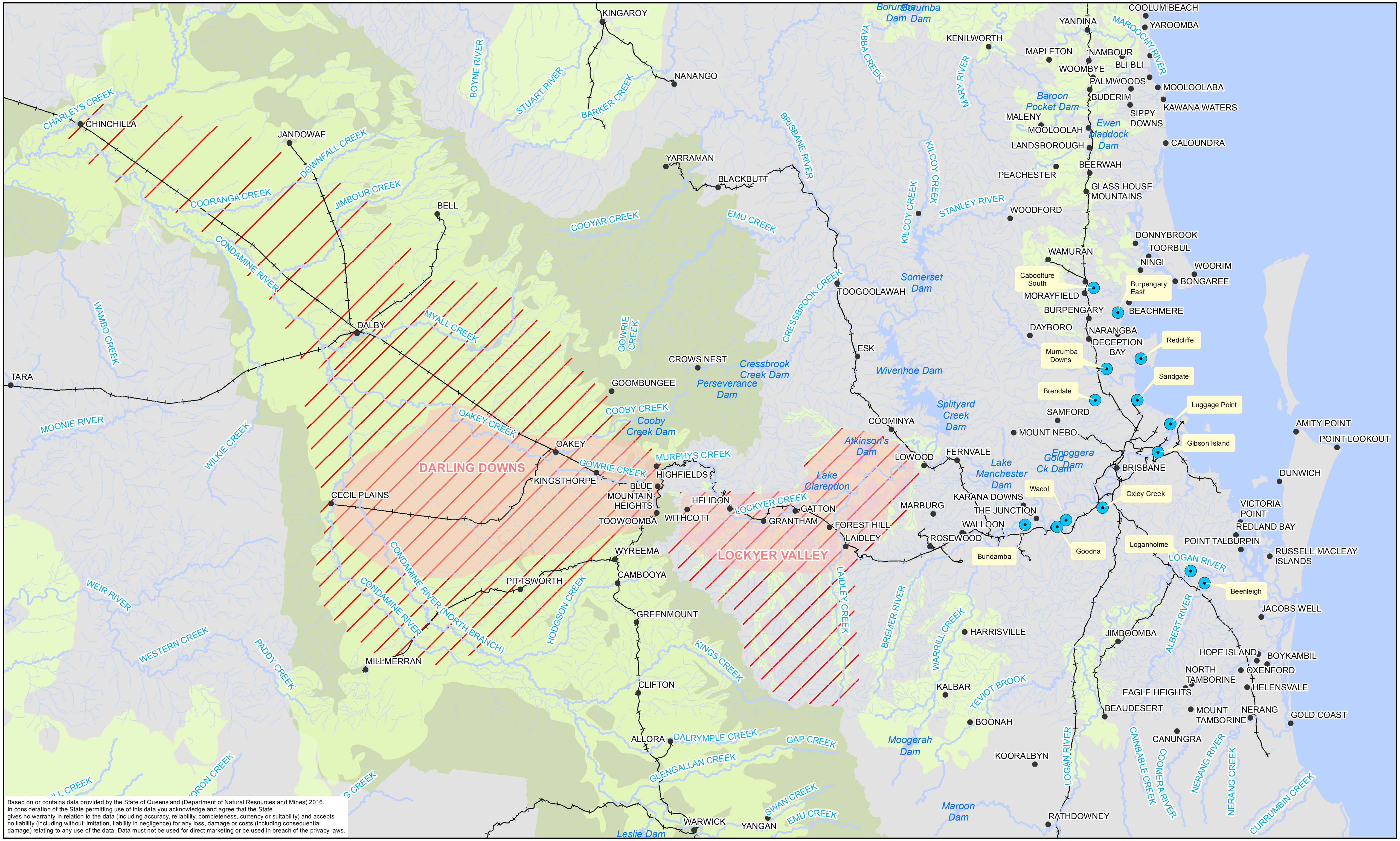
3.3.1 Recycled Water Demand

The problem statement for the project identifies the need for additional water supply in the Lockyer Valley and Darling Downs to support agricultural and industrial production growth. Representatives from established agricultural areas in both areas were involved in the options identification workshop and assisted with clarifying the extent and specifics of demand that may be serviced by this new recycled water product.

The identification of agricultural demand will build on previous work and update with the current outlook on potential demand and levels of interest; irrigation surveys have been distributed. Follow-up focus group meetings are yet to be facilitated and outcomes analysed however indications from the workshop and follow-up suggested:

- Indicative substantial water demand
- A greater capacity to take a range of water qualities on the Darling Downs
- A capacity to take large volumes of treated wastewater on the Darling Downs and use existing on-farm systems as balancing storages to manage the 'constant-flow' water characteristics of the supply source with temporarily variable water demands
- Ability to store and move water about between adjacent farms
- Over 90% of farms on the Darling Downs have tail water drains/recycle systems to capture runoff assist contain on-farm (Cotton BMP recommend the ability to capture 25 mm of runoff off the irrigated area of a farm)
- Increased flexibility around cropping decisions on the Darling Downs where producers utilise broad-acre commodity markets i.e. greater capacity to accommodate interruptions in water supply with less market driven pressures
- Broad requirement for higher quality water for irrigation use in the Lockyer Valley
- More market sensitive issues that would impact potential treated wastewater supplies to the Lockyer Valley
- Supply uncertainties as a result of current reviews of groundwater management in the Lockyer Valley and review of the Moreton Water Plan (affecting Lockyer Valley groundwater and surface water sources) contributed to the conversation in terms of where additional demand may result from changes to current supply arrangements.

Key areas of potential demand are shown on Figure 3-3.



Paper Size A3

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- ● Locations
- ⊙ STP (Discharge to Moreton Bay)
- Watercourse (minor)
- Watercourse
- Railway
- 🟥 Proximity to potential pipeline
- Indicative Project Extents
- 🟦 Waterbody
- 🟩 Important Agricultural Areas
- 🟩 Priority Agricultural Area

NuWater Project feasibility Study
Options Identification Report

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Revision	0
Date	25 Aug 2017

Indicative Recycled Water Demand Study Area

Figure 3-3

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Data source: DNRM: Agricultural Area/2015; Railway, Watercourse/2016; GHD: STP, Indicative Project Extents/2017. Created by:ihamilton

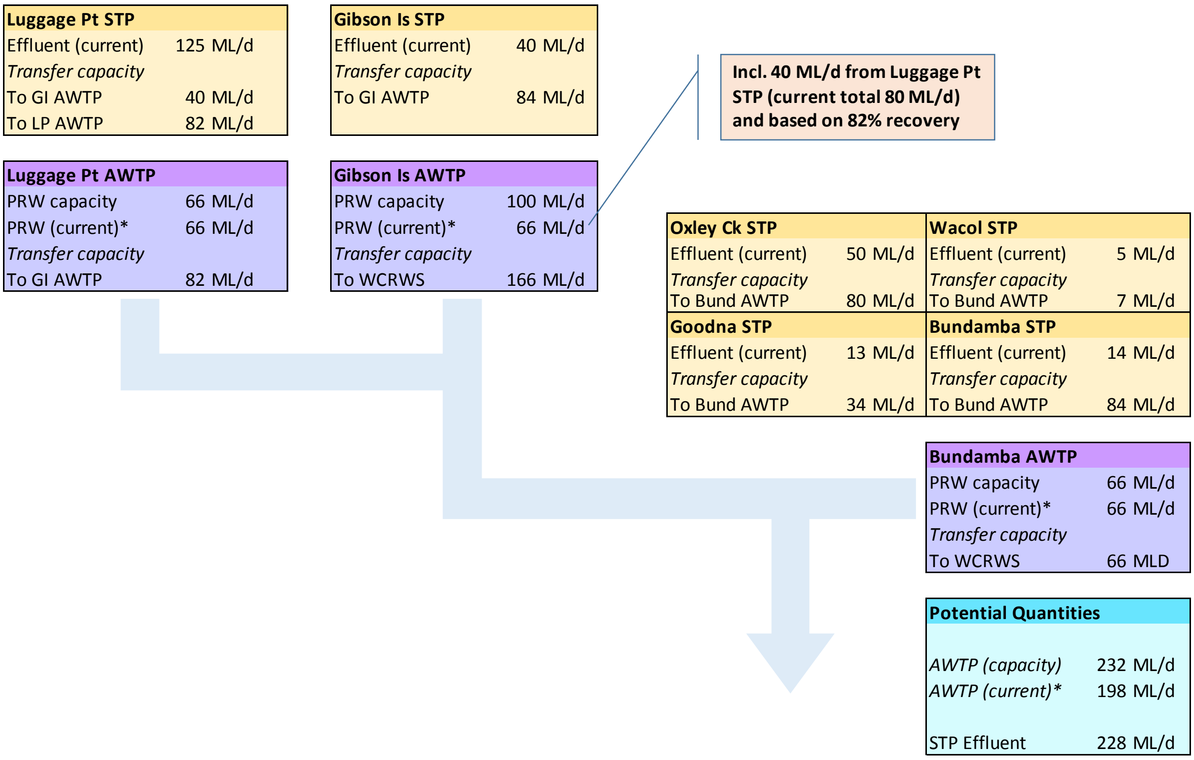
3.3.2 Recycled Water Transportation

Bulk Water Transportation

The WCRWS has a design capacity of approximately 232 ML/d, which translates to around 85,000 ML/year. Although this is less than the nominal target for the project, being 100,000 ML/year, it presents a significant advantage given the scheme collects source water from six significant STPs and delivers recycled water some 80km from the mouth of the Brisbane River to Lowood at the northeast extent of the Lockyer Valley and beyond.

A summary of the indicative source water quantities (i.e. STP average dry weather flows, AWTP treatment capacity) and transfer infrastructure capacity is represented schematically in Figure 3-4. This shows that, indicatively, there is sufficient source water and system delivery capacity to transfer close to the system design rate of 232 ML/d.

It is noted that to reach the design capacity of 232 ML/d, construction of a booster pump station located at Heathwood is required as this was not included in the original WCRWS commissioned works. There are also numerous other system configuration challenges such as bypassing treatment unit processes depending on the desired water quality and increasing the transfer rate at some pump stations. As options are defined as part of the project, evaluation of source water quantity, system delivery capacity, required system modifications and estimates of costs required to deliver the selected recycled water products will be undertaken to review the feasibility of individual infrastructure elements.



*based on AWTP source water (STP effluent) limitations. Also assumes recommissioned to full capacity

Figure 3-4 Indicative WCRWS Transfer Schematic

Additional pipeline arrangements have been considered as part of early options identification to identify potential links between recycled water sources and demand locations. These options have been included either as part of the recycled water system including existing infrastructure or potentially a supplementary means to increase supply as part of an expanded scheme. Pipeline connections have been listed in the following table. A figure has been prepared which includes each of the pipeline options described in Table 3-6, refer Figure 3-5.

Table 3-6 Recycled Water Pipeline Options for consideration

Pipeline Description	Function	Indicative Product Options	Indicative Details (length and nominal diameter (DN), mm)
Lowood Booster PS to Gatton (interim booster PS)	Deliver 232 ML/d from WCRWS to Lockyer Valley (Central Lockyer Valley Water Supply Scheme (CLVWSS) plus offtakes)	Delivery pipeline to demand areas for any product.	32km, DN1500 (1422 mm)
Gatton (interim booster PS) to Gowrie Creek	Deliver 232 ML/d to Darling Downs	Delivery pipeline to demand areas for any product.	48km, DN1500 (1422 mm)
Bundamba STP to Gatton (interim booster PS)	Deliver 81 ML/d from Oxley Creek, Wacol, Goodna and Bundamba STPs to Lowood Booster PS	More suited to delivering a lower quality product (Class A+ or Class B/C)	32.1km, DN900 (813 mm/ 914 mm)
Loganholme STP to Goodna STP	Deliver additional 44 ML/d to the WCRWS connecting at Goodna STP.	More suited to delivering a lower quality product (Class A+ or B/C)	32.6km, DN700
Redcliffe STP to Sandgate STP	Deliver additional 18.8 ML/d to the WCRWS joining Sandgate STP flows.	Potential source water for all products.	13.8km, DN450
Murrumba Downs STP to Sandgate STP	Deliver additional 16.5 ML/d to the WCRWS joining Sandgate STP flows.	Potential source water for all products.	11.7km, DN450
Sandgate STP to Luggage Point STP - Sandgate STP only - Combined Redcliffe, Murrumba Downs, Sandgate STP flows	Deliver additional 17.7 ML/d (or 53 ML/d combined) to the WCRWS connecting at Luggage Point STP/AWTP.	Potential source water for all products.	13.2km, DN450 (DN750 combined)

Pipeline Description	Function	Indicative Product Options	Indicative Details (length and nominal diameter (DN), mm)
Murrumba Downs STP to Brendale STP	Deliver additional 16.5 ML/d to the WCRWS joining Brendale STP flows.	More suited to delivering a lower quality product (Class A+ or Class B/C)	9.7km, DN450
Brendale STP to Lowood Booster PS - Brendale STP only - Combined Murrumba Downs, Brendale STP flows	Deliver additional 8.4 ML/d (or 24.8 ML/d combined) to the WCRWS connecting at Lowood Booster PS.	More suited to delivering a lower quality product (Class A+ or Class B/C)	43.8km, DN300 (DN500 combined)

Wynnum STP was also considered as a potential source augment supply to the WCRWS however given the low quantity at issue and the existing agreement QUU holds with Caltex to deliver recycled water, this option was not progressed.

It is noted that the diameters and pipeline lengths are high level and for indicative scale purposes only. Further, in each case, the pipeline would need to be supplied by a new pump station, the details of which will be prepared as part of the forthcoming options development phase. In subsequent project stages, more detailed review of pipeline routes, connection requirements and relevant delivery system sizing will be undertaken. In addition, for each of the identified pipeline/delivery options, a high level summary of potential operating cost elements will be prepared, which will include items such as:

- Pumping costs for new source water (i.e. delivery from STPs)
- Advanced Water Treatment Plant costs, whether for PRW production or a modified process requirement. This will include power costs for pumping (i.e. MF/UF membrane filtration, reverse osmosis (RO)) and additional consumables.
- Pumping costs associated with WCRWS pump stations (if applicable)
- Pumping costs with transferring water from WCRWS or other source locations to other demand areas.

Recycled Water Distribution

In delivering a new water product to the Lockyer Valley and Darling Downs areas, further distribution infrastructure will be required to take water from the major bulk water pipelines to the local points of demand. It is understood that a development distribution infrastructure network exists at the regional and farm level to efficiently transfer water within each area. At this stage, the description of options refers primarily to the high level identification of bulk water transportation infrastructure only.

The ability to leverage existing infrastructure to distribute water to individual farms or local water networks (channels, storages, etc.) will be subject to the demand analysis, which will assist by identifying in greater detail where the water needs to go and review of the water product and its appropriate transportation and distribution. This assessment, including identifying additional works required to transfer water to the farm gate (if required) will be undertaken as part of the options development phase.

3.3.3 Water Storage

It is anticipated that when operating, the NuWater Project recycled water scheme will be delivering water to the demand areas as it is being produced, meaning that excluding unforeseen outages and planned maintenance, water will be supplied “24/7.” The detailed distribution system will include examining the means to store recycled water for use as needed.

Each of the Lockyer Valley and Darling Downs areas have existing water storage resources, which can be included in the scheme depending on the water product and potentially other mitigating arrangements to manage multiple water sources. This evaluation will be undertaken as part of further options development and be subject to the demand analysis and the location of demand relevant to storage infrastructure.

Lockyer Valley

The Central Lockyer contains a number of potentially relevant water storages and distribution assets, which are generally part of existing water supply schemes operating in the area. These include the following:

- Bill Gunn Dam (Lake Dwyer)
- Clarendon Dam (Lake Clarendon)
- Atkinson Dam
- Kentville Weir
- Jordan 1 and 2 Weirs
- Wilson Weir
- Clarendon Weir
- Glenore Grove Weir
- Laidley Creek Diversion Weir
- Showgrounds Weir
- Crowley Vale Weir
- Morton Vale Pipeline[3]

Darling Downs

It is also understood that approximately 300,000 ML of on-farm water storage exists in the Condamine River catchment between Warwick and Chinchilla of which approximately 50% is under-utilised.[4] Individual storages may range in size from less than 10 ML to over 20,000 ML. There is often the capacity to move water between adjoining farms or with minimal modification connect systems into a local area scheme. These systems are well adapted to receive constant flows from treatment plants with sufficient ‘air space’ to store supply during periods of no irrigation requirement.

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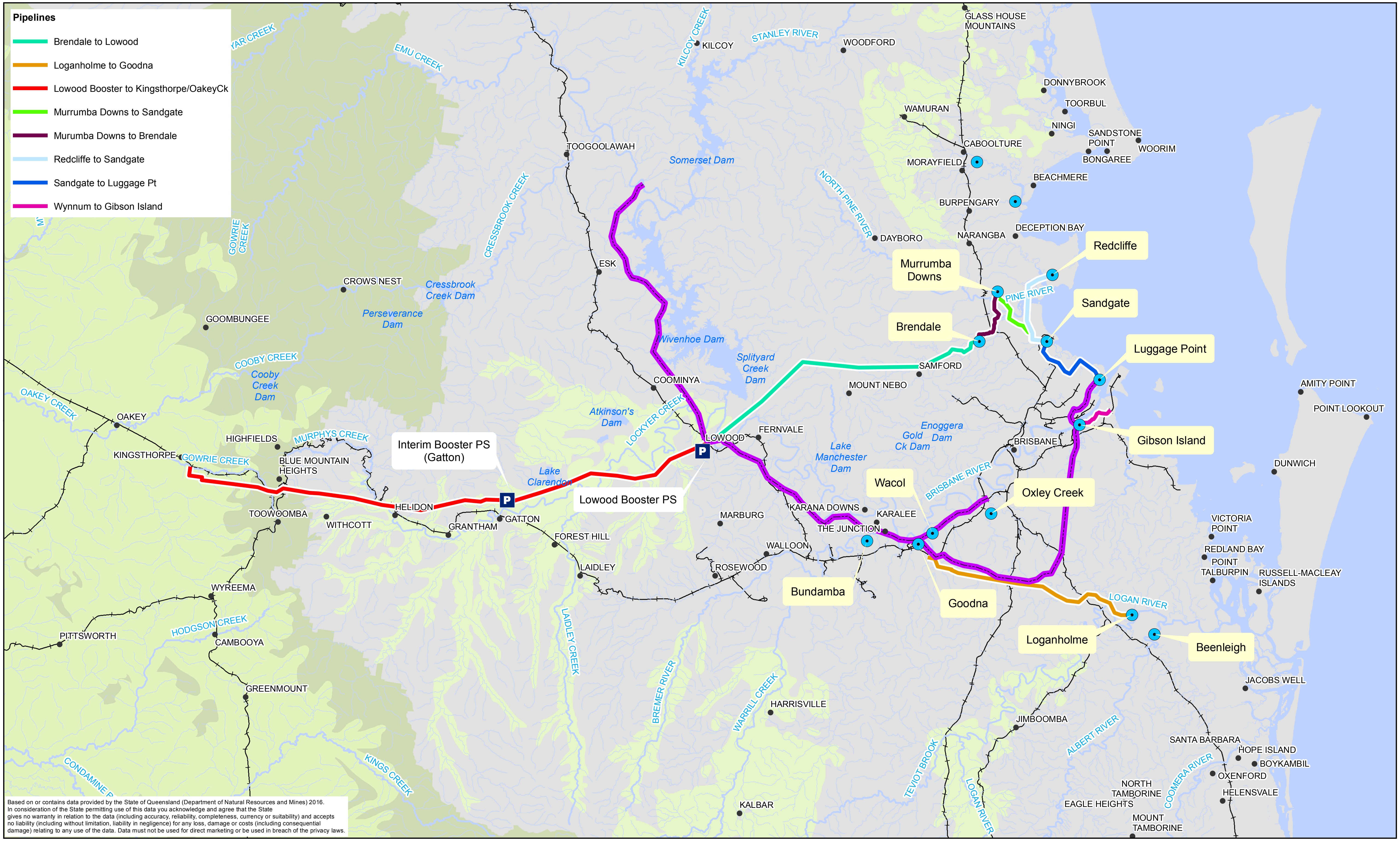
[3] *Central Lockyer Valley Water Supply Scheme, Network Service Plan, 2013-2017 Irrigation Pricing Submission to the QCA*, Seqwater

[4] Personal comment Graham Clapham June 2017



Based on or contains data provided by the State of Queensland (Department of Natural Resources and Mines) 2016. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

Paper Size A3

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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LEGEND
- ● Locations
- P Pump Station
- ● STP (Discharge to Moreton Bay)
- Western Corridor Recycled Water Scheme
- Watercourse (minor)
- Watercourse
- Railway
- Waterbody
- Important Agricultural Areas
- Priority Agricultural Area

GHD

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Indicative Recycled Water Pipeline Options

Figure 3-5

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Data source: DNRM: Agricultural Area/2015; Railway, Watercourse/2016; GHD: Pipeline Options, STP, Indicative Project Extents/2017. Created by:ihamilton

3.3.4 Power Supply

All options have significant energy requirements, with options supplying the Darling Downs involving substantial pumping head to traverse the Toowoomba Range.

The use of a pilot tunnel associated with investigative works for the Toowoomba Second Range Crossing road improvement project for the delivery pipeline has been flagged as a potential opportunity to reduce pumping requirements by avoiding a high point of the range. This is being investigated further in consultation with the Department of Transport and Main Roads (DTMR).

In order to feed the power requirements of the various pump stations, the capacity of the existing supply grid will require investigation. In addition, this new power demand presents an opportunity to explore alternative power supply options including renewable supplies. A number of potential options have been identified for addressing potential power supply demand, including:

- Traditional power supply grid network connection, including upgrades
- Solar energy, including battery storage
- Solar/diesel hybrid generators/power stations
- Hydro-power generation (including Spit-Yard Creek)
- Wind energy supply, plus battery storage or potentially pumped storage.

The feasibility of above options to meet the supply requirements will be reviewed as part of the project.

4. Project Options

4.1 Options Identification Workshop outcomes

The high level option elements included in Section 3.1, 3.2 and 3.3 were presented at the Options Identification Workshop. As part of the workshop, views from the stakeholder group were sought as to which options broadly met the objectives of each organisation represented. The outputs from this interactive exercise are included in Appendix C. In summary, the findings broadly indicated the following:

- There was an almost equal split of preferences for either lower quality water (effluent as produced from the STPs) or higher quality (PRW, Class A+)
- There was a minor preference for lowering the salt content in recycled water
- Lockyer Valley growers strongly favoured a higher quality product, being Class A+ or PRW
- Darling Downs growers strongly favoured a lower quality product, or effluent as produced from STPs
- Utilising the WCRWS and delivering recycled water to both Lockyer Valley and Darling Downs was favoured.

The options review outcomes conducted by the workshop attendees will be further investigated as part of the water demand assessment to be coordinated by Synergies Economic Consultants. The assessment aims to determine the nature of producers’ demand for additional irrigation water and will comprise several steps, including a general survey and later focus groups to be held with producers interested in obtaining water from the project in both the Lockyer Valley and on the Darling Downs.

4.2 Project Options to be progressed

The options identification process completed to date has included a high level review of opportunities that address the NuWater Project’s problem statements and a workshop process to further identify options for consideration as part of the Feasibility Study.

Section 3 outlines the alternatives for each project element that, in combination, will be used to form individual options. In selecting the form of options identified at this stage of the options development process, the following is noted:

- Numerous combinations of option elements will be possible however an assessment process has been identified to comparatively review the benefits afforded by option elements. In this way, certain option elements may be removed from further assessment if found to be relatively costly (CAPEX, OPEX) or not deliver a meaningful quantity of water. A description of the proposed assessment process is included in Section 5.2.
- All options include the bulk water transfer from the WCRWS (Lowood Booster PS) to Lockyer Valley (Gatton) and from Lockyer Valley (Gatton) to the Darling Downs (Gowrie/Oakey Ck).
- The described option elements include the bulk transportation of water only and do not specifically include the works required to distribute water to individual farms or local water networks (channels, storages, etc.).
- The outcomes of the demand analysis will be used to refine the extent of water distribution and storage infrastructure (i.e. from bulk water infrastructure to farm gate) and determine the extent to which existing infrastructure can be leveraged.

- Power supply requirements and energy costs will be a fundamental consideration for all options. It is proposed that, when required, more detailed investigation of options for additional supply of power will be developed on the basis of short-listed option requirements. Operating costs (i.e. energy consumption and energy price estimates) will be used for higher level comparative assessment of options (refer Section 5.2).

A summary of options to be progressed as part of the project has been included in Table 4-1.

Table 4-1 Potential NuWater Project Options

Option	Quality/ Product Options	Treatment Options	Sub-option	Delivery Option Description	Quantity (ML/d)
1	PRW	Fully recommission WCRWS AWTPs (note additional reject stream treatment for nutrient removal at Luggage Pt/ Gibson Is AWTPs)	1.1	WCRWS pipeline (current capacity)	182
			1.2	WCRWS pipeline, construction of Heathwood PS and upgrade of Gibson Island AWTP	198
			1.2.1	Pipeline from Sandgate STP to Luggage Point STP, transferring Sandgate STP flow	216
			1.2.2	Pipelines from Redcliffe/ Murrumba Downs STPs to Sandgate STP and from Sandgate STP to Luggage Point STP, transferring Sandgate/ Redcliffe/ Murrumba Downs STP flows	232
2	Class A+	Partially recommission WCRWS AWTPs (MF/UF plus disinfection)	2.1	WCRWS pipeline (current capacity)	182
			2.2	WCRWS pipeline, construction of Heathwood PS and upgrade of Gibson Island AWTP	232
3	Class B/C (as produced)	Nil (STP effluent) for Darling Downs End of pipe treatment (to Class A+) for Lockyer Valley	3.1	WCRWS pipeline (current capacity)	182
			3.2	WCRWS pipeline, construction of Heathwood PS	232
			3.2.1	Pipeline from Loganholme STP to Goodna STP to relieve load on Luggage Point STP (i.e. use effluent from Loganholme STP preferentially to effluent from Luggage Point STP)	232
			3.2.2	Pipeline from Brendale STP to Lowood Booster PS to relieve load on Luggage Point STP (i.e. use effluent from Brendale STP preferentially to effluent from Luggage Point STP)	232
			3.2.3	Pipeline from Murrumba Downs STP to Brendale STP, to Lowood Booster PS, transferring Brendale and Murrumba Downs STP flows to relieve load	232

Option	Quality/ Product Options	Treatment Options	Sub-option	Delivery Option Description	Quantity (ML/d)
				on Luggage Point STP (i.e. use effluent from Brendale STP preferentially to effluent from Luggage Point STP)	
4	Class B/C (as produced)	Nil (STP effluent) for Darling Downs End of pipe treatment (to Class A+) for Lockyer Valley	4.1	Pipeline from Bundamba AWTP to Lowood Booster PS (enables the WCRWS pipeline to remain solely for PRW transfer)	81
			4.1.1	Pipeline from Loganholme STP to Goodna STP to add source water (44 ML/d) to Bundamba AWTP	125
5	Wivenhoe (raw) water	Fully recommission WCRWS AWTPs (note additional reject stream treatment for nutrient removal at Luggage Pt/ Gibson Is AWTPs; offset water (PRW) required to replace Wivenhoe water for potable supply)	5.1	WCRWS pipeline (current capacity)	182
			5.2	WCRWS pipeline, construction of Heathwood PS and upgrade of Gibson Island AWTP	198
			5.2.1	Pipeline from Sandgate STP to Luggage Point STP, transferring Sandgate STP flow	216
			5.2.2	Pipelines from Redcliffe/ Murrumba Downs STPs to Sandgate STP and from Sandgate STP to Luggage Point STP, transferring Sandgate/ Redcliffe/ Murrumba Downs STP flows	232

5. Proposed Multi-Criteria Assessment (MCA) Tool

5.1 Proposed MCA Process

Multi-Criteria Assessment is a useful tool for filtering potential options to identify those options that should be taken forward for more detailed assessment. The strength of the MCA technique is its ability to include both qualitative and quantitative information in the option selection process. It also provides the opportunity to incorporate factors flagged by stakeholders during the workshop.

MCA is a technique that is commonly used to evaluate options when the relative merit of those options is not solely measured by monetary units (e.g. reduction of nutrient loads on Moreton Bay). Instead the performance of the options is assessed against some multiple assessment criteria. MCA techniques attempt to measure the effectiveness and not the absolute worth of each option.

The form of the MCA used for this study is known as the Goals Achievement Matrix (GAM) method. The primary focus of the GAM method is on the selected project outcomes as opposed to the effects or impacts of the project.

A three stage process is proposed to be developed to assess the long list of development options potentially able to meet project objectives, ending in a multi-criteria assessment to compare shortlisted options. These are discussed in the following sections.

5.2 Options Assessment Stages

5.2.1 Stage 1 – Hurdle Criteria

It is proposed that the long list of potential options be first assessed against an option's capacity to address each of the problem statements. Options unable to meet these initial criteria are proposed to be removed from further assessment in the Stage 2 process.

It was discussed during the workshop that a number of potential options would not directly meet the key project objectives i.e. capacity to reduce nutrient loads on Moreton Bay. These options have been retained inclusive of mitigating works that enable the option to address the relevant problem statement/s. For example,

- Where PRW forms the water product, treatment to effect nutrient removal from the ROC will be included in the overall option to ensure a net reduction of nutrients from Moreton Bay occurs.
- Where a lower water quality product is being transferred to Lockyer Valley (i.e. lower than Class A+), end of pipe treatment to produce minimum Class A+ water will be included in the overall option works.

5.2.2 Stage 2 – Short-listing process

It is proposed that the resulting list of options or option combinations be then assessed against the following criteria for comparative purposes:

- Total capital cost (high level estimate) per megalitre of yield ($/ML) at the farm
- Total operating cost (high-level estimate) per megalitre of yield ($/ML) at the farm.

The criteria above will provide a high-level cost estimate of the delivered price of water and also make provision for water distribution losses and cost of water storage and distribution system. This will provide the ability to assess the relative costs between option elements. It is noted that ultimately, the absolute costs are subject to a range of other factors yet to be assessed such as offsets and possible contributions by third parties (e.g. QUU).

5.2.3 Stage 3 – Multi-Criteria Assessment

The NuWater project is seeking to identify the preferred development option to advance project objectives that offers the best balance between:

- Economic/viability Goals
- Environmental Goals
- Social Goals.

These primary goals provide the base on which the MCA tool is proposed. The approach involves developing a series of nested selection criteria, which measure how well an option is likely to meet each of the required goals. Each goal is broken into a series of criteria and sub-criteria until a point is reached where the sub-criteria are easily evaluated for each project option. The final leaf on each branch of the tree represents an assessment criterion that will be used in the evaluation and ranking of projects.

The proposed assessment criteria is shown in Appendix D showing primary goals and nested criteria. The hierarchical structure assists in developing appropriate weights for each assessment criteria. Weights can then be assigned at each level that sum to 1.0 and differentiate the relative importance of the criteria. The resulting weight for each assessment criteria is developed by multiplying each of the weights that appear on the path from the assessment criteria back to the primary goal.

The alignment of issues and opportunities identified through the workshop is shown as Appendix E.

6. Conclusions and Recommendations

It is recommended that more detailed investigations be initiated to define preferred project/s and drive greater certainty and reduce project related risks associated with these options. The outcomes of these activities should form the basis of a Preliminary Business Case that justifies advancing the project. Areas of particular focus include:

- Understanding water availability/interruptibility including the estimated frequency and duration of WCRWS use to produce PRW to supplement SEQ's drinking water supplies
- Cost of recommissioning WCRWS, etc.
- Verification of water demand (including quality and ability to manage interruptibility)
- Understanding preconditions that need to be met/actions required of stakeholders before reuse may happen
- Characterising risks associated with wastewater reuse and disposal
- Optimising treatment cost to align with water demand needs
- Power needs and power supply/generation opportunities, matched to specific option requirements
- Refining cost estimates
- Carrying out the shortlisting process described in Section 5.2, including sufficient high-level development of options to enable the shortlisting process to occur
- Commencing with and without project assessments to determine the current state for use as a baseline to assess the benefits of the project and inform the preliminary business case
- Carrying out MCA process described in Section 5.2.3 to identify preferred option/s. This will involve further development of short-listed options consistent with the project requirements outlined in the NuWater Project Feasibility Study Part 2 – Specifications (QFF, 24 April 2017).

The above activities will be progressed as part of the next phases of the project.

Appendices

Appendix A – Options Identification Workshop Materials

Agenda

10 July 2017

Project	NuWater Project Feasibility Study	From	James Skene
Subject	Options Identification Workshop	Tel	+61 7 3316 3313
Venue/Date/Time	Lockyer Valley Cultural Centre / 18 July 2017 / 10am – 3pm	Job No	4130968
Copies to	All attendees/apologies		
Attendees	Full list to be available at workshop	Apologies	

Agenda	Action	Leader
10:00am	Morning tea upon arrival, attendees to find a seat	
10:15am	Welcome and Introductions *A welcome to the event, including safety, orientation and amenities from the Workshop Facilitator, followed by a short introduction (i.e. name, organisation, relevance to the NuWater Project) from workshop attendees.*	Elliot Willemsen-Bell
10.30am	Workshop Objectives *A description on the format and intent of each session and how attendees will have the opportunity to interact and add value.*	Elliot Willemsen-Bell
10:45am	Project Background and Intent from NuWater Project Management Committee (NPMC) representatives	Graham Clapham, Abel Immeraj, Anthony Staatz
11:15am	Session 1: Open discussion/brainstorming on individual ideas, issues *A session to seek input from stakeholders to inform the development of options.*	Elliot Willemsen-Bell
12:00pm	Lunch (James, Elliot and Tom to group ideas, issues etc. into themes over lunch break)	
12.30pm	Presentation and feedback on themes	Elliot Willemsen-Bell

Agenda	Action	Leader
12:50pm	Session 2: Source options *A discussion on treated wastewater and alternatives as a water source for the NuWater Project:* • *STPs – QUU, Unitywater, LCC, CoGC, TRC* • *Supplementary Sources - Purified recycled water, Surface Water, Groundwater, On-farm Efficiency*	James Skene
1.10pm	Session 3: Water Product Alternatives *A discussion on options for different water products (quality) and consistency of supply (quantity) produced by the scheme:* • *PRW* • *Effluent quality – Class A+ (low salt content, RO), Class A+ (higher salt content), Class A, B, C, D* • *Interruptibility of supply*	David Solley / James Skene
1:30pm	Session 4: Demand options *A discussion on potential customers for the water, individual opportunities and needs, including:* • *Overview of current survey and methodology* • *Location of demand: Lockyer Valley, Darling Downs* • *Other demands: CSG make-good water, other*	Dan Culpitt / Irrigators
1:50pm	Afternoon Tea Break	
2:00pm	Long list of supply options *Identify and discuss options, including any additional produced during the workshop*	Elliot Willemsen-Bell / James Skene
2.30pm	High-Level assessment of options *Options will be reviewed against 'problem statement' to determine in a group setting the degree of alignment with the project objectives.*	Elliot Willemsen-Bell
2:45pm	Next steps	James Skene
3:00pm	Workshop Close	

NuWater Project Problem Statement

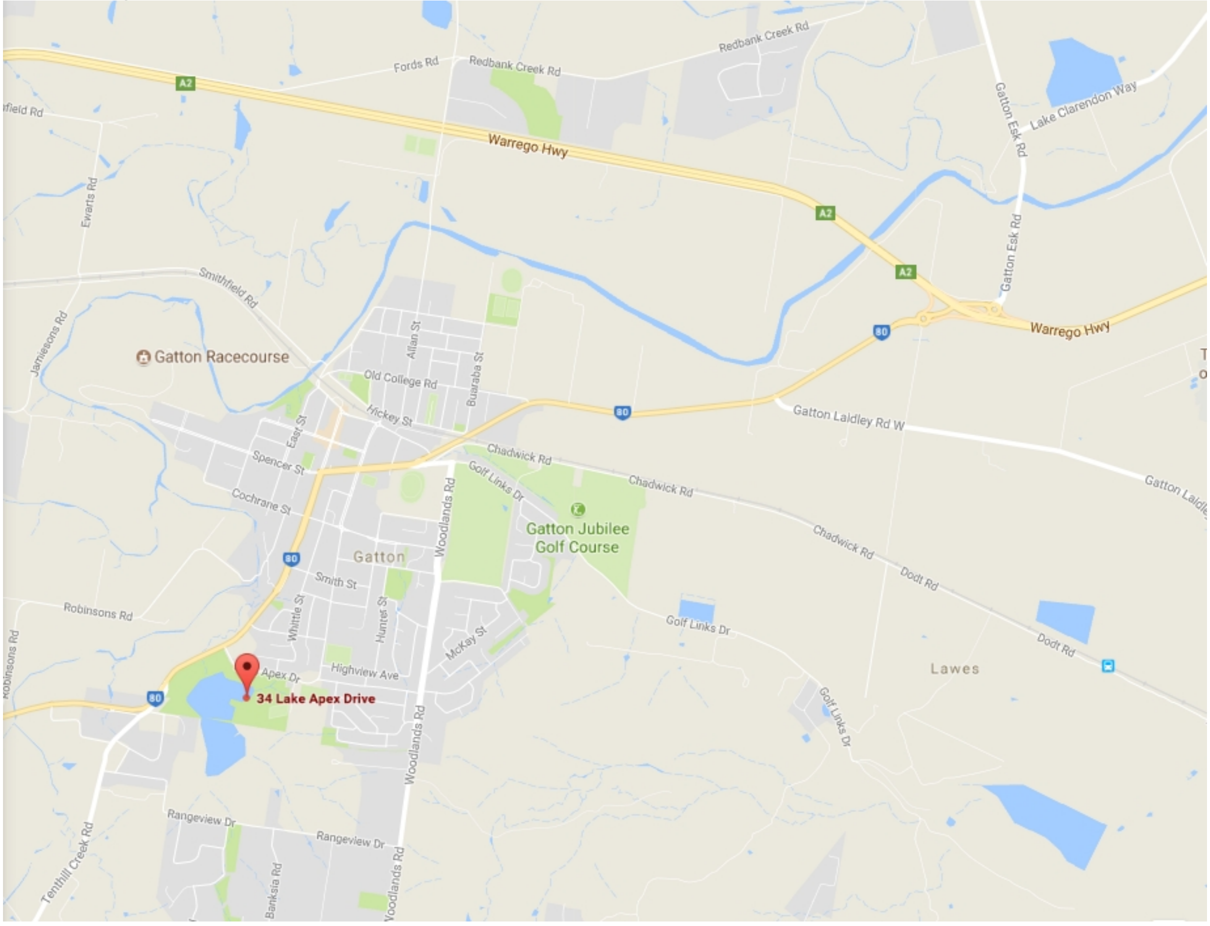
1.3 Problem Statement

The Project aims to examine the potential for synergistic solutions arising from the nexus of two separate problems:

- Costs of managing environmental impacts associated with treating South-East Queensland's wastewater and disposing the effluent to sea are expected to continue to increase driven by growing SEQ population and increasingly more stringent environmental standards that are in response to the communities' expectations for a maintaining the environmental health of Moreton Bay; and
- Growth in agricultural and industrial production and associated regional economic benefits (particularly as measured in regional jobs) in the Lockyer Valley and the Darling Downs is being significantly constrained by the lack of opportunities and access to traditional water source supplies and need to develop alternate supplies for the region.

Venue Location Map

34 Lake Apex Drive, Gatton



Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study
Options Identification Workshop

Date: 31/07/2017

Stakeholder List

OPTIONS IDENTIFICATION WORKSHOP	ACCEPTED	Organisation	Name	STATUS
YES	YES	Queensland Farmers' Federation (QFF)	Travis Tobin	
YES	YES	Cotton Australia	Michael Murray	
YES	YES	Gowrie-Oakey Creek Irrigators/McVeigh Partnership Trust	Matt McVeigh	
YES	NO	Food Leaders Australia	Georgie Uppington	Apology
YES	YES	Clapham Farming, Central Downs Irrigators Limited (CDIL)	Graham Clapham	
YES	YES	Sleba Enterprises, Central Downs Irrigators Limited (CDIL)	Rod Sleba	
YES	YES	Koala Farms	Anthony Staatz	
YES	NO	Queensland Urban Utilities	Abel Immaraj	Apology
YES	YES	Queensland Urban Utilities	Shane Tyrell	
YES	NO	Queensland Farmers' Federation (QFF)	Ian Johnston	Apology
YES	YES	Queensland Chicken Growers Association (QCGA), Queensland Chicken Meat Council (QCMC)	Rebecca Tkal	
YES	YES	Agforce	Kim Bremner	
YES	NO	Agforce	Dale Miller	
YES	NO	Seqwater	Ross Muir	Apology
YES	YES	Seqwater	Kate Lanskey	
YES	YES	Seqwater	Joseph Tam	
YES	YES	Department of Natural Resources and Mines	Fred Hundy	
YES	YES	Department of Natural Resources and Mines	Bob Tomkins	
YES	NO	Department of Natural Resources and Mines	Steve Goudie	Apology
YES	NO	Department of Energy and Water Supply	Virginia Hunter	Apology
YES	YES	Department of Agriculture and Farming	Richard Routley	
YES	YES	Lockyer Valley Regional Council	Belinda Whelband	Can attend from 11:30am
YES	NO	Lockyer Valley Regional Council	Paul Cranch	Apology
YES	YES	Cardno	Stephen Walker	
YES	YES	Toowoomba and Surat Basin Enterprise (TSBE)	Shane Charles	
YES	YES	Regional Development Australia - Darling Downs and South West (Federal)	Bryan Gray	Can stay till Lunch
YES	YES	Badu Advisory	Thomas Vanderbyl	
YES	YES	Synergies	Dan Culpitt	
YES	NO	GHD	Warren Traves	Apology
YES	NO	GHD	Murray Smith	Apology
YES	YES	GHD	James Skene	
YES	YES	GHD	Elliot	
YES	YES	GHD	David Solley	
YES	YES	GHD	Kristin Walduck	

GHD Synergies
ECONOMIC CONSULTING

QFF NuWater Project Feasibility Study

Options Identification Workshop

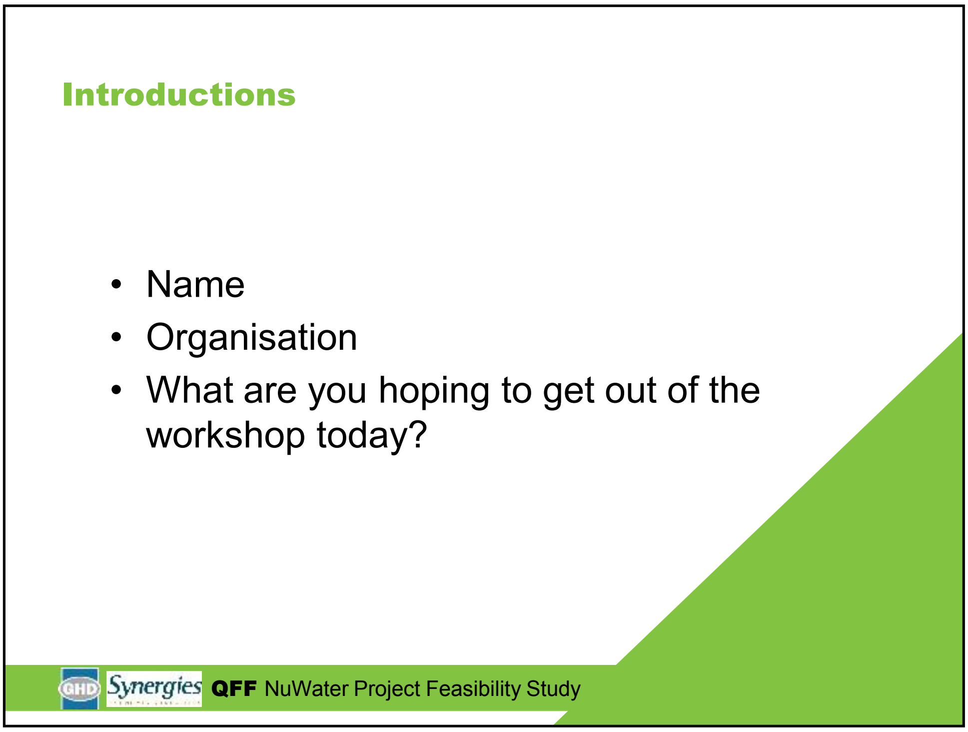
Tom Vanderbyl, Warren Traves
James Skene, Murray Smith

Options Identification Workshop

WELCOME

Housekeeping:

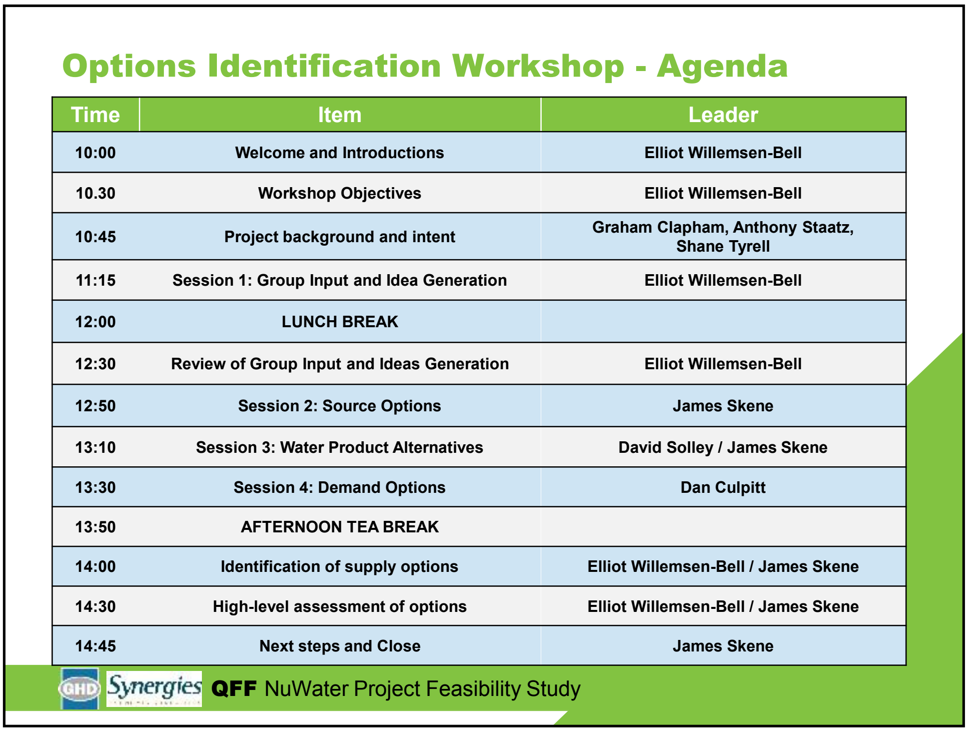
- Toilets
- Tea/Coffee
- Emergency Assembly Point



Introductions

- Name
- Organisation
- What are you hoping to get out of the workshop today?

QFF NuWater Project Feasibility Study



Options Identification Workshop - Agenda

Time	Item	Leader
10:00	Welcome and Introductions	Elliot Willemsen-Bell
10.30	Workshop Objectives	Elliot Willemsen-Bell
10:45	Project background and intent	Graham Clapham, Anthony Staatz, Shane Tyrell
11:15	Session 1: Group Input and Idea Generation	Elliot Willemsen-Bell
12:00	LUNCH BREAK	
12:30	Review of Group Input and Ideas Generation	Elliot Willemsen-Bell
12:50	Session 2: Source Options	James Skene
13:10	Session 3: Water Product Alternatives	David Solley / James Skene
13:30	Session 4: Demand Options	Dan Culpitt
13:50	AFTERNOON TEA BREAK	
14:00	Identification of supply options	Elliot Willemsen-Bell / James Skene
14:30	High-level assessment of options	Elliot Willemsen-Bell / James Skene
14:45	Next steps and Close	James Skene

QFF NuWater Project Feasibility Study

Workshop Objective

“To review Project Problem Statements, discuss key considerations/drivers and identify preferred options for further investigation”

- Establish baseline understanding of Project, including drivers and previous work undertaken
- Provide an open platform for raising and discussing new ideas and issues
- Discuss previously identified matters, including source options, water product alternatives and demand options
- Develop list of options
- Refine and prioritise options for further investigation

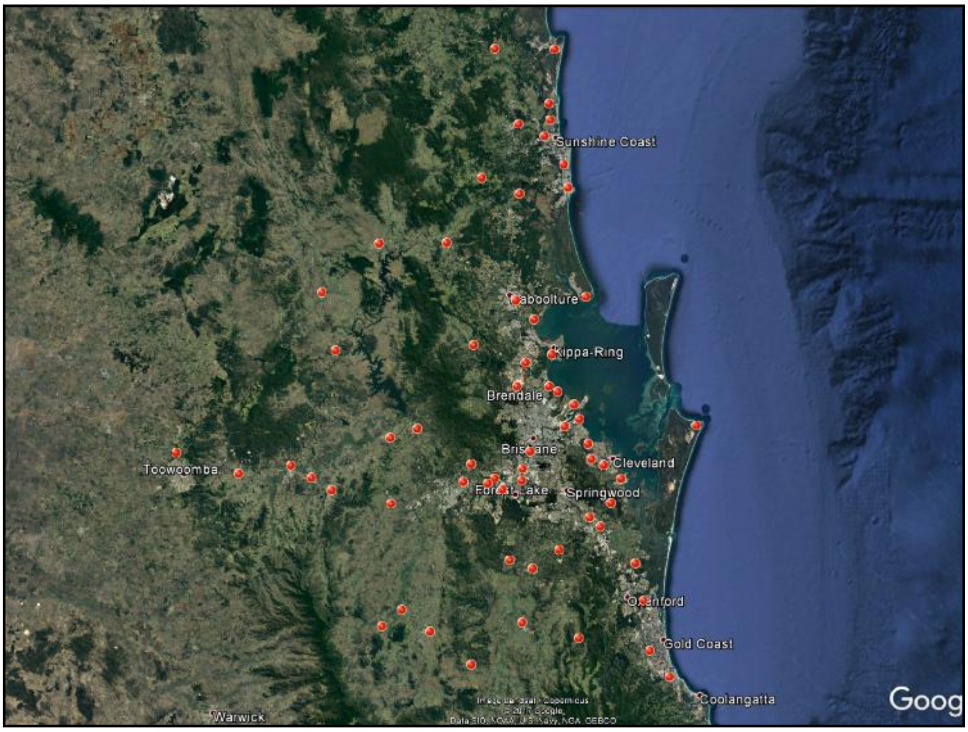
NuWater Project Process

Deliverables	Timing
Workshop Report identifying Potential Options	End of July 2017
Draft Feasibility Study Report/Preliminary Business Case Presentation to NPMC	8 November 2017
Agency Consultation Report Updated Draft Feasibility Study Report/ Preliminary Business Case Presentation to NPMC	8 February 2018
Final Feasibility Study Report/Preliminary Business Case Draft Community Prospectus Outline Presentation to NPMC	7 March 2018

NuWater Project "Problem Statement"

The Project aims to examine the potential for synergistic solutions arising from the nexus of two separate problems:

- **Costs of managing environmental impacts associated with treating South-East Queensland's wastewater and disposing the effluent to sea are expected to continue to increase driven by growing SEQ population and increasingly more stringent environmental standards that are in response to the communities' expectations for a maintaining the environmental health of Moreton Bay; and**
- **Growth in agricultural and industrial production and associated regional economic benefits (particularly as measured in regional jobs) in the Lockyer Valley and the Darling Downs is being significantly constrained by the lack of opportunities and access to traditional water source supplies and need to develop alternate supplies for the region.**



Project background

NuWater Project Management Committee representatives:

- Graham Clapham - Background and perspective from the Darling Downs
- Anthony Staatz – Perspective from the Lockyer Valley
- Shane Tyrell – Queensland Urban Utilities

Session 1: Group input and idea generation

Consider the Problem Statements and prepare some sticky notes on the following areas:

- Opportunities
- Constraints/limitations
- Benefits
- Risks

Place sticky notes under the appropriate heading around the room

RULES:

✓ One idea per sticky note – try to be succinct!
✓ No idea is off the table
✓ No limit to the number of notes you can write
✓ This is not a silent session! Feel free to discuss with your table

This is an open platform for raising issues and sharing ideas. Don't let your ideas or issues go unheard!

NuWater Project “Problem Statement”

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LUNCH – 30 mins

Review of Topics

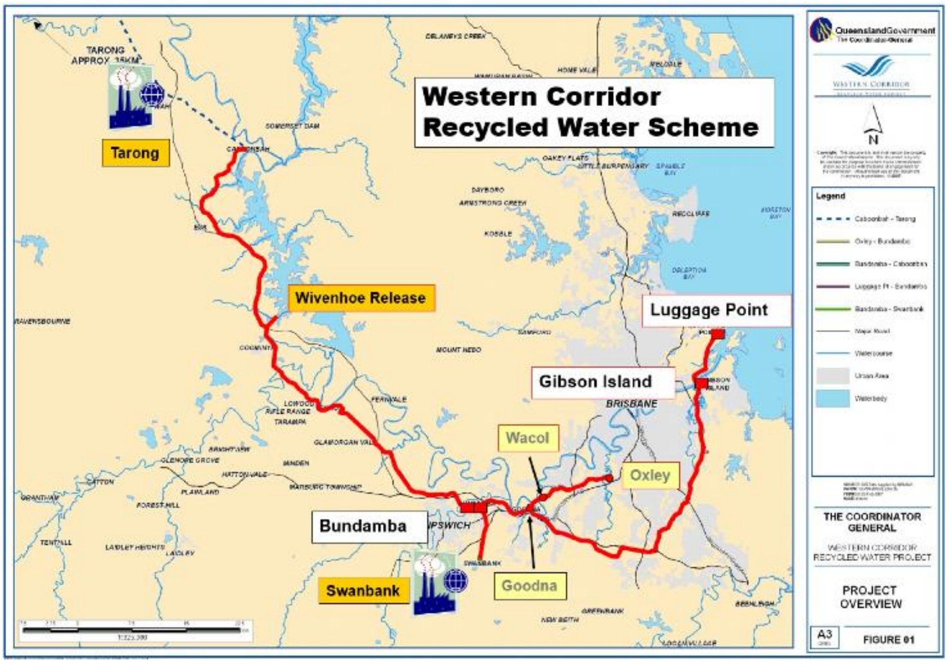
Initial options discussion

- Source Options – James Skene
- Water Product Alternatives – David Solley
- Demand Options – Dan Culpitt

Session 2: Source Options
James Skene

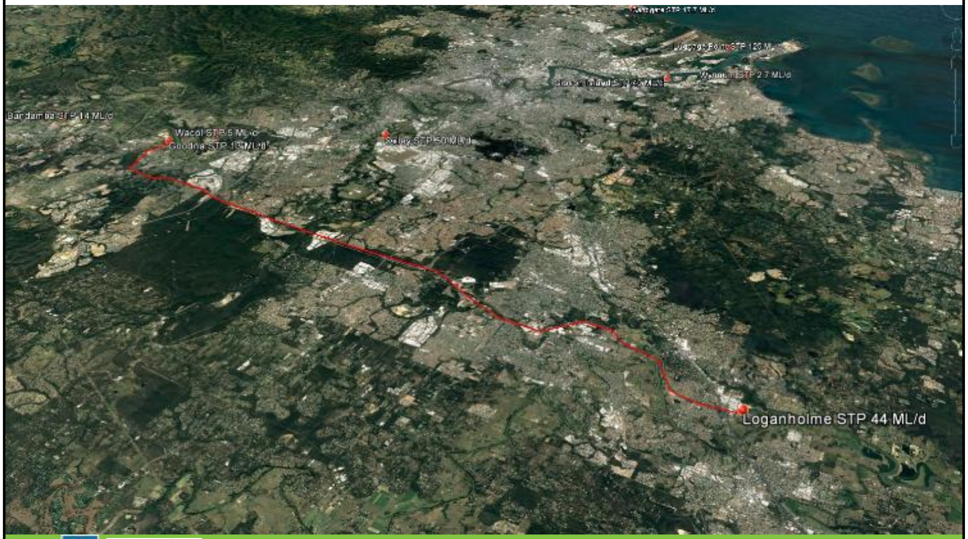
A discussion on treated wastewater and alternatives a water source for the NuWater Project

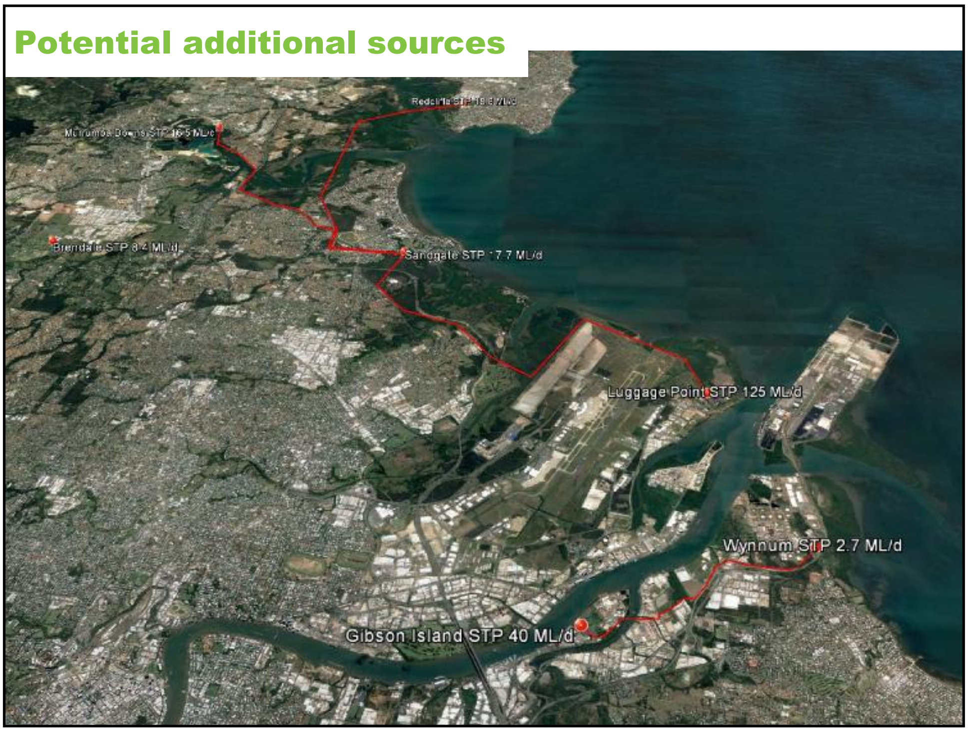
- STPs – QUU, Unitywater, LCC, CoGC, TRC
- AWTPs – Luggage Pt, Gibson Is, Bundamba
- Supplementary sources – Surface water, groundwater, on-farm efficiency



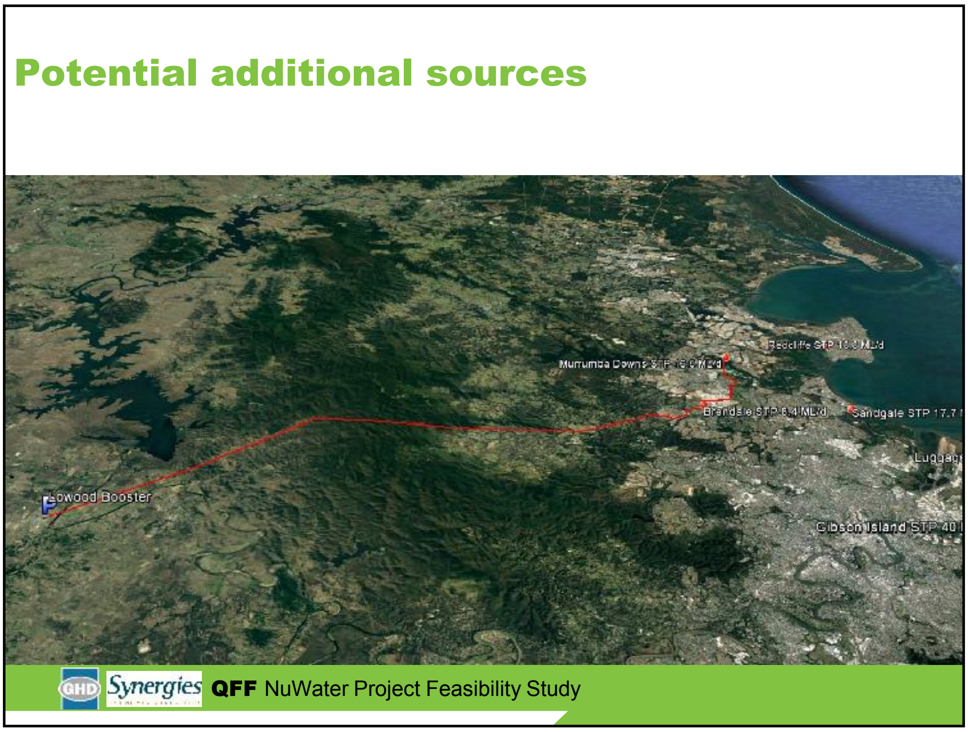
Source Water for WCRWSS

Potential additional sources





Potential additional sources



Potential additional sources

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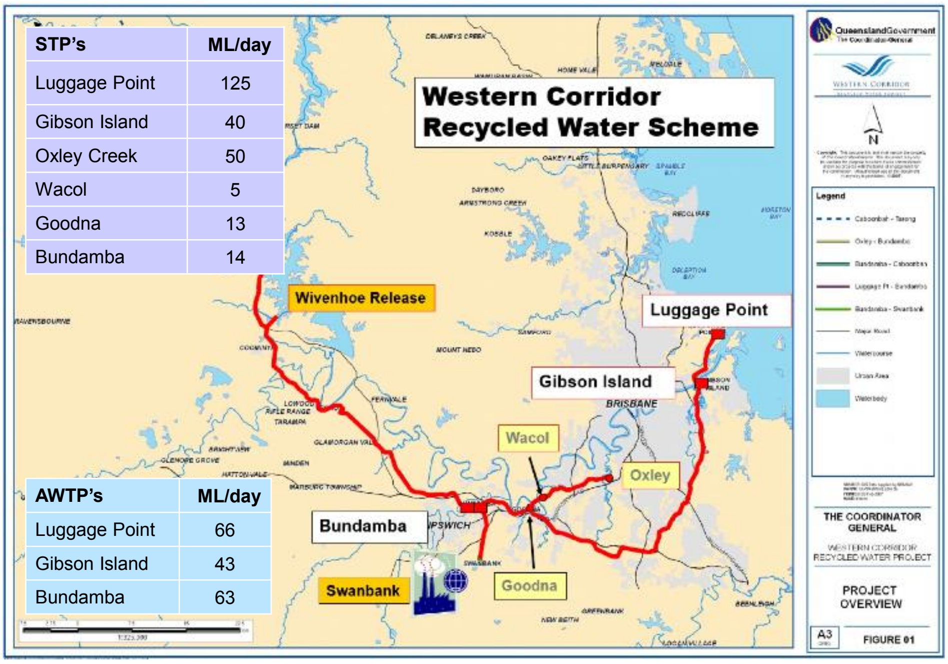


STP's	ML/day
Luggage Point	125
Gibson Island	40
Oxley Creek	50
Wacol	5
Goodna	13
Bundamba	14

AWTP's	ML/day
Luggage Point	66
Gibson Island	43
Bundamba	63

Session 3: Water Product Alternatives
David Solley, GHD

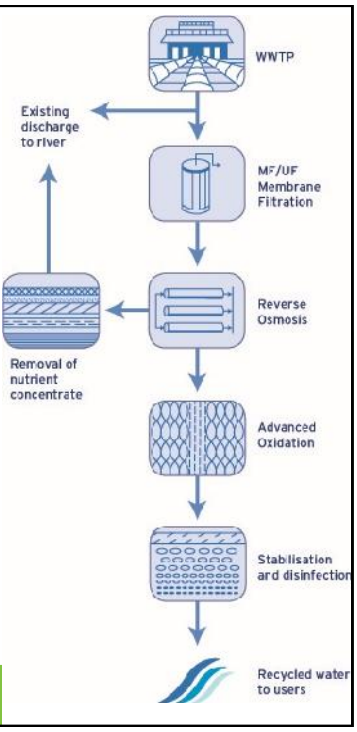
A discussion on the options for different water products (quality) and consistency of supply (quantity) produced by the scheme.

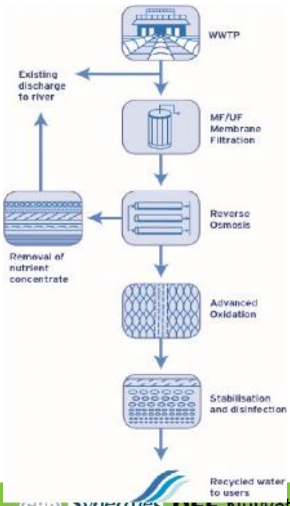
- Purified recycled water (PRW)
- Effluent quality – Class A+ (low salt content, reverse osmosis), Class A+ (high salt content), Class A, B, C, D
- Interruptibility of supply

General Process Schematic

General process design the same across the three Advanced Water Treatment Plants:

- Coagulation
- Membrane filtration (MF/UF)
- Reverse osmosis
- Advanced oxidation (UV/peroxide)
- Stabilisation
- Residual disinfection





Treatment		Grade	Salt	N	P
Raw		-	1	60	10
WWTP		B/C	1	5	2
AWTP	**Coag**	B/C	1	5	1
	MF/UF	A+	1	5	0.5
	RO	A+	0	1	0
	UV/H_2O_2	PRW	0	1	0
	Stabilise	PRW	0	1	0

Achieving appropriate water quality

- ✓ Queensland *Public Health Regulation 2005*
- ✓ "Fit for purpose" recycled water – aligning crops and usage

Table 2-1 Standards For Quality Of Recycled Water For Irrigating Minimally Processed Food Crops

Crop type	Example	Spray	Drip	Flood/ furrow	Sub-surface
Root crops	Onion, carrot	A	A	A	A
Crops with produce grown on or near the ground – skin typically removed	Pumpkin				
Rockmelon	-	A+	A+	A+	A+
Crops with produce grown on or near the ground – skin typically retained	Tomato, broccoli, cabbage	A+	A	A+	C
Crops with produce grown away from the ground – skin typically removed	Mango, avocado, banana	B	C	C	C
Crops with produce grown away from the ground– skin typically retained	Apple, olive, peach	A+	B	B	C
Crops for produce grown in hydroponic conditions	Lettuce, herb	A+	A+	A+	A+




Achieving appropriate water quality

Salinity of wastewater

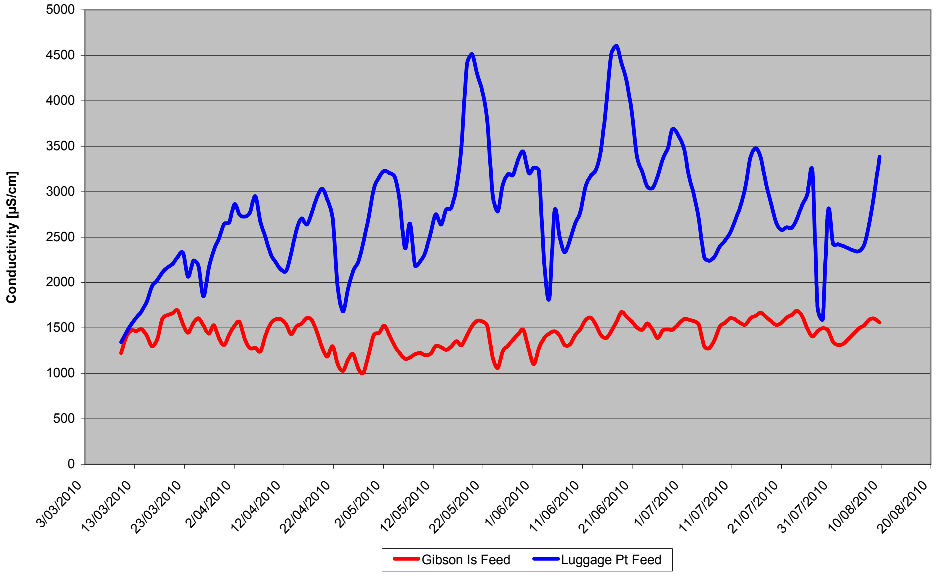
- ✓ Purified Recycled Water (PRW) – drinking water
- ✓ Recycled water from STPs - direct or blended
    - ✓ Luggage Point ~1500mg/L TDS / 2.34 dS/m
    - ✓ Gibson Island ~1000mg/L TDS / 1.56 dS/m
    - ✓ Other STPs 300-500mg/L TDS / 0.47-0.78 dS/m
- ✓ Anything below 0.65 dS/m is suitable for almost all crops

Department of Primary Industries

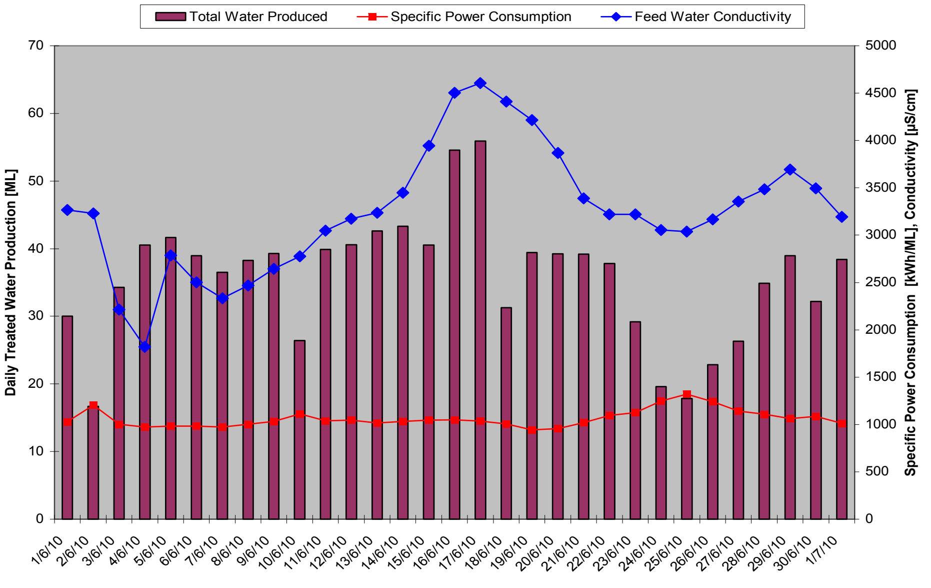
primefact

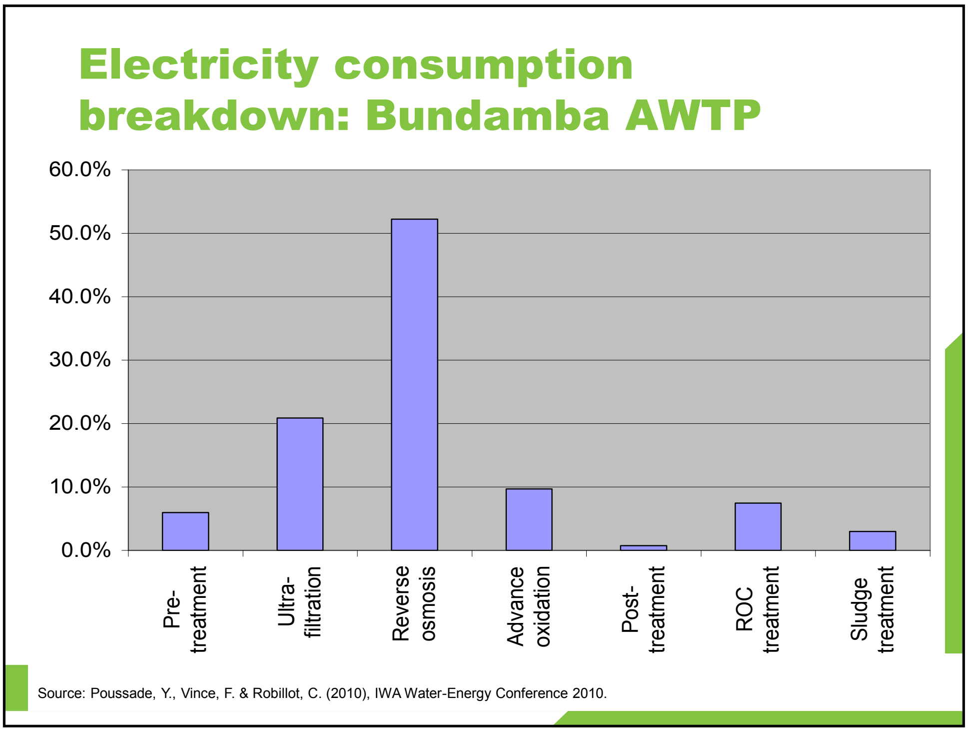
Salinity tolerance in irrigated crops

Feed Water Conductivity



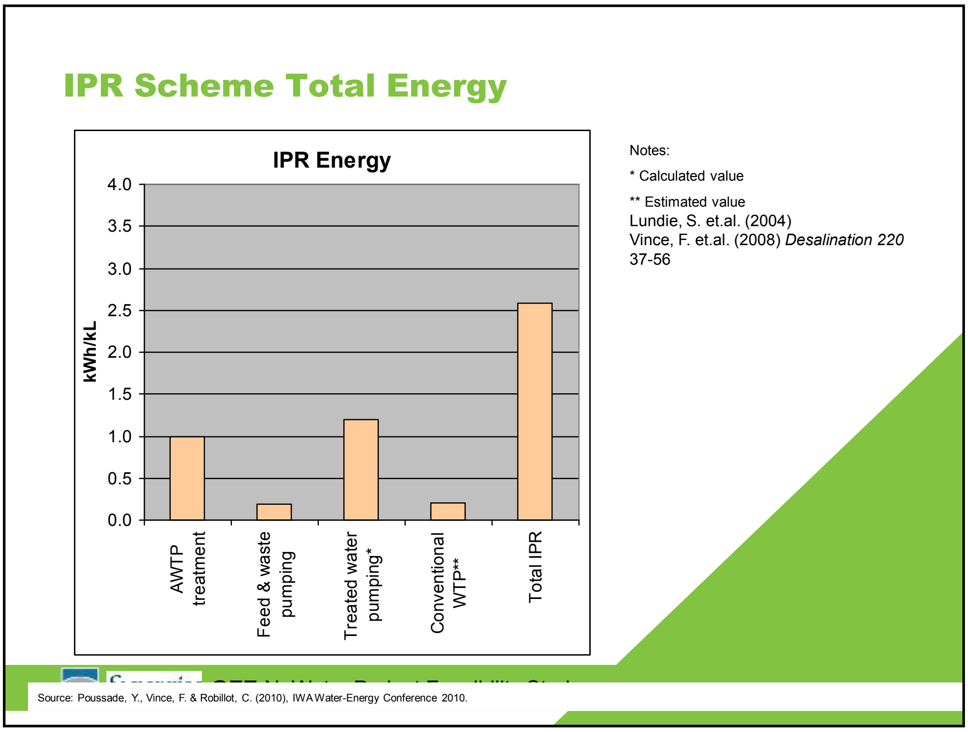
Luggage Pt AWTP Specific Power Consumption





Electricity consumption breakdown: Bundamba AWTP

Source: Poussade, Y., Vince, F. & Robillot, C. (2010), IWA Water-Energy Conference 2010.



IPR Scheme Total Energy

Notes:

* Calculated value

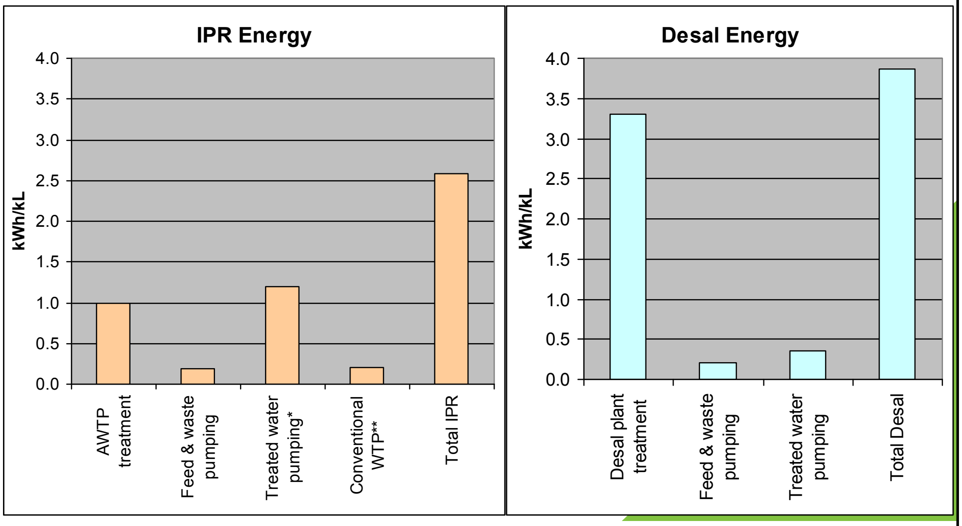
** Estimated value

Lundie, S. et.al. (2004)

Vince, F. et.al. (2008) *Desalination 220* 37-56

Source: Poussade, Y., Vince, F. & Robillot, C. (2010), IWA Water-Energy Conference 2010.

IPR vs Desal Total Energy



Source: Poussade, Y., Vince, F. & Robillot, C. (2010), IWA Water-Energy Conference 2010.

Session 4: Demand Options
Dan Culpitt, Synergies

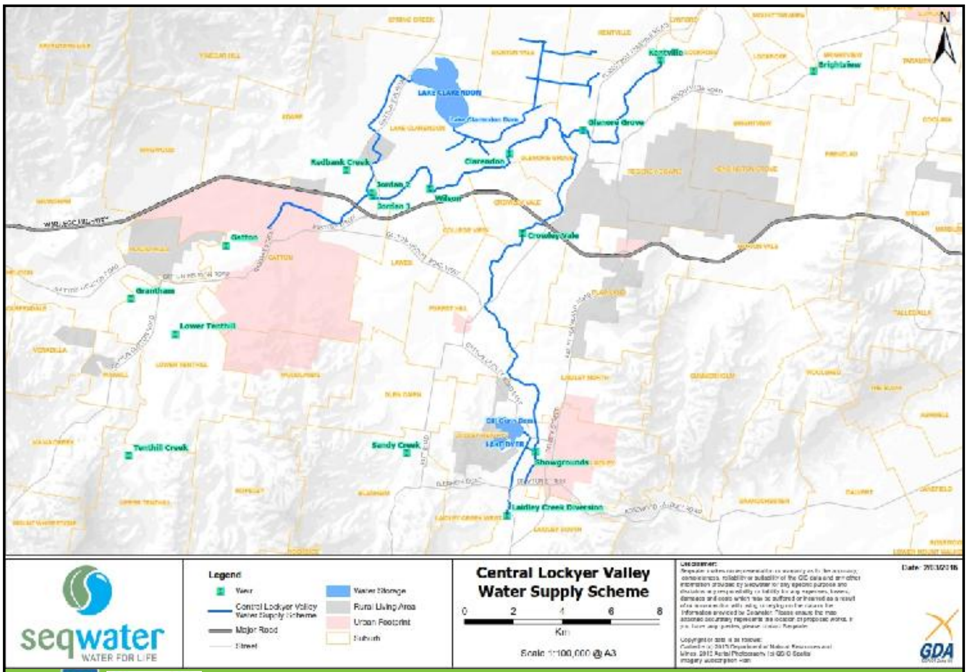
A discussion on potential customers for the water product, individual opportunities and needs, including:

- Overview of current survey and methodology
- Location of supply: Lockyer Valley, Darling Downs
- Other demands: CSG make-good water, other

Location of demand

Review of Water Demand / Stakeholder consultation (Synergies)

- Agricultural demand – build on previous work and update with current outlook on potential demand and levels of interest
  - What additional water is likely to be used for?
  - Any issues around water quality and salinity to be assessed/ considered?
  - Grower reliability requirements
  - Nature of water rights/products growers would be seeking
  - Likely quantum of water use
  - Timing of supply requirements (both uptake profile and time of year)
  - Prevalence and capacity of on-farm storages
- QUU – impact on treatment, other costs/benefits, potential for offsets
- CSG Producers – potential water demand; alternative water costs



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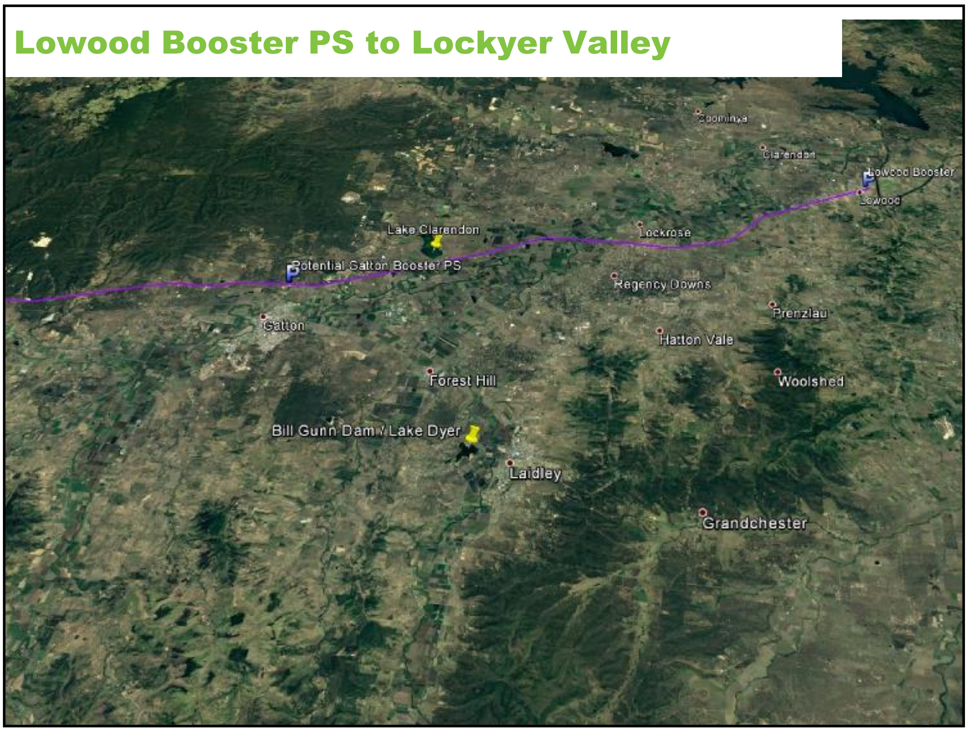
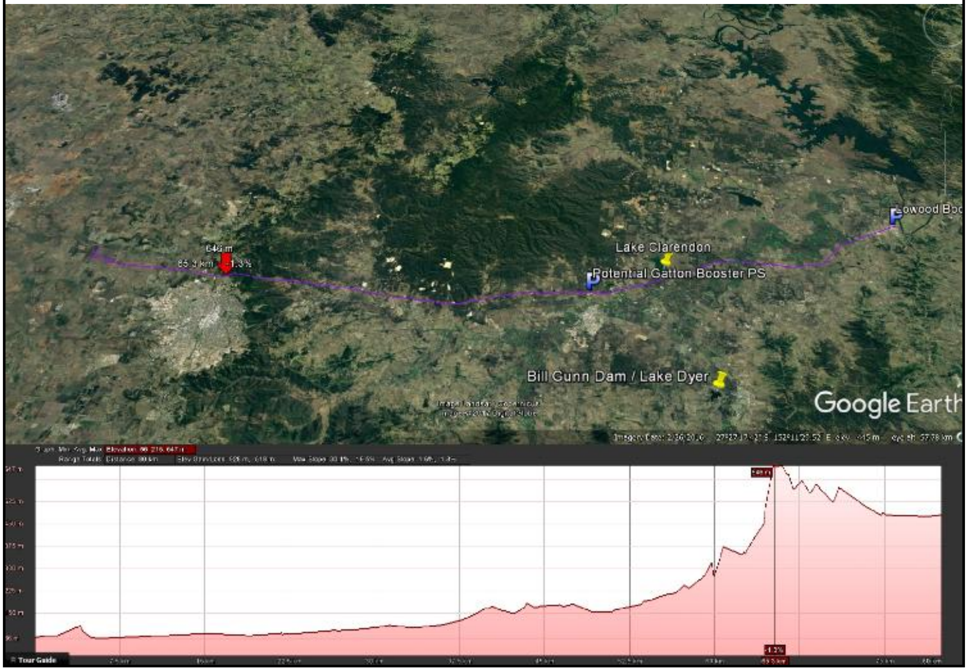
Lowood Booster PS to Lockyer Valley



Lowood Booster PS to Darling Downs



Storage Options

- Balancing/“Off-stream” storage
- On-farm storages
- Discharge to waterways
- Aquifer recharge

What is the real storage availability?

AFTERNOON TEA BREAK

NuWater Project “Problem Statement”

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Identification of Supply Options

Based on what we have heard and said today, how do we address the Problem Questions?

Some key considerations:

- Does the supply option utilise existing infrastructure?
- Is the option a “partial solution” that may be developed or integrated with another option to maximise outcomes?
- (Other?)

High-level assessment of Supply Options

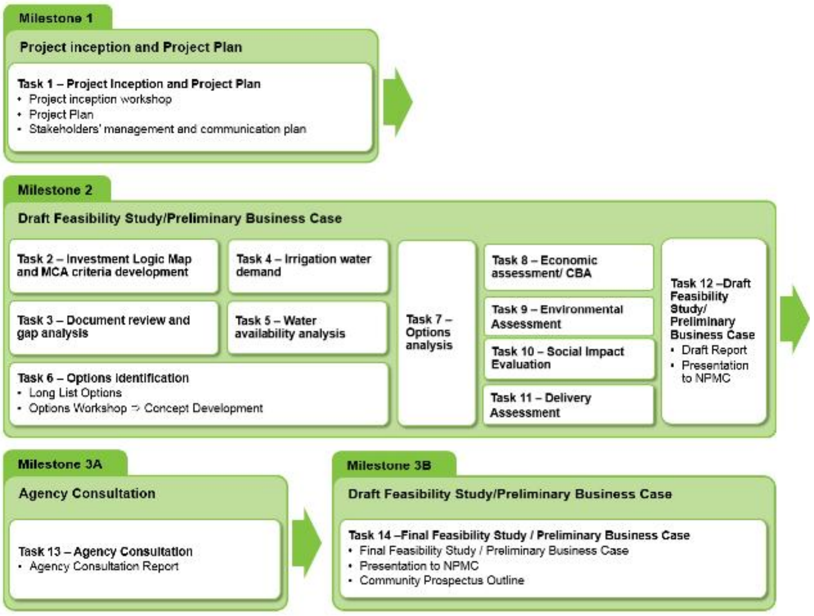
Does the proposed option address, or partially address, the issues raised in the Problem Statements?

Does the proposed option take into account matters of demand, water product alternatives, limitations, risks and opportunities?

High-level assessment of Supply Options

TIME TO PRIORITISE!

Next steps



Milestone 1

Project inception and Project Plan

Task 1 – Project Inception and Project Plan
- Project inception workshop
- Project Plan
- Stakeholders' management and communication plan

Milestone 2

Draft Feasibility Study/Preliminary Business Case

Task 2 – Investment Logic Map and MCA criteria development

Task 3 – Document review and gap analysis

Task 4 – Irrigation water demand

Task 5 – Water availability analysis

Task 6 – Options identification
- Long List Options
- Options Workshop ⇒ Concept Development

Task 7 – Options analysis

Task 8 – Economic assessment/ CBA

Task 9 – Environmental Assessment

Task 10 – Social Impact Evaluation

Task 11 – Delivery Assessment

Task 12 –Draft Feasibility Study/ Preliminary Business Case
- Draft Report
- Presentation to NPMC

Milestone 3A

Agency Consultation

Task 13 – Agency Consultation
- Agency Consultation Report

Milestone 3B

Draft Feasibility Study/Preliminary Business Case

Task 14 –Final Feasibility Study / Preliminary Business Case
- Final Feasibility Study / Preliminary Business Case
- Presentation to NPMC
- Community Prospectus Outline

Review and Close Out

"To review Project Problem Statements, discuss key considerations/drivers and identify preferred options for further investigation"

- Establish baseline understanding of Project, including drivers and previous work undertaken
- Provide an open platform for raising and discussing new ideas and issues
- Discuss previously identified matters, including source options, water product alternatives and demand options
- Develop list of options
- Refine and prioritise options for further, detailed investigation

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Appendix B – Workshop Notes

Notes

19 July 2017

Project	NuWater Project Feasibility Study	From	James Skene
Subject	Options Identification Workshop	Tel	+61 7 3316 3313
Venue/Date/Time	Lockyer Valley Cultural Centre / 18 July 2017 / 10am - 3pm	Job No	41/30968/
Copies to	All attendees and apologies		
Attendees	Travis Tobin – Queensland Farmers' Federation Michael Murray – Cotton Australia Matt McVeigh – Gowrie-Oakey Creek Irrigators Graham Clapham, Rod Sleba – Central Downs Irrigators Limited (CDIL) Anthony Staatz – Lockyer Valley Growers Group Shane Tyrell - Queensland Urban Utilities Rebecca Tkal - Queensland Chicken Growers Association (QCGA) Kim Bremner – Agforce Kate Lanskey, Joseph Tam – Seqwater Fred Hundy, Bob Tomkins – Department of Natural Resources and Mines	Richard Routley – Department of Agriculture and Farming Shane Charles – Toowoomba and Surat Basin Enterprise (TSBE) Belinda Whelband – Lockyer Valley Regional Council Stephen Walker - Cardno Bryan Gray - Regional Development Australia - Darling Downs and South West (Federal) Thomas Vanderbyl - Badu Advisory Elliot Willemson-Bell, James Skene, David Solley, Kristin Walduck – GHD Dan Culpitt – Synergies Economic Consultants	
Apologies	Abel Immeraj - Queensland Urban Utilities Georgie Uppington – Food Leaders Australia Ian Johnston – Queensland Farmers' Federation Dale Miller – Agforce Ross Muir – Seqwater	Steve Goudie – Department of Natural Resources and Mines Virginia Hunter, Russell Cuerel – Department of Energy and Water Supply Paul Cranch – Lockyer Valley Regional Council Warren Traves, Murray Smith – GHD	

Notes	**Action**
Welcome and Introductions	
Workshop Objectives	

Notes	Action
Project Background and Intent from NuWater Project Management Committee (NPMC) representatives - An initial study was undertaken regarding the feasibility of re-using wastewater, with the overall finding being that this was not feasible. - The Beattie Government shut down the further investigation of irrigation supply options in 2003/2004 based on the need for water to be used for drinking water purposes (due to the low levels in the dams at that time) - After the dam levels returned to acceptable levels, the Newman Government started looking at options for using the Western Corridor Recycled Water Scheme (WCRWS) - The creation of the National Water Infrastructure Development Fund (NWIDF) was a catalyst for the Queensland Farmers' Federation QFF) to reconsider irrigation options from the WCRWS - Pricing, availability and quality are seen as key considerations - QUU is interested in a 'best for community' approach and will be actively involved in this study - QUU has been exploring ways to create resources from their waste streams but has been focussing more on the solid waste to date and not as much on the liquid streams.	
Session 1: Open discussion/brainstorming on individual ideas, issues - QUU is trying to reduce overall costs of treatment plants and their impacts to the surrounding environment (e.g. nutrient offsets) - Discussion on removal of salts vs. nutrients and the source of the salts in the wastewater - The WCRWS forms part of Seqwater's Water Security Program (WSP) by supplementing drinking water supplies if required - If lower quality water is to be used for irrigation and supplied through the WCRWS, the impacts to the recommissioning process (time and budget) would need to be assessed - Option raised to consider construction of a new pipeline for irrigation, utilising the same pipeline corridor as that used for the WCRWS - Energy costs may vary and this should be taken into account by conducting a sensitivity analysis on the impacts of energy costs to the feasibility of the project	

Notes	**Action**
• Attendees were invited to write down ideas and categorise into the following four fields: Opportunities, Benefits, Constraints and Risks	
• A summary of the outcomes of this session have been included in the Options Identification Workshop Report.	
Lunch	
• Ideas, issues etc. were grouped into themes – Quality, Economic, Water storage and distribution, Water security, Financial, Other, Public Perception & Politics, Asset utilisation, Environment , Alternative Water Sources and Energy)	
Presentation and feedback on themes	
• The WCRWS is currently in care and maintenance mode of operation (system is operating at a basic level but the membranes have been stripped out)	
• Current WCRWS infrastructure can provide up to 182 ML/d. An additional pump station (planned but never constructed) would be required to achieve a flow of 232 ML/d	
• Seqwater has a contract with Tarong Power Station (Tarong) to supply PRW from Bundamba AWTP, which has recently been re-negotiated. This contract permits Tarong Energy to use a maximum of 80 ML/d PRW, however they are not obligated/required to take the full amount	
• In terms of quality and nutrient vs. salt removal, it was noted that removal of Phosphorus improves the recovery rate of the RO/overall plant. If TP was to remain at higher levels, the recovery rate would be lower (i.e. current state of low-nutrient water vs. higher-nutrient water at a lower quantity)	
• QUU raised concerns that if AWTP water is used for irrigation, the RO concentrate stream still needs to be dealt with, so this option may not meet the project's problem statements.	
• An option of whether the RO concentrate could be added back into the permeate was raised	GHD to review.
• It was noted that Dalby use shandied bore water and RO water to improve the water quality	
Session 2: Source options	
• Current salinity levels in waterways are approximately 1200-1300 mg/L	

Notes	**Action**
• Water sources are audited (i.e. samples are collected) to ensure compliance with food safety laws. • It was noted that salinity levels of 1100-1300 mg/L had been experienced in Lockyer Valley and may be acceptable.	
Session 3: Water Product Alternatives • Seqwater advised that the greater the reduction in water quality from PRW, the longer it will take for Seqwater to recommission the WCRWS (e.g. more validation steps), meaning the supply would be interrupted earlier. Sufficient time is required for Seqwater to recommission the scheme and achieve the targets as set out in the WSP. • It was noted that Luggage Point AWTP has one train in an operational mode and so could be brought online in up to 12 months, as it is in a higher state of readiness • There may be community opposition to the use of recycled water, based on historical experiences. It was noted that there is still a lack of general understanding of the process involved in supplying water	
Session 4: Demand options • A survey will be distributed shortly to gauge demand requirements (quality, quantity, reliability, security) • Seqwater can provide numbers on likelihood/probability of WCRWS trigger being reached for recommissioning, so as to assist in determining the security/reliability of water supply • There is a WCRWS Master Plan under development however this isn't due for completion until the end of 2017 • Irrigators are used to using water from a variety of sources with different levels of quality and reliability • Irrigators currently have the ability to buy additional water allocation rights from the market and build infrastructure to use this water. Irrigators can also lease a seasonal water allocation (i.e. owning entity retains the allocation/ pays overheads, but can lease a portion of the water allocation)	Synergies to forward to relevant organisations for distribution. Seqwater to provide WCRWS use profile as per GHD information request.
Options long list presentation and high level assessment • Various options were presented to attendees, who were given three dots to allocate to their preferred choice for each the following areas:	

Notes	Action
o Quality/product o Demand/customer o Delivery • Options were to be reviewed against ‘problem statement’ to determine in a group setting the degree of alignment with the project objectives • A summary of these results is included in the Options Identification Workshop Report.	
Parking Lot Items • Source of salinity in incoming flow to STP • Organic Certification Requirements (and associated Food Standards) • Recommissioning o Cost/time (variation depending on water class) o Benefit/cost of care and maintenance vs. operational • Community literacy regarding water (education/information) • Engagement with political parties • Practices currently undertaken by TRC at the Wetalla STP (currently discharges approximately 10 ML/d into Oakey Creek)	QUU to comment on any actions and current findings in terms of sewage received at key STPs Re: Organic Certification, GHD to review available literature Re: recommissioning, Seqwater to advise any available detailed information on cost/time assumptions. Re: Wetalla STP, GHD to contact TRC to confirm arrangements, licences etc.
Next steps and Workshop Close	GHD to complete workshop notes and outputs and Options Identification Workshop Report for review and eventual distribution to relevant parties.

James Skene
Principal Engineer

Appendix C – Workshop Outcomes

Appendix C1 Outputs from Session 1: Open Discussion/brainstorming on individual ideas, issues

As part of the Options Identification Workshop, held on Tuesday 19th July 2017 at Gatton Cultural Centre, attendees were asked to come up with ideas in regards to the scheme that fell under the following headings: opportunities, constraints, benefits and risks
These ideas were then taken and organised by theme; these themes include quality, economic, water storage and distribution, water security, financial, other public perception & politics, asset utilisation, environmental, alternative water sources and energy.

Type	Area	Idea
Opportunity	Alternative Water Sources	Use spill from Wivenhoe
Opportunity	Alternative Water Sources	Reuse all SEQ water
	Alternative Water Sources	Freeing up existing potable water access on Darling Downs to a higher value use e.g.
Constraint	Alternative Water Sources	Can some of the supply be highly reliable?
Opportunity	Alternative Water Sources	Stormwater? Capture or other water source which is uncaptured
	Alternative Water Sources	Alternative sources of Brisbane's 'drought water'
	Alternative Water Sources	Further types of recycled water to be introduced into the system
Risk	Asset utilisation	Increased treatment required at AWTPs if treatment is reduced at STPs
Constraint	Asset utilisation	PRW recommissioning
Risk	Asset utilisation	If WCRWS is used to produce water to a lower grade to potable water standard, it will
Risk	Asset utilisation	Timeframes required to restart for PRW if treated to lower quality
Risk	Asset utilisation	Approvals required to convert back to PRW if used for lower quality at other times
Opportunity	Asset utilisation	Proposed infrastructure corridors
Opportunity	Asset utilisation	More utilisation of the WCRWS
Opportunity	Asset utilisation	Asset utilisation
	Asset utilisation	Improved utilisation of current assets (govt and corporate)
	Asset utilisation	Use of existing unused infrastructure (e.g. WCRWS)
	Asset utilisation	Existing distribution network
Opportunity	Asset utilisation	Under-utilised arable land in the Lockyer
	Asset utilisation	Utilise existing (unused) assets
	Asset utilisation	Under-utilised pumped storage
Opportunity	Asset utilisation	Connectivity to Surat Basin (Nathan Dam, CSG, Wetalla)
	Asset utilisation	Proposed tunnel through range (inland rail/pilot hole)
Opportunity	Asset utilisation	Inland rail
Benefit	Asset utilisation	Increased utilisation of infrastructure
	Asset utilisation	Could irrigate over 50,000 HA ('some of the best agricultural soils in the world')
Benefit	Asset utilisation	Value of using existing asset for reuse and production
Benefit	Asset utilisation	Utilisation of assets
Risk	Economic	Rising energy costs
Opportunity	Economic	Increased productivity - industry/agriculture
Opportunity	Economic	Expand agriculture in Lockyer Valley
Opportunity	Economic	New crop and industry opportunity to develop
Opportunity	Economic	Added economic development
Opportunity	Economic	Develop export revenue
	Economic	The flow-on benefit to the community would be on an average of 10 to 1 i.e. for every
	Economic	WCRWS recommissioning
	Economic	Darling Downs - Lockyer - Ipswich - Brisbane value chain
Risk	Economic	Risk of future energy costs
	Economic	Community Economic Benefit
Constraint	Economic	Need for scheme to handle future growth
Opportunity	Economic	$500M + extra GVP
	Economic	Beneficiaries pay
	Economic	Growth and expansion of industries
	Economic	Darling Downs is close to Wellcamp Airport for export of produce grown
	Economic	Employment would vastly increase with the irrigation. Our committee (Vision 2000) in
Benefit	Economic	Intensive agriculture
Benefit	Economic	Food production - food manufacture
	Economic	Regional growth
	Economic	Jobs and growth
	Economic	Stimulate SEQ economy
Opportunity	Energy	Hydro (using Toowoomba range)

Type	Area	Idea
Opportunity	Energy	Cheap solar power (approaching zero)
Opportunity	Energy	Nuclear Energy
	Energy	Multiple energy sources
	Energy	Saving energy in treatment but using energy to pump water to Darling Downs
	Energy	Reduced power/chem through treatment modifications
Opportunity	Energy	Offset energy costs through renewable generation
Constraint	Environment	Regulatory impediments (over-regulation)
Benefit	Environment	Enhanced environmental/ecological outcomes
Benefit	Environment	Environmental benefits on discharge into bay
Opportunity	Environment	Divert nutrient from Moreton Bay
Benefit	Environment	On flow benefit to MDB (Murray-Darling Basin)
Benefit	Environment	Regional solutions for 'bubble licences'
Benefit	Environment	Carbon neutral - increased crop production
Benefit	Environment	Nil nutrient discharge to SEQ environment
Constraint	Financial	cost/benefit - capacity to pay
Constraint	Financial	Cost-effectiveness (high cost water = high cost production)
Constraint	Financial	The water would have to be delivered at an economical cost
Constraint	Financial	Costs of treatment and delivery of recycled water
Constraint	Financial	Cost
Constraint	Financial	how much flexibility is required for water quality products?
Constraint	Financial	Product quality for end use --> different in Lockyer to Darling Downs
Constraint	Financial	Quality
Constraint	Financial	Quality vs price
Constraint	Financial	Organisational financial constraints
Constraint	Financial	Energy costs
Constraint	Financial	Energy costs (renewables, gas, pumped storage)
Constraint	Financial	Ensuring all beneficiaries pay
Opportunity	Financial	Reduced cost of nutrient removal
Risk	Financial	Cost of water to end-user
Constraint	Financial	Darling Downs can grow a huge variety of crops - water is the only part missing from
Constraint	Financial	Cost of salt reduction
Risk	Financial	Cost of the water at the farm
Opportunity	Public Perception & Politics	Community education and engagement to better understand water cycle
Opportunity	Public Perception & Politics	Community expectations of sustainability
Risk	Public Perception & Politics	Community acceptance in regards to use of recycled water for food production
Risk	Public Perception & Politics	Public perception of recycled water on leaf crops (i.e. minimal processed crops)
Risk	Public Perception & Politics	Accessibility (haves vs. have-nots)
Risk	Public Perception & Politics	Political intervention (election)
Benefit	Public Perception & Politics	Gaining community's acceptance to the use of recycled water
Constraint	Public Perception & Politics	Community attitudes/perception
Opportunity	Quality	Water treatment options
Opportunity	Quality	Challenge to separate salt and nutrients
	Quality	Water quality
	Quality	Nutrient trading
Opportunity	Quality	Fix source of salinity in wastewater
Constraint	Quality	Significant differences in water quality and reliability needs across different users
Constraint	Quality	Water would need to be treated so that it would be safe to irrigate all crops
Opportunity	Quality	Value of nutrients
Opportunity	Quality	Reduce operating costs by reducing treatment level to irrigation need
Risk	Quality	Understanding suitability for various users
Risk	Quality	Recycled water not as good as rain water
Risk	Quality	Water quality fit for purpose
Opportunity	Quality	Produce desal from AWTPs
Opportunity	Quality	Offset nutrient abatement investments
	Water security	Offset potable + supply from Wivenhoe
Opportunity	Water security	Increased quantity and reliability of supply to support decision making
	Water security	Security - water supply
	Water security	Consistent supply
Opportunity	Water security	Groundwater recharge in Lockyer

Type	Area	Idea
Constraint	Water security	Guarantee water security
Constraint	Water security	Life of the system in terms of infrastructure
Constraint	Water security	Certainty for investment security
Constraint	Water storage and distribution	Reliability
Constraint	Water storage and distribution	Interruptible supply - retain as primary purpose for drinking water supply during
Opportunity	Water storage and distribution	300,000 ML of storage available (Downs. Ring tanks privately owned)
	Water storage and distribution	How much of the Downs will be able to access the water?
Opportunity	Water storage and distribution	Seqwater to increase supply with small storages
	Water storage and distribution	Distributed storage increase
	Water storage and distribution	Potential to deliver at least some of the water on-farm at pressure
	Water storage and distribution	Utilise Splityard Creek (water + energy storage)
	Water storage and distribution	Potential to manage interruptible supply through aquifer management
Risk	Water storage and distribution	Availability of source water volumes
	Water storage and distribution	Distribution and storage of water
Opportunity	Water storage and distribution	Use of Toowoomba pipeline from Wivenhoe
	Water storage and distribution	Non-potable supply from Bundamba STP
	Water storage and distribution	What happens when it really rains?
Benefit	Other	Operator training and retention of knowledge if WCRWS is partially operating
	Other	Moreton Water Plan review
	Other	Water trading in Lockyer/ Water Plan Review
Constraint	Other	Fix hole under Brisbane River
Opportunity	Other	Gaining more experience in the use of recycled water if the WCRWS is in use for other alternative uses (e.g. irrigation)

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study
Options Identification Workshop

Date: 31/07/2017

Appendix C2 Outputs from Session 4: High-level assessment of options

The following were offered as choices and attendees were given 3 dots per area to allocate to their preferred choice

Location	Options	Count	
	Quality/Product Options		
All	PRW	11	22%
	Class A+ (reduced salt/RO)	9.5	19%
	Class A+ (higher salt)	5.5	11%
	Class A, B, C, D (effluent as produced)	25	49%
	Total	**51**	
	Demand/Customer Options		
Lockyer Valley	PRW	5	12%
	Class A+ (low salt)	4	10%
	Class A+ (as produced)	4	10%
	Class A, B, C, D (low salt)	0	0%
	Class A, B, C, D (as produced)	0	0%
Darling Downs	PRW	2	5%
	Class A+ (low salt)	0	0%
	Class A+ (as produced)	0	0%
	Class A, B, C, D (low salt)	5	12%
	Class A, B, C, D (as produced)	22	52%
	Total	**42**	
	Delivery Options		
	Western Corridor Recycled Water Plant - Lockyer Valley and Darling Downs via pipelines	29	58%
	Western Corridor Recycled Water Plant -Darling Downs only, via pipelines	4	8%
	Western Corridor Recycled Water Plant - Lockyer Valley only, via pipelines	2	4%
	Lockyer Valley via pipelines	2	4%
	Lockyer Valley via Central Lockyer Valley Water Supply Scheme (CLVWSS)	2	4%
	Lockyer Valley via aquifer recharge	2	4%
	Darling Downs via pipelines	3	6%
	Darling Downs via channels	1	2%
	Darling Downs via Gowrie and Oakey Creeks	5	10%
	Total	**50**	

Appendix D – Proposed MCA Criteria and Weightings

Assessment Criteria

MCA Tool Scenarios to Solutions

Primary Goals	weight	Criteria	weight	Sub-criteria 1	weight	Measurable	weight
Economic	50%	Project viability	40%	Scaleable to drive significant increase in irrigated agricultural production	25%	Rank by system yield supporting farmland development <10,000ML, 10-20,000ML, 20-40,000ML, 40-60,000ML, >60,000ML	5.0%
				Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of wate storage and distribution system	50%	<$1,000/ML, $1-2,000/ML, $2-3,000/ML, $3-4,000/ML, >$4,000/ML	10.0%
				Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)	25%	0-50m, 51-100m etc	5.0%
		Project risks	40%	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay	35%	Complexity, Investor risks, multiple investors, asset ownership complexity etc.	7.0%
				Approvals pathway - ability to meet planning requirements including licenced use of treated effluent (depender on quality) Water Plans etc	25%	<2 years, 4 years, 6 years, 8 years, > 8 years	5.0%
				Reliability of water supply (anticipated periods of interrupted supply)	15%	Considered together with total yield	3.0%
				Quality of water supply	15%	Reflect factors such as quality (e.g. A+, C, etc.), salt loads etc - Higher quality = higher score	3.0%
				Construction risks (including geological, tunnel, infrastructure footprint etc)	10%	High to low (bigger and more complex footprint potentially will score lower)	2.0%
		Regional impact	20%	Offsetting chemical fertiliser needs	25%	High to low	2.5%
				Impacts on regional infrastructure	20%	High to low (relocate and additional needs etc)	2.0%
				Impact on downstream water allocations (infrastructure)	20%	High to low (also considers D/S reliability factors)	2.0%
				Employment (direct operation including irrigation and related activities)	25%	<20, 20-50, 50-80, 80-110, >110	2.5%
				Increased utilisation of regional/community infrastructure (asset utilisation)	10%	High to low (factor of scale and diversity of potential offerings - including Wellcam airport etc)	1.0%
Environmental	30%	Ecology	45%	Net biodiversity (based on biodiversity mapping)	20%	Low to high impact	2.7%
				Rare and threatened ecosystems, habitats and taxa of high conservation value (based on RE database mapping)	30%	Low to high impact	4.1%
				Protected Areas (conservation areas, wetlands, etc. mapping)	30%	Low to high impact	4.1%
				Potential to change or improve existing seasonal flow pattern (changes to aquatic habitats)	20%	Low to high impact	2.7%
		Water values	46%	Risks associated with inter-basin transfer	15%	Low to high impact	2.1%
				Improvement in riparian buffer zone outcomes	20%	Low to high impact	2.8%
				Opportunity to replace potable water sources, sustainable use of water resources	20%	Low to high impact (Largely a function of buffer to watercourses etc.)	2.8%
				Downstream impacts on water quality in the Bay	25%	Low to high impact	3.5%
				Potential to affect groundwater	20%	Low to high impact (positive impacts on recharge in the Lockyer to negative by increasing salinity hazard)	2.8%
			9%	Compliance with Water Plans; rules regulating release of recycled water to the environment	100%	High suitability to significant management inputs/costs	2.7%
Social	20%	Community	100%	Impact on regional demographics	10%	Low to high impact	2.0%
				Likelihood of community support	25%	High to low	5.0%
				Consistency with planning intents of other government authorities	10%	High to low	2.0%
				Health and safety risk	5%	High to low	1.0%
				Aesthetics and community amenity	10%	High to low	2.0%
				Capacity of local communities to take advantage of opportunities, including jobs	15%	High to low	3.0%
				Locality to/suitability of existing regional services/resources	10%	High to low	2.0%
				Cultural heritage impact	15%	High to low	3.0%

Appendix E – Alignment of Workshop Issues and Opportunities with MCA Criteria

Alignment of Workshop Issues and Opportunities with MCA Criteria

Type	Theme	Idea / Issue	MCA primary goal	MCA criteria	MCA Sub-criteria 1	MCA primary goal	MCA criteria	MCA Sub-criteria 1 (additional)
Opportunity	Alternative Water Sources	Use spill from Wivenhoe	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)	-	-	
Constraint	Alternative Water Sources	Can some of the supply be highly reliable?	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)	-	-	
Opportunity	Alternative Water Sources	Stormwater? Capture or other water source which is uncaptured	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)	-	-	
Benefit	Asset utilisation	Use of existing unused infrastructure (e.g. WCRWS)	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	-	-	
Opportunity	Economic	Added economic development	Economic	Project risks	Construction risks (including geological, tunnel, infrastructure footprint etc)	-	-	
Benefit	Economic	Growth and expansion of industries	Economic	Project risks	Construction risks (including geological, tunnel, infrastructure footprint etc)	-	-	
Opportunity	Economic	Darling Downs is close to Wellcamp Airport for export of produce grown	Economic	Project risks	Construction risks (including geological, tunnel, infrastructure footprint etc)	-	-	
Benefit	Economic	Jobs and growth	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)	-	-	
Constraint	Environment	Regulatory impediments (over-regulation)	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)	-	-	
Benefit	Environment	Enhanced environmental/ecological outcomes	Economic	Regional impact	Employment (direct operation including irrigation and related activities)	-	-	
Benefit	Environment	Nil nutrient discharge to SEQ environment	Economic	Regional impact	Employment (direct operation including irrigation and related activities)	-	-	
Constraint	Financial	Energy costs	Economic	Project risks	Quality of water supply	-	-	
Constraint	Financial	Energy costs (renewables, gas, pumped storage)	Economic	Project risks	Quality of water supply	-	-	
Constraint	Financial	Ensuring all beneficiaries pay	Economic	Project risks	Quality of water supply	-	-	
Risk	Financial	Cost of water to end-user	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay	-	-	
Constraint	Financial	Darling Downs can grow a huge variety of crops - water is the only part missing from the equation	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)	-	-	
Constraint	Financial	Cost of salt reduction	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)	-	-	
Risk	Financial	Cost of the water at the farm	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay	-	-	
Opportunity	Quality	Water treatment options	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	-	-	
Opportunity	Quality	Challenge to separate salt and nutrients	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	-	-	
Constraint	Quality	Water quality	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)	-	-	
Opportunity	Quality	Fix source of salinity in wastewater	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	-	-	
Constraint	Quality	Significant differences in water quality and reliability needs across different users	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)	-	-	
Risk	Quality	Understanding suitability for various users	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	-	-	
Risk	Quality	Recycled water not as good as rain water	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)	-	-	
Risk	Quality	Water quality fit for purpose	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)	-	-	
Constraint	Water security	Security - water supply	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	-	-	
Constraint	Water security	Consistent supply	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	-	-	
Constraint	Water security	Guarantee water security	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	-	-	
Constraint	Water security	Life of the system in terms of infrastructure	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	-	-	
Constraint	Water storage and distribution	Interruptible supply - retain as primary purpose for drinking water supply during drought	Economic	Project risks	Quality of water supply	-	-	
Opportunity	Water storage and distribution	300,000 ML of storage available (Downs. Ring tanks privately owned)	Economic	Project risks	Quality of water supply	-	-	
Opportunity	Water storage and distribution	Distributed storage increase	Economic	Project risks	Quality of water supply	-	-	
Constraint	Water storage and distribution	Distribution and storage of water	Economic	Project risks	Quality of water supply	-	-	
Opportunity	Economic	$500M + extra GVP	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	-	-	
Benefit	Economic	Intensive agriculture	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	-	-	
Opportunity	Other	Water trading in Lockyer/ Water Plan Review	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	-	-	
Opportunity	Asset utilisation	Under-utilised pumped storage	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Opportunity	Asset utilisation	Connectivity to Surat Basin (Nathan Dam, CSG, Wetalla)	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Opportunity	Asset utilisation	Proposed tunnel through range (inland rail/pilot hole)	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Opportunity	Asset utilisation	Inland rail	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Benefit	Asset utilisation	Increased utilisation of infrastructure	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Benefit	Asset utilisation	Could irrigate over 50,000 HA ('some of the best agricultural soils in the world')	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Benefit	Asset utilisation	Value of using existing asset for reuse and production	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Benefit	Asset utilisation	Utilisation of assets	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)	Economic	Regional impact	Impacts on regional infrastructure
Risk	Economic	Rising energy costs	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay
Opportunity	Economic	Increased productivity - industry/agriculture	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay	Economic	Regional impact	Impacts on regional infrastructure
Opportunity	Economic	Expand agriculture in Lockyer Valley	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay	Economic	Regional impact	Impacts on regional infrastructure
Opportunity	Economic	New crop and industry opportunity to develop	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay	Economic	Regional impact	Impacts on regional infrastructure
Opportunity	Economic	Develop export revenue	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Benefit	Economic	The flow-on benefit to the community would be on an average of 10 to 1 i.e. for every $1 spent on irrigation, there would be a flow-on benefit to the community of $10	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Benefit	Economic	WCRWS recommissioning	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Benefit	Economic	Darling Downs - Lockyer - Ipswich - Brisbane value chain	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Risk	Economic	Risk of future energy costs	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)

Alignment of Workshop Issues and Opportunities with MCA Criteria

Type	Theme	Idea / Issue	MCA primary goal	MCA criteria	MCA Sub-criteria 1	MCA primary goal	MCA criteria	MCA Sub-criteria 1 (additional)
Benefit	Economic	Community Economic Benefit	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay
Constraint	Economic	Need for scheme to handle future growth	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Regional impact	Impacts on regional infrastructure
Benefit	Economic	Employment would vastly increase with the irrigation. Our committee (Vision 2000) in conjunction with Griffith Uni identified 8 employees would be needed for every 1000 acres of intensified irrigation	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Benefit	Economic	Food production - food manufacture	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Benefit	Economic	Regional growth	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Opportunity	Energy	Reduced power/chem through treatment modifications	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Benefit	Environment	On flow benefit to MDB (Murray-Darling Basin)	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay
Benefit	Environment	Carbon neutral - increased crop production	Economic	Regional impact	Impacts on regional infrastructure	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Constraint	Financial	Cost-effectiveness (high cost water = high cost production)	Economic	Regional impact	Employment (direct operation including irrigation and related activities)	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Constraint	Financial	The water would have to be delivered at an economical cost	Economic	Regional impact	Employment (direct operation including irrigation and related activities)	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Constraint	Financial	Costs of treatment and delivery of recycled water	Economic	Regional impact	Employment (direct operation including irrigation and related activities)	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Constraint	Financial	Cost	Economic	Regional impact	Employment (direct operation including irrigation and related activities)	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Constraint	Financial	how much flexibility is required for water quality products?	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay
Constraint	Financial	Product quality for end use --> different in Lockyer to Darling Downs	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay
Constraint	Financial	Quality	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay
Constraint	Financial	Quality vs price	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Constraint	Financial	Organisational financial constraints	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Opportunity	Financial	Reduced cost of nutrient removal	Economic	Project risks	Quality of water supply	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Benefit	Other	Operator training and retention of knowledge if WCRWS is partially operating	Economic	Project risks	Quality of water supply	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Constraint	Other	Moreton Water Plan review	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system
Constraint	Other	Fix hole under Brisbane River	Economic	Project risks	Quality of water supply	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Opportunity	Other	Gaining more experience in the use of recycled water if the WCRWS is in use for other alternative uses (e.g. irrigation)	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Constraint	Quality	Water would need to be treated so that it would be safe to irrigate all crops	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system
Opportunity	Quality	Value of nutrients	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Opportunity	Quality	Produce desal from AWTPs	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Opportunity	Water security	Increased quantity and reliability of supply to support decision making	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay
Constraint	Water security	Certainty for investment security	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	Economic	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk -capacity of beneficiaries to pay
Constraint	Water storage and distribution	Reliability	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project risks	Quality of water supply
Opportunity	Water storage and distribution	Seqwater to increase supply with small storages	Economic	Project risks	Quality of water supply	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Opportunity	Water storage and distribution	Utilise Splityard Creek (water + energy storage)	Economic	Project risks	Quality of water supply	Economic	Regional impact	Offsetting chemical fertiliser needs
Opportunity	Water storage and distribution	Potential to manage interruptible supply through aquifer management	Economic	Project risks	Quality of water supply	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Risk	Water storage and distribution	Availability of source water volumes	Economic	Project risks	Quality of water supply	Economic	Project risks	Approvals pathway - ability to meet planning requirements including licenced use of treated effluent (dependent on quality) Water Plans etc
Opportunity	Water storage and distribution	Non-potable supply from Bundamba STP	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Risk	Water storage and distribution	What happens when it really rains?	Economic	Project risks	Quality of water supply	Economic	Regional impact	Offsetting chemical fertiliser needs
Constraint	Economic	Beneficiaries pay	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Benefit	Economic	Stimulate SEQ economy	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Opportunity	Energy	Hydro (using Toowoomba range)	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Opportunity	Energy	Cheap solar power (approaching zero)	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Opportunity	Energy	Nuclear Energy	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Opportunity	Energy	Multiple energy sources	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Risk	Energy	Saving energy in treatment but using energy to pump water to Darling Downs	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Opportunity	Energy	Offset energy costs through renewable generation	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Opportunity	Environment	Divert nutrient from Moreton Bay	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Benefit	Environment	Regional solutions for 'bubble licences'	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Constraint	Financial	cost/benefit - capacity to pay	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Regional impact	Employment (direct operation including irrigation and related activities)
Opportunity	Quality	Nutrient trading	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Economic	Project viability	Operating cost (e.g. proxy of pumping head - energy cost, treatment costs)
Opportunity	Alternative Water Sources	Reuse all South East Queensland (waste)water	Economic	Project risks	Approvals pathway - ability to meet planning requirements including licenced use of treated effluent (dependent on quality) Water Plans etc	Environmental	Water values	Compliance with Water Plans; rules regulating release of recycled water to the environment
Opportunity	Asset utilisation	More utilisation of the WCRWS	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	Environmental	Water values	Opportunity to replace potable water sources, sustainable use of water resources
Benefit	Asset utilisation	Utilise existing (unused) assets	Economic	Project viability	Scaleable to drive significant increase in irrigated agricultural production	Environmental	Water values	Opportunity to replace potable water sources, sustainable use of water resources
Opportunity	Quality	Offset nutrient abatement investments	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	Environmental	Water values	Downstream impacts on water quality in the Bay
Opportunity	Water security	Groundwater recharge in Lockyer	Economic	Project risks	Reliability of water supply (anticipated periods of interrupted supply)	Environmental	Water values	Potential to affect groundwater
Constraint	Water storage and distribution	How much of the Downs will be able to access the water?	Economic	Project risks	Quality of water supply	Environmental	Water values	Downstream impacts on water quality in the Bay
Opportunity	Alternative Water Sources	Freeing up existing potable water access on Darling Downs to a higher value use e.g. putting recycled water on crops and potable water for urban and high-value agriculture	Environmental	Water values	Compliance with Water Plans; rules regulating release of recycled water to the environment	-	-	

Alignment of Workshop Issues and Opportunities with MCA Criteria

Type	Theme	Idea / Issue	MCA primary goal	MCA criteria	MCA Sub-criteria 1	MCA primary goal	MCA criteria	MCA Sub-criteria 1 (additional)
Opportunity	Alternative Water Sources	Alternative sources of Brisbane's 'drought water'	Environmental	Water values	Compliance with Water Plans; rules regulating release of recycled water to the environment	-	-	
Risk	Asset utilisation	Increased treatment required at AWTPs if treatment is reduced at STPs	Environmental	Water values	Downstream impacts on Water quality in the Bay	-	-	
Constraint	Asset utilisation	PRW recommissioning	Environmental	Water values	Downstream impacts on Water quality in the Bay	-	-	
Risk	Asset utilisation	Timeframes required to restart for PRW if treated to lower quality	Environmental	Water values	Downstream impacts on water quality in the Bay	-	-	
Risk	Asset utilisation	Approvals required to convert back to PRW if used for lower quality at other times	Environmental	Water values	Opportunity to replace potable water sources, sustainable use of water resources	-	-	
Opportunity	Asset utilisation	Proposed infrastructure corridors	Environmental	Water values	Downstream impacts on Water quality in the Bay	-	-	
Opportunity	Asset utilisation	Asset utilisation	Environmental	Water values	Opportunity to replace potable water sources, sustainable use of water resources	-	-	
Benefit	Asset utilisation	Improved utilisation of current assets (govt and corporate)	Environmental	Water values	Opportunity to replace potable water sources, sustainable use of water resources	-	-	
Opportunity	Asset utilisation	Under-utilised arable land in the Lockyer	Environmental	Water values	Opportunity to replace potable water sources, sustainable use of water resources	-	-	
Opportunity	Water security	Offset potable + supply from Wivenhoe	Environmental	Water values	Opportunity to replace potable water sources, sustainable use of water resources	-	-	
Benefit	Asset utilisation	Existing distribution network	Environmental	Water values	Opportunity to replace potable water sources, sustainable use of water resources	Economic	Project viability	Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system
Opportunity	Quality	Reduce operating costs by reducing treatment level to irrigation need	Environmental	Water values	Potential to affect groundwater	Economic	Regional impact	Increased utilisation of regional/community infrastructure (asset utilisation)
Risk	Alternative Water Sources	Further types of recycled water to be introduced into the system	Environmental	Water values	Improvement in riparian buffer zone outcomes	Environmental	Water values	Downstream impacts on Water quality in the Bay
Risk	Asset utilisation	If WCRWS is used to produce water to a lower grade to potable water standard, it will take more time and changes to (recommission) the scheme back to potable water use	Environmental	Water values	Risks associated with inter-basin transfer	Environmental	Water values	Compliance with Water Plans; rules regulating release of recycled water to the environment
Benefit	Environment	Environmental benefits on discharge into bay	Social	Community	Impact on regional demographics	-	-	
Opportunity	Public Perception & Politics	Community education and engagement to better understand water cycle	Social	Community	Likelihood of community support	-	-	
Opportunity	Public Perception & Politics	Community expectations of sustainability	Social	Community	Likelihood of community support	-	-	
Risk	Public Perception & Politics	Community acceptance in regards to use of recycled water for food production	Social	Community	Likelihood of community support	-	-	
Risk	Public Perception & Politics	Public perception of recycled water on leaf crops (i.e. minimal processed crops)	Social	Community	Likelihood of community support	-	-	
Risk	Public Perception & Politics	Accessibility (haves vs. have-nots)	Social	Community	Capacity of local communities to take advantage of opportunities, including jobs	-	-	
Risk	Public Perception & Politics	Political intervention (election)	Social	Community	Likelihood of community support	-	-	
Benefit	Public Perception & Politics	Gaining community's acceptance to the use of recycled water	Social	Community	Likelihood of community support	-	-	
Constraint	Public Perception & Politics	Community attitudes/perception	Social	Community	Likelihood of community support	-	-	
Risk	Water storage and distribution	Potential to deliver at least some of the water on-farm at pressure	Social	Community	Health and safety risk	Economic	Project risks	Approvals pathway - ability to meet planning requirements including licenced use of treated effluent (dependent on quality) Water Plans etc
Opportunity	Water storage and distribution	Use of Toowoomba pipeline from Wivenhoe	Social	Community	Health and safety risk	Economic	Project risks	Approvals pathway - ability to meet planning requirements including licenced use of treated effluent (dependent on quality) Water Plans etc

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Appendix C – Water demand assessment for the NuWater Project feasibility study

Final report to the Queensland Farmers' Federation

Water demand assessment for the NuWater Project feasibility study

March 2018

Synergies Economic Consulting Pty Ltd
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Executive Summary

Purpose and approach

The NuWater Project involves the use of recycled wastewater from treatment plants in South East Queensland (SEQ) for irrigated crop production, and potentially other agricultural and industrial uses, in the Lockyer Valley and on the Darling Downs. This includes potentially utilising infrastructure developed as part of the Western Corridor Recycled Water Scheme (WCRWS).

This report presents the water demand assessment undertaken for the NuWater project. The purpose of this assessment is to obtain a preliminary view on the level of demand for recycled water in the region across a range of uses, including irrigated crop production, intensive animal production, and other potential uses (e.g. satisfying 'make good' water requirements of Coal Seam Gas (CSG) producers). The findings from this demand assessment will be used as key inputs into the economic and financial and commercial assessments of the shortlisted project options.

The following sources of potential demand were assessed, based on a review of available documentation on water supply and demand in the region and consultation with key stakeholders:

- horticultural producers in the Lockyer Valley;
- broadacre crop producers on the Darling Downs;
- intensive animal producers, including chicken meat producers and processors, pig producers, egg producers, feedlot operators and dairy farmers; and
- CSG producers on the Darling Downs.

Water supply-demand balance

The first stage of the water demand assessment involved undertaking a detailed assessment of the water supply-demand balance in the region. The key outcomes from this assessment were as follows:

- water use in both the Lockyer Valley and on the Darling Downs is dominated by agricultural production, in particular irrigated crop production. In the Lockyer Valley, industrial water use is limited predominantly to agricultural support activities and is supplied by reticulated networks, whilst on the Darling Downs, coal mines and electricity generators have established water supply arrangements.

In terms of future industrial water demand, the future 'make good' requirements of CSG producers on the Darling Downs are the most likely source of demand;

- in terms of agricultural water use in the Lockyer Valley:
  - whilst it is difficult to determine total water use for agricultural production in the Lockyer Valley, recent estimates of around 60,000 ML per annum have been generated, with around 44,000 ML (73 per cent) sourced from unregulated (and mostly unmetered) groundwater resources (the remainder being sourced from supplemented surface water resources that have low levels of reliability); and
  - there is uncertainty over the long-term sustainability of current groundwater use in the region and the management arrangements that are to apply to these resources, with the Moreton Water Plan currently under review. It is possible that as a result of this review, groundwater use in the Lockyer Valley will become subject to regulation, with users required to comply with volumetric entitlements that constrain usage at below current levels;
- in terms of agricultural water use on the Darling Downs:
  - as in the Lockyer Valley, water for agricultural production on the Darling Downs is primarily sourced from groundwater resources, with supplementary supply accessed from surface water supplies. There is also considerable reliance on on-farm storage of water, which provides producers significant flexibility in managing water supplies. In 2015/16, water use by agricultural businesses in the Darling Downs-Maranoa region was estimated at around 487,000 ML (noting that these figures will be greater than those for the region directly relevant for this demand assessment);
  - insufficient access to water supplies is a key constraint on the expansion of production for several crops on the Darling Downs. The significant on-farm storage capacity on the central Darling Downs, estimated at around 300,000 ML in the Condamine Catchment upstream of Chinchilla, provides an indication as to the potential expansion of irrigation water use in the region; and
  - water use for intensive animal production is small relative to the volume of water used for irrigated crop production.

Consultation with water users

The consultation undertaken as part of the demand assessment including the following:

- initial discussions with peak industry bodies and irrigator representatives, including Central Downs Irrigators Limited (CDIL), Gowrie-Oakey Creek

Irrigators, Cotton Australia, Lockyer Valley Growers, AgForce, the Queensland Dairyfarmers' Organisation, and the Queensland Chicken Growers Association;

- a survey was provided to irrigators located in areas that could be supplied by the NuWater project. The purpose of the survey was to identify those growers with an interest in accessing water from the project and to obtain information to inform the farm-level modelling to be undertaken both to inform the demand assessment and the economic and financial and commercial analyses of the project; and
- open grower consultation days were held in both the Lockyer Valley (Gatton) and on the Darling Downs (Cecil Plains and Dalby) to assist growers in completing the survey and to identify key inputs and assumptions for the farm-level modelling.

The key findings from the consultation undertaken with growers were as follows:

- whilst little inference can be drawn from the survey responses in the Lockyer Valley, with only 2,650 ML of demand identified in survey responses, the assessment identified considerable potential demand on the Darling Downs, with survey responses identifying demand of over 46,000 ML;
- in terms of the intended use of water from the project by growers on the Darling Downs, the majority of water is expected to be applied to cotton crops, both existing and new crops, with water also to be applied to other broadacre crops produced in the region, including corn, sorghum, wheat and chickpeas. Survey responses were not sufficient to provide an indication as to the likely use of additional volumes of water by producers in the Lockyer Valley (growers consulted with noted that additional water would be used to produce a range of vegetable crops, to be determined by market factors);
- consultation with growers in the Lockyer Valley confirmed that water would primarily be applied to increase the area of crop production in the region. However, survey responses from growers on the Darling Downs indicate that around 65 per cent of additional water would be applied to increase yields on existing areas of crop production, with the remainder to be applied to expand the area under crop production;
- the poor response rate in the Lockyer Valley can be attributed, at least in part, to the uncertainly regarding the future regulatory arrangements for the use of groundwater resources in the region.[1] The outcomes from the current review of the

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[1] Growers consulted with also communicated confusion in relation to an alternative project proposal involving the construction of a pipeline from Wivenhoe Dam to water storages in the Lockyer Valley.

sustainability of groundwater use in the Lockyer Valley has the potential to significantly impact the level of demand for water from the project in the Lockyer Valley;

- there are significant differences in terms of the water quality levels required by growers in the Lockyer Valley and on the Darling Downs. Whilst growers on the Darling Downs are flexible in terms of the quality of the water to be supplied by the project, growers in the Lockyer Valley have relatively stringent quality requirements;
- the majority of growers stated that the potential for water supply to be interrupted as a result of the WCRWS infrastructure being required for urban water supply would not impact on their demand, however several growers noted that supply disruptions would negatively impact on-farm returns and thus the value of the water rights (and hence the price that growers would be willing to pay for water from the project); and
- demand for water from growers on the Darling Downs is highly sensitive to price. Demand declines significantly at prices above $600 per ML per annum.

Returns to water use

Based on the outcomes of consultation with growers and a review of available information in relation to crop production and water use in the region, modelling was undertaken to estimate the on-farm returns from the application of additional water to irrigated crops in the Lockyer Valley and on the Darling Downs. Returns were modelled for the two different applications of additional water, being:

- to derive additional yield by increasing irrigation application rates on existing crops; or
- use of water to expand the area under irrigated crop production (including increasing the number of crops produced per annum or moving from skip row cotton to full cotton planting).

Based on consultation with growers, it is considered unlikely that growers in the Lockyer Valley would apply additional water to existing cropped area. Vegetable crop producers in the Lockyer Valley stated that due to the stringent quality requirements for crops to be saleable, decisions on the area of crop to plant are made on a periodic basis taking into account future water availability. As such, growers vary their areas of crop production based on their expected future water availability, rather than maintaining the same area of production and varying irrigation application rates. Hence, additional water supplied to growers in the Lockyer Valley would be applied to expand (or maintain) areas under crop production.

Lockyer Valley demand

The following table summarises the results of the crop modelling for the Lockyer Valley. Due to the limited survey responses received from growers in the Lockyer Valley, modelling of the on-farm returns was based on available information on crop production and agricultural water use (including cost and yield estimates provided by growers), focusing on the key crops produced. The table below summarises the results for the Lockyer Valley.

Summary of modelling results for the Lockyer Valley

Crop	Gross margin per ha	Gross margin per ML[a]	On-farm return per ML[b]
Lettuce	$14,583	$3,314	$3,223
Broccoli	$3,947	$1,196	$1,075
Onions	$12,390	$2,253	$2,180
Carrots	$14,933	$3,394	$3,303
Cabbage	$6,140	$1,395	$1,305
Cauliflower	$25,089	$5,702	$5,611
Crop averages	**$12,847**	**$2,876**	**$2,783**

a Includes an allowance of 10% for water security requirements.

b Takes into account the opportunity cost of land, with a value of $400 per hectare per annum applied.

Source: Synergies modelling based on data obtained from various sources, including direct consultation with growers.

In terms of the volume of demand in the Lockyer Valley, due to the limited survey responses from growers, it was necessary to rely on discussions with growers to assess the potential demand. Based on these discussions, two potential demand scenarios were identified:

- 7,500 ML per annum under the continuation of current groundwater management arrangements; and
- 25,000 ML per annum under the scenario in which groundwater resources become regulated and subject to volumetric allocations.

Darling Downs demand

For the Darling Downs, the returns from additional water use were modelled for both increased application to existing crops and the expansion of the area of crop production. The results of the modelling for the key crops identified by growers on the Darling Downs are set out in the table below.

Summary of modelling results for the Darling Downs

Crop	On-farm returns from application to existing crops	On-farm returns from expansion of cropping area
Cotton	$637 per ML	$502 per ML
Maize	$416 per ML	$331 per ML
Chickpeas	$766 per ML	$497 per ML
Sorghum	$100 per ML	$196 per ML
Wheat	$496 per ML	$448 per ML

Source: Synergies modelling based on data obtained from various sources, including direct consultation with growers.

The table below presents the breakdown in water use by crop type and application for the Darling Downs. These proportions are based on grower survey responses. It is noted that sorghum has been excluded from the demand profile due to the lower returns derived from water use relative to the other crops.

Breakdown of water use for crop production on the Darling Downs

Crop	Water use on existing crops		Water use for expansion of crop area	
	% of total demand	ML	% of total demand	ML
Cotton	47.4	21,828	22.3	10,269
Maize	6.4	2,947	4.3	1,980
Chickpeas	3.6	1,658	6.7	3,085
Wheat	7.1	3,270	2.4	1,105

Source: Based on survey responses from Darling Downs growers and results of modelling of on-farm returns from water use.

In interpreting the above volume estimates, it is important to recognise the preliminary stage of this demand assessment and the limited number of growers that responded to the survey (relative to the total number of crop producers on the central Darling Downs). As such, based on the consultation with growers and outcomes from the crop modelling, it is considered that actual demand for additional water for crop production on the Darling Downs is significantly greater than identified in this demand assessment.

Other sources of demand

In relation to demand from other users (i.e. intensive animal producers and CSG producers), consultation with industry representatives and key stakeholders indicated that it is not possible to include these producers in the demand profile for the project based on currently available information. For intensive animal producers, this is largely attributable to the importance of reliability of water supply to the feasibility of operations (noting that the water supply is likely to be subject to periodic disruptions), whilst for CSG producers, the key constraint is uncertainty in relation to the timing and magnitude of producers' 'make good' water requirements.

Noting this, it is recommended that as part of the Detailed Business Case, further investigation be undertaken of the potential for water to be supplied to intensive animal producers, particularly feedlot operators on the Darling Downs. Whilst CSG producers may become a source of demand in the future, it is not appropriate for these producers to be included in the demand profile for the project, given the uncertainty regarding the timing and volume of their water requirements.

Contents

Figures and Tables

1 Introduction

The NuWater Project involves the use of recycled wastewater from treatment plants in South East Queensland (SEQ) for irrigated crop production, and potentially other agricultural and industrial uses, in the Lockyer Valley and on the Darling Downs. This includes potentially utilising infrastructure developed as part of the Western Corridor Recycled Water Scheme (WCRWS).

In January 2016, a consortium led by Queensland Farmers' Federation (QFF) secured funding under the 'Feasibility' component of the National Water Infrastructure Development Fund (NWIDF) to undertake a feasibility study on the project. Synergies Economic Consulting (Synergies) has been engaged to undertake the demand assessment as well as the financial and economic analysis components of the feasibility study.

This report presents the water demand assessment undertaken for the NuWater project. The purpose of this assessment is to obtain a preliminary view on the level of demand for recycled water in the region across a range of uses, including irrigated crop production, intensive animal production, and other potential uses (e.g. satisfying 'make good' water requirements of Coal Seam Gas (CSG) producers). The findings from this demand assessment will be used as key inputs into the economic and financial assessment of the shortlisted project options.

The report is set out as follows:

- section 2 sets out the background information relevant to the demand assessment and summarises the approach to be adopted;
- section 3 provides an overview of economic activity in both the Lockyer Valley and Darling Downs regions;
- section 4 summarises current water supply and demand in both regions;
- section 5 includes an analysis of water market trading activity;
- section 6 summarises the consultation undertaken with agricultural water users;
- section 7 identifies the crops on which modelling was undertaken and the approaches adopted to assessing the on-farm returns from increased water use;
- section 8 reports the results of the modelling on a crop-by-crop basis;
- section 9 assesses water demand for other uses, including intensive animal production and CSG production; and

- section 10 presents the summary and conclusions from the demand assessment.

The questionnaire that was distributed to growers as part of the demand assessment has been included as an attachment to the report.

2 Background and approach

This section sets out the background information relevant to the demand assessment for the NuWater project, including a high-level overview of the approach to be applied in undertaking the assessment.

2.1 Project overview

The delivery of wastewater from treatment plants in SEQ to agricultural producers in the Lockyer Valley and on the Darling Downs has been under consideration for over two decades. During the late 1990s and early 2000s, around $2 million of public and private funding was allocated to the Darling Downs Vision 2000, the purpose of which was to assess the feasibility of such a scheme.

Despite a business case being completed and recommending the project proceed to financial close (see below), the project was discontinued in 2004. This coincided with the continued worsening of the urban water supply outlook in SEQ, which resulted in significant investment in supply-side solutions, including the WCRWS. As a result, the diversion of treated wastewater for agricultural and industrial use was removed from consideration.

In 2016, consideration of the project re-commenced with the Commonwealth Government allocating funding for a feasibility study under the NWIDF. The funding is to be used to re-assess the feasibility of the NuWater project, taking into consideration the potential for the existing WCRWS infrastructure (including the $2.7 billion pipeline constructed as part of the scheme) to be used to facilitate the delivery of treated wastewater from plants in SEQ to the Lockyer Valley and the Darling Downs.

The key features of the NuWater project are as follows:

- were the project to proceed to construction, up to around 86,000 ML of treated wastewater could be made available to agricultural producers and potentially industrial users in the Lockyer Valley and on the Darling Downs;
- there is growing concern in relation to the environmental impact of the release of treated wastewater, and the associated nutrient and sediment loads, from wastewater treatment plants into Moreton Bay. The NuWater project presents the opportunity for the avoidance of these adverse environmental impacts; and
- since the project was under consideration in the late 1990s and early 2000s, there has been significant investment in water treatment and transportation

infrastructure, in particular the WCRWS pipeline infrastructure, which is not currently being utilised.[2]

2.2 Previous reports

In 2003, a business case was completed for the project, which concluded that the project had reached a point of commercial, economic and environmental feasibility. A decision by the Queensland Government in the mid-2000s to reserve treated wastewater for potable (or indirect potable) use, and the subsequent construction of the $2.7 billion WCRWS, resulted in the NuWater project not being subject to further assessment.

The 2003 business case was conducted on the following project:

- a network of wastewater collection points in and around the greater Brisbane region that would direct and transport wastewater from Luggage Point, Gibson Island, Oxley Creek and Wynnum wastewater treatment plants to a water reclamation plant at the West Bank WTP site at Mt Crosby for treatment and storage;
- a bulk water pipeline that would transport treated wastewater from Mt Crosby west to the Lockyer Valley and Darling Downs; and
- a wastewater reticulation and distribution network in and around the Lockyer Valley and Darling Downs for direct distribution to growers and other customers.

The business case identified two primary benefits associated with the project:

- the provision of a reliable source of water to agricultural producers currently experiencing critical water shortages; and
- the diversion of effluent from discharge into the waterways and bays in and around SEQ to a more economically efficient and ecologically responsible use.

The economic benefits attributed to the supply of additional water to agricultural producers included the following:

- increased operational efficiency and production for growers resulting from access to a highly secure water supply; and
- increased regional economic activity by at least $195 million per annum (based on a multiplier of 3.1 and an estimated increase in the long run gross value of farm production of approximately $63 million per annum).

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[2] Seqwater currently maintains the WCRWS infrastructure in 'care and maintenance' mode.

As assessment conducted by Psi-Delta found that the project would result in an increase in agricultural production in the Lockyer Valley of $17.33 million, with water to be applied to vegetable crops, lucerne, tomatoes, fruits and nuts, pumpkins, beans, melons, sweet corn, and pasture for grazing.

Increased agricultural production on the Darling Downs was estimated at $45.67 million per annum, with water to be primarily applied to cotton, in addition to maize and other cereal crops. An economic multiplier of 3.1 was applied to the combined total value resulting in a total estimate for the increase in regional economic activity as a result of the project of $195 million.

Whilst the 2003 business case and the estimates derived for the increase in agricultural production resulting from the project provide an indication as to the potential economic benefits achievable from the reuse of recycled wastewater for agricultural production in the Lockyer Valley and on the Darling Downs, the demand assessment underpinning the benefit estimates are unlikely to be sufficiently robust to satisfy the requirements under Building Queensland’s Business Case Development Framework or Preliminary Business Case Guidelines.

Satisfying the requirements set out in these guidelines requires a robust and comprehensive consideration of project need. In this case, the economic value of the reuse of recycled wastewater for agricultural production is one of two key drivers of the NuWater project. This report satisfies this requirement by presenting the outcomes of a comprehensive assessment of agricultural water demand relevant to the project.

2.3 Current status

As previously stated, QFF has secured funding under the NWIDF to undertake a feasibility assessment of the NuWater project. A successful feasibility study will result in the project proceeding to a formal assessment by the Queensland Government, to be led by Building Queensland.

Whilst this feasibility assessment is to build upon the work conducted in developing the 2003 business case, it is important that the assessment is conducted in a manner that is consistent with the relevant business case guidelines and is underpinned by current data and information. This report presents the outcome of the demand assessment, which is a key component of this feasibility assessment.

In this context, it is important to note that several factors have changed since the previous assessment of the feasibility of the project was undertaken:

- increase in urban wastewater volumes available for beneficial reuse;

- increased controls and requirements for the disposal of treated effluent into the Brisbane River system and Moreton Bay;
- the construction of the WCRWS, which has resulted in significant trunk infrastructure being potentially available for use;
- increased value of intensive agricultural production in both the Lockyer Valley and on the Darling Downs;
- the construction of the Toowoomba Wellcamp Airport, which has resulted in additional export opportunities being created; and
- the development of the CSG industry in the Darling Downs region.

2.4 Approach to demand assessment

This section summarises the approach to be applied in assessing water demand relevant to the NuWater project.

2.4.1 Approach to assessing agricultural water demand

A five-stage approach was applied to assess the demand for water from crop producers in the Lockyer Valley and on the Darling Downs:

1) Review of previous studies and reports to obtain an understanding of current water supplies and water use for crop production in the regions;
2) Consultation with peak bodies and irrigator representatives to understand the key demand-side drivers relevant to the project and to understand, at a high level, the nature of demand for additional water in the regions;[3]
3) Survey of crop producers in the Lockyer Valley and on the Darling Downs to obtain information on current water use levels, the nature of demand for water from the NuWater project and the key characteristics of this demand, including in relation to water quality and reliability levels, and growers' willingness to pay for water from the project;
4) Focus groups were held with growers in the Lockyer Valley and on the Darling Downs to consult with individual growers to refine the assumptions and inputs to be used in the farm-level modelling; and

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[3] Peak industry bodies and irrigator representative groups consulted with included Central Downs Irrigators Limited, Lockyer Valley Growers, Gowrie-Oakey Creek Irrigators, and Cotton Australia.

5) Modelling was undertaken to estimate the on-farm return from the use of additional volumes of water on crops identified in the survey responses and focus groups. The purpose of this modelling was to substantiate growers' capacity to pay for water from the project, as indicated in the survey responses, and to estimate the economic benefits to be derived from the use of the water for crop production.

In addition to the above, consultation was also undertaken with representative bodies for intensive animal producers in the region. This included:

- chicken meat producers and processors
- dairy farmers
- pig producers
- egg producers
- feedlot operators.

The aim of this consultation was to identify:

- the extent to which future water availability may be a constraint on intensive animal producers in the region;
- the nature of demand for water for intensive animal production, including water quality, salinity and reliability requirements;
- the likely magnitude of any future unmet demand for water from intensive animal producers; and
- the return from the use of the water for intensive animal production and producers' willingness to pay for water from the project.

2.4.2 Approach to assessing industrial water demand

The potential industrial demand relevant to the project was identified through targeted consultation with key stakeholders to determine:

- the extent to which future water availability may be a constraint on industrial activity;
- the nature of demand for water for industrial production, including water quality, salinity and reliability requirements;

- the likely magnitude of any future unmet demand for water from industrial producers; and
- the return from the use of the water for industrial production and producers' willingness to pay for water from the project.

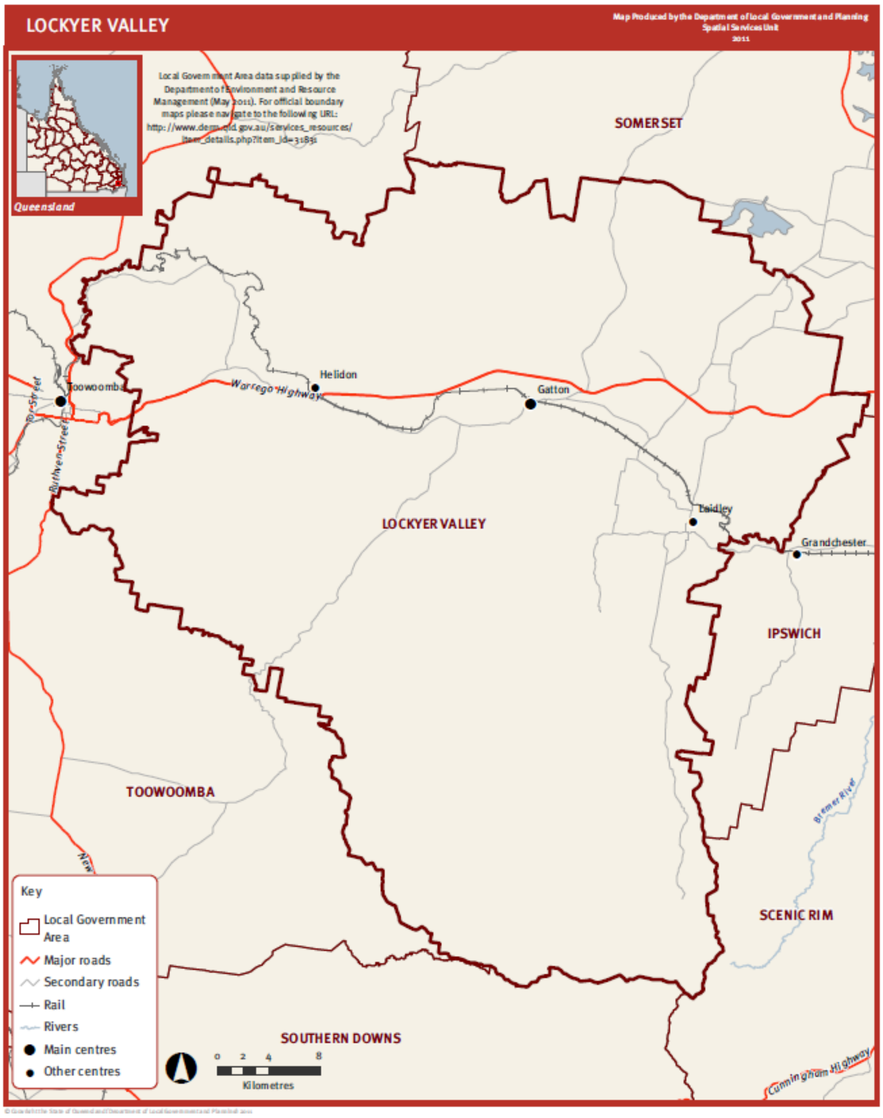
3 Regional economic overview

This section presents an overview of agricultural production and industrial activity in the Lockyer Valley and on the Darling Downs, focusing on those activities most likely to represent potential sources of demand for the NuWater project.

3.1 Lockyer Valley

The Lockyer Valley region spans approximately 3,000 square kilometres between Brisbane and Toowoomba. The major towns in the region are Gatton and Laidley.

Figure 1 Map of the Lockyer Valley region



Source: http://edq.qld.gov.au/resources/map/reform/lockyer-valley-map.pdf

3.1.1 Agricultural production

Agricultural producers are the dominant water users in the Lockyer Valley and on the Darling Downs. Irrigated crop production will be the main source of demand for water from the project in both regions. This section summarises agricultural production in the Lockyer Valley and on the Darling Downs.

The following factors combine to make the Lockyer Valley a highly productive agricultural region:

- fertile soils and biophysical properties, with the black alluvial clay and clay loams the most productive soils in the region;
- favourable topography, with most horticultural production occurring on flat, slightly sloping and undulating soils along major streams and their tributaries;
- climate conditions that are favourable to horticultural production;
- close proximity to major domestic markets in SEQ;
- access to export markets via reliable transportation infrastructure (i.e. the Port of Brisbane and the Toowoomba and Brisbane airports); and
- access to reliable groundwater supplies.

The Lockyer Valley typically accounts for approximately 25 per cent of total horticultural production in Queensland. Table 1 sets out the key vegetable crops that are produced in the Lockyer Valley.

Table 1 Overview of horticultural production in the Lockyer Valley (2010-11)

Crop	Production (tonnes)	Proportion of total production
Lettuce	26,157	22.9%
Potatoes	21,786	19.1%
Cauliflower	13,455	11.8%
Onions	11,240	9.9%
Broccoli	9,529	8.4%
Pumpkins, triambles and trombones	9,265	8.1%
Carrots	6,510	5.7%
Beans – French and runner	5,871	5.1%
Sweet corn	4,737	4.2%
Other	5,522	4.8%
Totals	**114,071**	**100.0%**

Note: Cabbages are excluded from the above table however it is understood there are significant tonnages of cabbages currently being produced in the Lockyer Valley.

Source: The Stafford Group (2013). Regional Food Sector Strategy. Prepared for Lockyer Valley Regional Council.

For several of the crops in the above table, the Lockyer Valley accounts for a significant proportion of Queensland's total production. This includes around 70 per cent of total lettuce production, 66 per cent of broccoli production, 55 per cent of cauliflower production, and 51 per cent of onion production.[4] Recent trends in production show that whilst total tonnages of production have remained relatively stable, there has been significant growth in the production of cauliflower, broccoli, lettuce and onions.[5]

In terms of the value of agricultural production in the Lockyer Valley, lettuce and broccoli were the two highest value commodities produced in 2011, totalling $30.5 million and $22.0 million respectively.[6] In 2010/11, the total value of agricultural production in the Lockyer Valley was estimated at around $263 million, of which almost 80 per cent is attributable to vegetable production.[7] The other major agricultural commodities produced are livestock slaughterings ($28.7 million); nurseries and cut flowers ($9.3 million); fodder crop production ($7.7 million); and milk production ($3.0 million).

3.1.2 Industrial activity

Industrial activity in the Lockyer Valley is dominated by activities related to agricultural production, including logistics operators and food production and processing operations and other agribusinesses.[8] These activities, whilst playing an important role in supporting the agricultural sector in the Lockyer Valley, are not significant water users and are therefore not material to this demand assessment.

3.2 Darling Downs

The Darling Downs region spans 170,710 square kilometres and is located on the western slopes of the Great Dividing Range in southern Queensland (see Figure 2).

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[4] Australian Bureau of Statistics (ABS) (2008). *Agricultural commodities, Australia, 2005-06*. Cat no. 7121.0, Canberra, Australia.

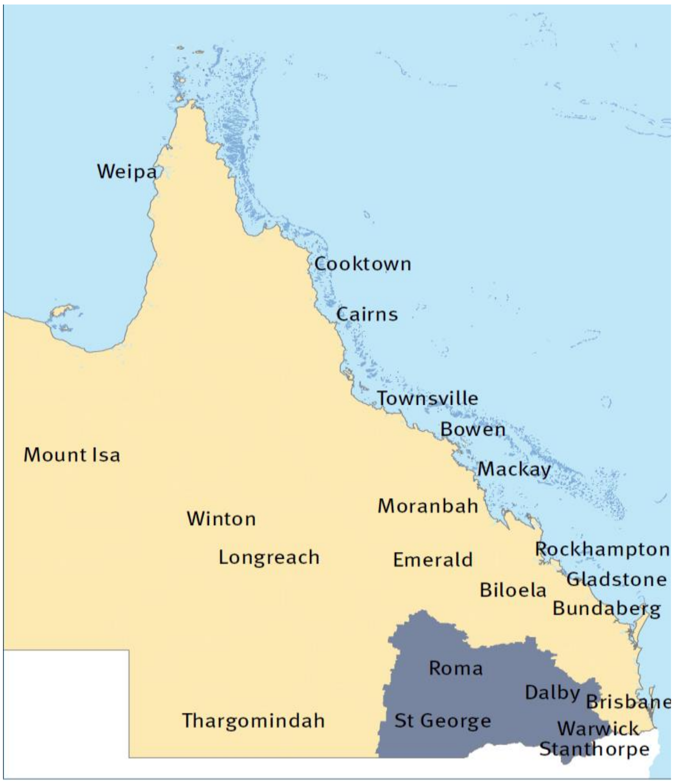
[5] AEC (2013). Economic analysis and social impact assessment of the Lockyer Valley Recycled Water Scheme. Final Report.

[6] Australian Bureau of Statistics (2012). Value of agricultural commodities produced, Australia, 2010-11. Cat No. 7503.0.

[7] Australian Bureau of Statistics (2012). Value of Agricultural Commodities Produced, Australia, 2010-11. Cat No 7503.0.

[8] Lockyer Valley Regional Council (2013). Lockyer Valley Regional Development Framework 2013-2023.

Figure 2 Map of the Darling Downs Region



3.2.1 Agricultural production

There is considerable diversity in terms of agricultural production on the Darling Downs, which accounts for around 20 per cent of the value of total agricultural production in Queensland. The soils on the Darling Downs vary considerably in terms of their fertility and water-holding capacity. Vertosols (cracking clays) are the dominant soil types used for cropping on the Darling Downs and are most commonly found in the Condamine Catchment. The region also has large areas of fertile cracking clay soils.

Crop production on the Darling Downs is most intensive in areas conducive to irrigation. The eastern region of the Darling Downs around Cecil Plains and Dalby contains highly production agricultural land which supports extensive broadacre cropping, horticulture production and significant intensive livestock production. The Darling Downs region also contains around 56 per cent of Queensland's pig herd, which totals around 280 herds with over 61,000 sows.[9]

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[9] 'Queensland pig industry'; Department of Agriculture and Fisheries; https://www.daf.qld.gov.au/animal-industries/pigs/about-the-industry/in-queensland; DOA: 11 October 2017.

Table 2 shows the production of agricultural commodities on the Darling Downs in 2010/11, including the percentage change in production since 2000/01 and the proportion of total production in Queensland accounted for by the region.

Table 2 Overview of production of agricultural commodities on the Darling Downs

Agricultural commodity	Production on Darling Downs (2010-11)	% change from 2000-01	% of total production in Queensland
Broadacre Crops			
Crops Cut For Hay (t)	127,977	+49.5%	13.0%
Cereal Crops (t)			
Wheat (t)	734,964	+56.0%	48.2%
Sorghum (t)	787,648	+57.4%	66.6%
Barley (t)	108,295	+10.2%	74.1%
Maize (t)	98,614	+67.1%	57.5%
Other Cereal Crops (t)	29,346	-84.1%	53.1%
Legumes for Grain (t)			
Chickpeas (t)	37,334	+48.3%	26.9%
Mung Beans (t)	15,549	-16.1%	34.6%
Other Legumes for Grain (t)	17,740	+455.1%	36.4%
Oilseeds (t)	8,680	-28.4%	43.8%
Cotton (t)			
Irrigated Cotton (t)	114,756	+47.3%	40.3%
Non-Irrigated Cotton (t)	46,453	+156.5%	75.7%
Other Crops (t)	753	-91.9%	0.0%
Total Broadacre Crops (t)	**2,128,110**	**+36.1%**	**7.4%**
Livestock			
Sheep and Lambs (n)	599,951	-40.7%	12.4%
Cattle and Calves (n)	1,237,700	-1.9%	9.8%
Pigs (n)	412,022	+34.1%	64.5%
Goats (n)	25,143	NA	15.1%
Poultry (n)	3,758,422	+103.5%	19.0%
Other Livestock n.e.c. (n)	23,335	-45.3%	11.9%
Total Livestock (n)	**6,056,573**	**+35.5%**	**15.8%**
Livestock Products			
Eggs Production (n)	**799,889,100**	**+206.9%**	**88.1%**

Note: Although data for horticultural commodities were available, they were excluded from the table for the reason that they did not reflect the commodities in the focus areas. T and n denote tonnage and number, respectively. 'Other crops' represents lavender, pasture seed, peanuts, sugar cane, coriander and all other crops not elsewhere classified (n.e.c.).

Sources: ABS (2008). *Agricultural commodities: small area data, Australia, 2000-01*. Cat. no. 7125.0, Canberra, Australia; ABS (2012). *Agricultural commodities, Australia, 2010-11.* Cat. no. 7121.0, Canberra, Australia.

The key observations from the above table are as follows:

- the Darling Downs region accounts for a significant proportion of total Queensland production for a range of agricultural commodities, in particular cotton, broadacre crops, pigs and eggs;
- significant growth in production of a range of broadacre crops was observed between 2000/01 and 2010/11, including cotton (particularly non-irrigated cotton), wheat, sorghum, maize, other cereal crops and chickpeas; and
- there has been significant reductions in production of some livestock products, including sheep and lambs, and growth in others, such as eggs, poultry and pigs.

In terms of value of production, the most significant agricultural commodities produced on the Darling Downs (as of 2010/11) are cotton ($361.3 million); cattle and calves ($269.2 million); wheat ($182.5 million); sorghum ($167.6 million): pigs ($142.7 million); and eggs ($131.3 million).[10] Chickpea production on the Darling Downs has also grown significantly in recent years, driven by strong demand in major export markets (an estimated 80 to 90 per cent of chickpea production is exported into Asian markets). Approximately one-third of Australia's total chickpea production is grown in Queensland, with over half of this crop produced in the southern corner of the State.[11]

Of the intensive animal industries, cattle production is the most significant in terms of the value of production. Toowoomba and the surrounding regions host Australia's largest concentration of feedlots that supply several meat processors, the majority of which export significant quantities of product. It is estimated that around 30 per cent of Australia's feedlots are located in the southern corner of Queensland.[12]

3.2.2 Industrial activity

The key industrial activities on the Darling Downs are as follows:

- agricultural support services, including logistics, food processing and manufacturing;
- construction, predominantly associated with the mining and property development sectors; and

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[10] ABS (2008). *Agricultural commodities: small area data, Australia, 2000-01*. Cat. no. 7125.0, Canberra, Australia; ABS (2012). *Agricultural commodities, Australia, 2010-11*. Cat. no. 7121.0, Canberra, Australia.

[11] TIQ Darling Downs regional profile.

[12] TIQ Darling Downs regional profile.

- energy production, particularly energy generation, coal mining and CSG production.

In terms of the relevance to this water demand assessment, the third of the above categories is the key area of focus (water requirements for the first two activities can be readily met by existing reticulated water networks).

The South West region has become a major energy hub over the past decade, with the region containing several major power stations a large number of significant coal mining and CSG projects. There are several coal and gas power stations located in the Darling Downs, including the Condamine Power Station (144 MW gas); the Kogan Creek power station (744 MW coal); the Darling Downs power station (643 MW gas); the Braemar power station (504 MW gas); and the Braemar 2 power station (519 MW gas); the Daandine power station (33 MW gas); and the Oakey power station (282 MW gas).[13]

The region also contains several major CSG projects. The Surat Basin is the major source of CSG accounting for around 60 per cent of Queensland's total CSG production. The Surat Basin also accounts for over 75 per cent of Queensland's CSG reserves.[14] Figure 3 shows the CSG projects located in the Surat Basin. CSG projects within the Surat Basin are represented by green dots. As shown in the figure, there are several projects located within the project area, particularly east of Condamine and south of Chinchilla.

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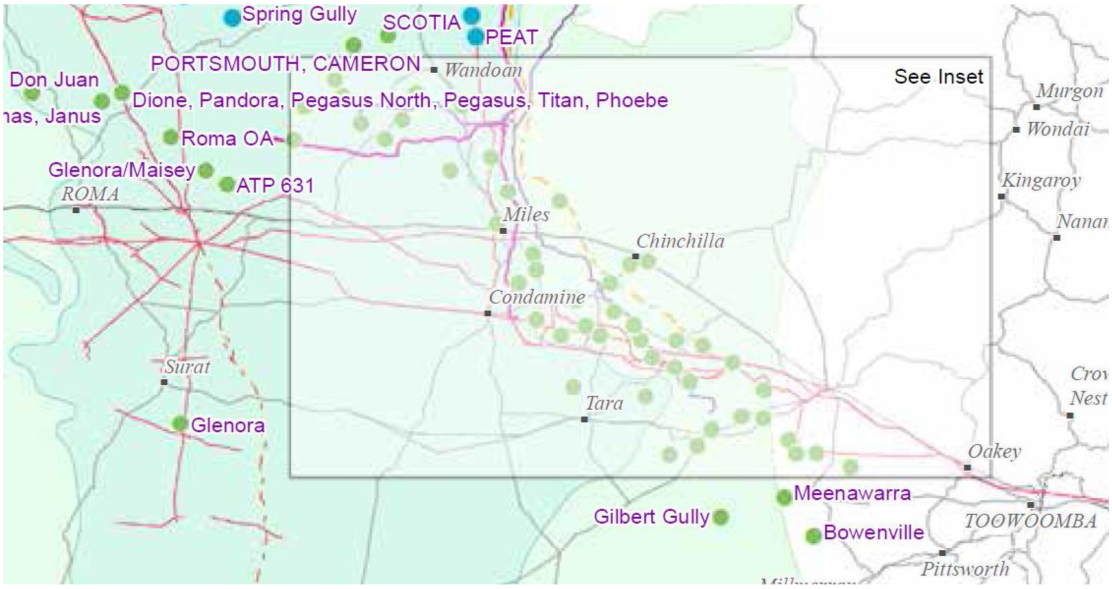
[13] https://maps.dnrm.qld.gov.au/electricity-generation-map/#results

[14] Queensland Government (2017). Queensland's petroleum and coal seam gas 2015-16.

Figure 3 Location of CSG projects in the project area



Source: Queensland Government (2017). Queensland's petroleum and coal seam gas 2015-16.

DNRM estimates that there are around 4,600 CSG production wells in the Surat Basin. It is also estimated that this figure increased by approximately 207 per cent between 2012 and 2016.[15]

Coal mining has been a key component of industrial activity on the Darling Downs for several decades. The future of coal mining in the region, and in the Surat Basin more generally, is currently unclear. The planned sale of Peabody Coal's Wilkie Creek Mine, which is currently under care and maintenance, has been delayed subject to successful financing by the proposed purchaser, whilst final approvals for the New Acland Stage Three expansion project (New Hope Group) remain on hold pending the results of legal proceedings.[16]

It has previously been estimated that the Darling Downs contains over 10 per cent of Queensland's coal deposits and 65 per cent of its CSG reserves.[17]

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[15] Department of Natural Resources and Mines (2016). *Underground water impact report for the Surat Cumulative Management Area.* Queensland Government, The State of Queensland.

[16] Queensland Government Statistician's Office (2017). Surat Basin non-resident population projections, 2017 to 2023.

[17] Department of State Development, Infrastructure and Planning (2013). *Darling Downs Regional Plan*. Queensland Government, The State of Queensland.

4 Current water supply and demand

This section summarises the current water supply-demand situation in both the Lockyer Valley and on the Darling Downs.

4.1 Lockyer Valley

4.1.1 Water supply

Water for agriculture in the Lockyer Valley is supplied by two sources – groundwater and surface water, with groundwater being the main source of water for irrigation. The unregulated use of groundwater resources in the Lockyer Valley makes it difficult to determine the current use of water for agricultural production. DNRM has estimated that total water use for agricultural production in the Lockyer Valley is around 60,000 ML per annum, with around 44,000 ML being sourced from groundwater resources (other estimates have placed total groundwater use for agriculture at around 45,000 ML and 46,500 ML per annum).[18]

Groundwater

Agricultural producers in the Lockyer Valley access groundwater resources primarily from alluviums, with additional groundwater supply obtained from the Great Artesian Basin (GAB) sediments. There are some concerns that these groundwater resources may be under pressure due to the impacts of drought as well as the extraction of groundwater resources in excess of recharge. There are also concerns about water quality, with increasing salinity in the groundwater, surface water and soil.[19]

Groundwater use in most of the Lockyer Valley has historically not been regulated, with no licensing and limited metering of groundwater use in the region. Past assessments have concluded that the alluvial aquifers of the Lockyer Valley are under stress, with water use exceeding the estimated sustainable yield. Sandstone aquifers are also reported to be experiencing major stress in some areas.[20]

Under the current management arrangements and climatic conditions, the Lockyer Valley alluvial aquifer remains under stress, and the groundwater resources there are

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[18] Cardno (2017). Draft options development report. Prefeasibility study – Water for agriculture productivity and sustainability. Prepared for Lockyer Valley Regional Council.

[19] Lockyer Catchment Action Plan 2015-2018. Resilient Rivers Initiative, July 2016, p. 23.

[20] See: https://www.dnrm.qld.gov.au/water/catchments-planning/catchments/moreton/lockyer-valley-groundwater [Accessed 6 September 2017)

exploited beyond their sustainable yields with pumping often continued until bore yields significantly decline. However, groundwater levels partially recover during high rainfall years.[21] A 2007 study found that, during average rainfall years, the total groundwater pumping throughout the Lockyer Valley exceeded recharge by approximately 3,375 ML/year.[22]

In the context of the future water supply-demand balance in the Lockyer Valley, it is important to note that the Moreton Water Plan, the scope of which covers surface and groundwater resources in the Lockyer Valley, is currently under review by the Queensland Government.

Whilst consultation on water supply and allocation arrangements to be defined in the revised Water Plan is ongoing, there is the potential that the revised Plan will restrict the use of groundwater resources for agricultural production in the Lockyer Valley (noting that sustainable groundwater extractions have previously been estimated at as low as 25,000 ML per annum). This has potentially significant implications for the water supply-demand balance in the region and the security of future water supply for irrigators in the region.

Surface water

The Lockyer Valley is a highly connected surface water-groundwater system. Surface water supplies in the Lockyer Valley are constrained by climatic variability and the configuration of surface water storages and supply channels. Surface water resources generally have relatively poor reliability.

The Central Lockyer Valley WSS was established to support irrigation in dairy, vegetable and forage crops sectors following construction of the Bill Gunn Dam, Lake Clarendon Dam and the Morton Vale Pipeline. Both dams are offstream storages filled by diverting water from nearby creeks during significant flow events. The scheme supplies water for the Morton Vale Pipeline, assists in the recharge of the groundwater areas adjacent to Lockyer Creek, and supplies downstream area-based surface water entitlements.

The Central Lockyer Valley WSS supplies approximately 315 water entitlements, of which 115 are interim water allocations to take surface water (150 are to take

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[21] See: http://www.bioregionalassessments.gov.au/assessments/11-context-statement-clarence-moreton-bioregion/1143-groundwater-flow [Accessed 6 September 2017]

[22] Hair I (2007) Hydrogeological study of the benefits of supplying recycled water to the Lockyer Valley, South East Queensland, Queensland Water Commission, Brisbane. Cited in: Australian Government, Bioregional Assessments. Available at: http://www.bioregionalassessments.gov.au/assessments/11-context-statement-clarence-moreton-bioregion/1143-groundwater-flow [Accessed 6 September 2017]

groundwater and 50 land owners on the Morton Vale pipeline supplied under water supply agreements with Seqwater).[23]

One of the aims of the Moreton Water Plan Review is to convert interim water allocations that currently apply to the Central Lockyer Valley WSS to tradeable, volumetric water allocations, to provide flexibility and water supply security to water users. It is proposed that the amendments will set the volume for each water allocation in the scheme as well as detailing the management rules for water sharing infrastructure operating and trading water within the Central Lockyer Valley WSS.[24]

Whilst, acknowledging the ongoing Moreton Water Plan Review, it is important to note that there is currently no plan that identifies how water will be secured for agricultural production in the Lockyer Valley over the long term.

The Lower Lockyer Valley WSS is located to the west of Lowood. The scheme was established following the construction of Atkinson Dam in 1970 to supply water to irrigators. The scheme is managed by Seqwater. Poor inflows into Atkinson Dam means that supply in the WSS is highly unreliable.[25]

4.1.2 Water demand

As the majority of water use for crop production in the Lockyer Valley is unmetered, it is difficult to determine the total volume of water demand for agricultural production in the region. There is an estimated 20,000 hectares of land under agricultural production in the Lockyer Valley, of which around 15,000 hectares is irrigated (noting this changes from year to year based on market conditions, climate, water availability, etc.). It is estimated there are 6,700 hectares of land growing vegetables in the Lockyer Valley.[26]

As shown in Table 3 below, there is significant variation in irrigation application rates in the Lockyer Valley, both across crop types and within crop types. Noting this variation, when combined with the above estimates for area under crop production, these application rates are broadly consistent with the previously derived estimates for total water use for agricultural production in the region.

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[23] Department of Natural Resources and Mines (2015). Statement of Proposals to amend the Water Resource (Moreton) Plan 2007 and Moreton Resource Operations Plan 2009, October 2015.

[24] Department of Natural Resources and Mines (2015). Statement of Proposals to amend the Water Resource (Moreton) Plan 2007 and Moreton Resource Operations Plan 2009, October 2015.

[25] 'Lower Lockyer Valley Water Supply Scheme'; Seqwater; See: http://www.seqwater.com.au/water-supply/irrigation/lower-lockyer-valley-water-supply-scheme; DOA: 16 November 2017.

[26] The Stafford Group (2013). Regional Food Sector Strategy. Prepared for Lockyer Valley Regional Council, August 2013, p. 15

Table 3 Irrigation water use on crops in the Lockyer Valley

Crop type	Annual usage (ML per hectare)
Lucerne and cereal crops cut for hay	1.3-2.7
Lucerne and cereal crops cut for silage	1.0-1.7
Lucerne and cereal crops used for grazing or fed off	1.0-2.2
Vegetables for human consumption	1.2-4.4
Fruit trees, nut trees, plantation or berry fruits	1.5-5.0
Nurseries, cut flowers and cultivated turf	3.3-4.8
Other broadacre crops	0.9-1.7
Cereals for grain or seed (e.g. wheat, oats, maize)	1.3-2.0
Other crops	1.5-2.5

Source: Australian Bureau of Statistics (2016). Water Use on Australian Farms, Australia 2014-15.

In terms of demand in excess of current water use, land use surveys have identified there is considerable areas of land deemed suitable for intensive horticultural production that are not currently being used for this purpose,[27] (although we note that growers communicated throughout the consultation process that most arable land is already under production). This indicates that land is not a constraint on the expansion of irrigated crop production in the Lockyer Valley, with the potential for this to increase should additional irrigation water become available. This is consistent with the views expressed by Lockyer Valley growers consulted with as part of this demand assessment (see section 6).

Water use in the Lockyer Valley is dominated by agricultural producers, with industrial users accounting for a significantly smaller proportion of total water use. Industrial water users are typically supplied via reticulated distribution networks in the region.

4.2 Darling Downs

4.2.1 Water supply

Water for agricultural production on the Darling Downs is primarily sourced from groundwater, with supplementary supply accessed from surface water supplies. Producers on the Darling Downs predominantly maintain their own on-farm storages in which water is stored for use on crops. There is significant on-farm storage capacity in the central Darling Downs (estimated at around 300,000 ML in the Condamine Catchment upstream of Chinchilla).[28] This provides producers with a significant amount of flexibility in managing their water supply and future irrigation requirements.

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[27] Queensland Agricultural Land Audit.

[28] Based on consultation with growers.

Groundwater

The majority of groundwater used for irrigation in the region is sourced from shallow alluvial aquifers in the Condamine catchment. Recharge of the aquifer is primarily from local surface river flows and from rainfall infiltration in the eastern catchment. Groundwater is managed under Groundwater Management Units (GMUs).

Groundwater levels have declined in the Central Condamine Alluvium and tributaries. The alluvium and tributaries have been extensively developed for irrigation, industrial, stock and domestic uses and are characterised by overdevelopment and over allocation relative to the productive yield of the system. Overdevelopment is a historic legacy from major irrigation growth in the 1960s. To manage this, annual entitlement limitations on take have been implemented in certain areas since 1995. A process to address over-allocation by amending the Condamine and Balonne Water Resource Plan began in 2009 with the aim of aligning water use with sustainable levels.[29] To address sustainability issues, groundwater users in recent years have seen access cut by up to 50 per cent in an effort to bring usage to sustainable levels.[30]

Table 4 shows the allocations and estimated yields for GMUs in the Central-Northern Downs as estimated in a 2010 non-urban water use study.

Table 4 Water allocations and estimated yields, Central-Northern Downs

GMU	Allocation (ML)	Estimated yield (ML)
Eastern Downs Basalts	40,709	36,500
Eastern Downs Sandstones	10,249	10,000
Condamine Groundwater Management Area (CGMA)	72,500	26,000
Oakey Creek	14,034	10,000
Myall/Moola Creeks	3,396	8,800
Condamine river (downstream of CGMA)	2,488	5,000
Upper Hodgson Creek GMA	4,935	4,800
Hodgson/Emu Creeks	2,285	3,500

Source: Psi Delta (2010). Healthy Headwaters. Coal Seam Gas Water Feasibility Study. South West Queensland Water Demand Analysis. Non-Urban Demand, August 2010, p. 34.

It is understood that water use from groundwater aquifers has continued to decline since the time at which this study was undertaken. Based on consultation with growers in the region, it is understood that groundwater use in the central-northern Darling Downs region is now less than 40,000 ML per annum.

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[29] Available at: https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0003/104844/upper-condamine-alluvium-factsheet.pdf [Accessed 11 September 2017]

[30] Central Downs Irrigators Limited (2014). Submission on the Agricultural Competitiveness Green Paper, 11 December 2014, p. 1.

Surface water

Dams in the region include the Leslie Dam (106,200 ML), Cecil Plains Weir (700 ML) and Cooby Creek Dam (23,092 ML). The region includes three WSS that are operated by SunWater – Upper Condamine WSS, Macintyre Brook WSS, and Chinchilla Weir WSS. The volume of water supplied by these schemes is relatively small in comparison with unsupplemented supplies in the region (i.e. groundwater and flow harvesting).

Water harvesting provides a significant volume of water to agricultural producers on the Darling Downs, with irrigators diverting from both major streams and tributaries using large diversion pumps and private ring tank storages. These water supplies are highly reliant on rainfall. Capture of overland flows – also highly dependent on rainfall – is also a very common source of water in the region.[31]

Growers consulted with during the water demand assessment estimated total surface water diversion for agricultural use at around 100,000 ML per annum.

4.2.2 Water demand

As in the Lockyer Valley, it is difficult to estimate total water use for agricultural production on the Darling Downs. In 2015-16, there were 706 agricultural businesses in the Darling Downs-Maranoa region using a total of 486,581 ML. Of this total, 47,684 ML (9.8%) was taken from irrigation channels or pipelines; 197,856 ML (40.7%) was taken from on-farm dams or tanks; 147,698 ML (30.4%) was taken from rivers, creeks and lakes; and 71,088 ML (14.6%) was taken from groundwater resources (ie. bores, springs, wells). The total area watered in the Darling Downs-Maranoa region was 113,587 hectares, with 441,375 ML applied at an average application rate of 3.9 ML per hectare.[32] Irrigation water use for key crops in the region are shown in Table 5.

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[31] Psi Delta (2010). Healthy Headwaters. Coal Seam Gas Water Feasibility Study. South West Queensland Water Demand Analysis. Non-Urban Demand, August 2010, p.31-32.

[32] Australian Bureau of Statistics (2017). 4618.0 Water Use on Australian Farms 2015-16. We note that this ABS data reports at the level of the Darling Downs Maranoa Statistical Area Level 4, which extends further west and south than the central Darling Downs region that is the focus of this demand assessment. As such, these estimates will likely overstate the irrigation water demand for the target region.

Table 5 Irrigation water demand for key crops in Darling Downs-Maranoa, 2015-16

	Total area (ha)	Area irrigated (ha)	Volume applied (ML)	Application rate (ML/ha)
Pastures (including Lucerne) cereal and other crops cut for hay	50,192	5,581	17,040	3.1
Other cereals for grain or seed (e.g. wheat, oats, maize)	935,556	25,692	51,250	2.0
Other broadacre crops	272,106	14,182	28,639	2.0
Vegetables for human consumption	3,463	2,842	7,234	2.5

Source: Australian Bureau of Statistics (2017). 4618.0 Water Use on Australian Farms 2015-16.

A 2010 study of non-urban water demand in south west Queensland (including the Central-Northern Darling Downs which covers this study area) estimated water demand projections for key industries in the region. As shown in Table 6, the results show the predominance of cotton, other irrigated broadacre crops and horticulture.

Table 6 Base projection of water demand by industry – Central-Northern Downs

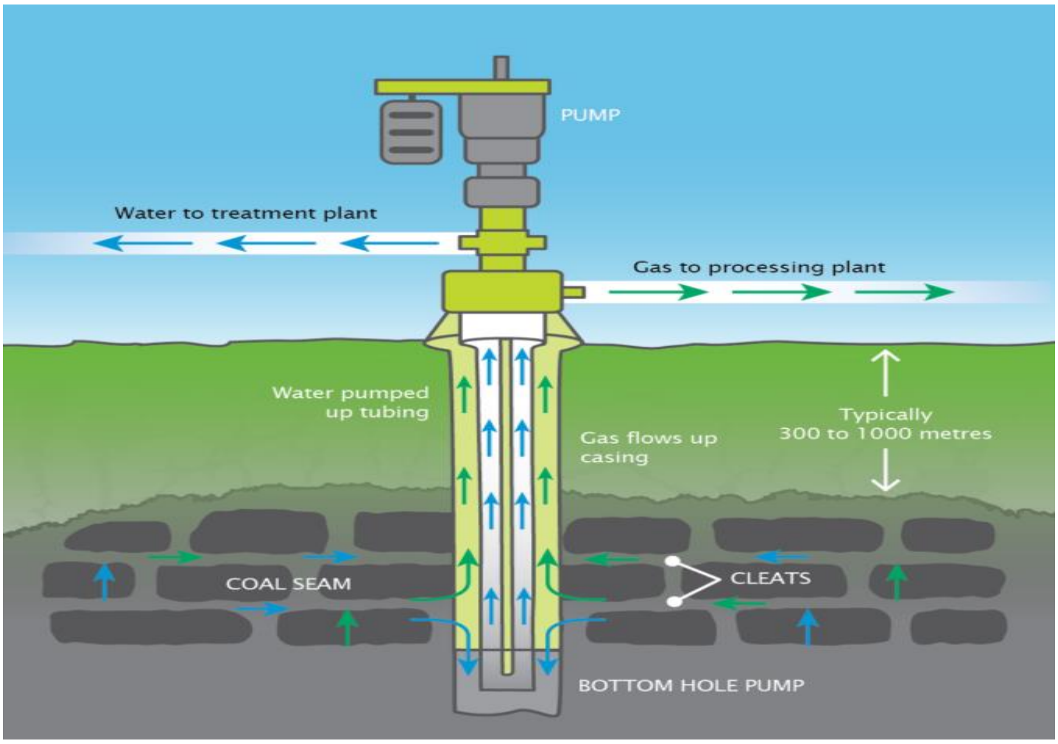
Activity	Total water use per annum (ML)			
	2010	2020	2040	2060
Cotton	130,200	132,460	128,150	118,140
Broadacre	64,800	63,180	66,540	75,540
Horticulture	32,670	30,460	30,070	30,870
Livestock	6,770	6,890	7,050	6,700
Electricity generation – gas	120	120	180	200
Electricity generation – coal	340	350	170	0
Coal mining	1,620	3,400	4,710	5,410
Total	**236,520**	**236,860**	**236,870**	**236,860**

Source: Psi Delta (2010). Healthy Headwaters. Coal Seam Gas Water Feasibility Study. South West Queensland Water Demand Analysis. Non-Urban Demand, August 2010, p. 5.

The above table demonstrates the extent to which agriculture dominates water use in the region. At the time the study was undertaken, agricultural activities accounted for 99 per cent of assessed non-urban water demand in the Central-Northern Darling Downs. Established coal mines and electricity generators in the region have already established water supply arrangements to meet their water requirements and as such are unlikely to represent potential customers for the NuWater project. In addition, given current market conditions in the coal mining and electricity generation sectors, it is unlikely there will be significant growth in water use by these activities in the region over the study period.

In terms of future industrial water demand in the region, the 'make good' requirements of CSG producers are likely to represent the most likely source of potential demand. CSG production requires water to be pumped from the target coal seam to the surface in order to release gases from coal particulars. The ratio of gas to water gradually increases over the duration of the life of the gas well due to the decreasing pressure resulting from the pumping of water. This extraction process is demonstrated in the figure below.

Figure 4 Schematic diagram of a standard CSG extraction process



Source: Gas Industry Social and Environmental Research Alliance (2017). How is coal seam gas extracted?. Available from: https://gisera.org.au/more-information/frequently-asked-questions/how-is-coal-seam-gas-extracted/ [Accessed 15 August 2017].

The production of CSG from the Surat Basin requires the extraction of significant volumes of water from coal seams (recently estimated at 65,000 ML per annum). This has the potential to impact on groundwater resources on the Darling Downs.[33]

In accordance with the 'Make Good' obligations under the *Water Act 2000*, if a groundwater bore supply is impaired by CSG water extraction at any time, the CSG producer is required to undertake actions that aim to restore water supply to water bores with impaired capacity or provide the bore owner with alternative water supply options.

For example, Arrow Energy, which operates in the Surat Basin, has outlined the steps it takes to comply with the 'make good' framework in its Coal Seam Gas Water and Salt Management Strategy. Through ongoing monitoring, bores potentially impacted by groundwater extraction are identified, with a bore assessment undertaken to determine

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[33] Department of Natural Resources and Mines (2016). Surat Underground Water Impact Report 2016 – Summary.

if bore capacity is impaired. The outcome of the assessment is documented in a *Make Good Agreement* negotiated with the owner of the bore, which also includes monitoring arrangements and measures to address the impairment (e.g. modifying pumping infrastructure, modifying or deepening the bore, installing a new bore, supplying an alternative water source, and monetary compensation).[34]

It has been estimated that over the lifetime of the CSG industry in the Surat Basin, up to 459 groundwater bores are expected to experience water-level decline beyond the trigger threshold in the Surat Cumulative Management Area (CMA).[35] Of those 459 bores, 91 are predicted to be adversely impacted within the next three years.[36] This indicates that CSG producers may be exposed to significant 'make good' requirements in the future. This represents a potentially significant source of future water demand in the region.

4.3 Summary

The key points in relation to the water supply-demand balance are as follows:

- water use in both the Lockyer Valley and on the Darling Downs is dominated by agricultural production, in particular irrigated crop production. In the Lockyer Valley, industrial water use is limited predominantly to agricultural support activities and is supplied by reticulated networks, whilst on the Darling Downs, coal mines and electricity generators have established water supply arrangements. In terms of future industrial water demand, the future 'make good' requirements of CSG producers on the Darling Downs are the most likely source of potential demand;
- in terms of agricultural water use in the Lockyer Valley:
  - whilst it is difficult to determine total water use for agricultural production in the Lockyer Valley, recent estimates of around 60,000 ML per annum have been generated, with around 44,000 ML (73 per cent) sourced from groundwater.

    This is consistent with estimates suggesting there is around 20,000 hectares of land used for crop production in the Lockyer Valley, of which around 15,000 hectares is currently irrigated;

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[34] Available at: https://www.arrowenergy.com.au/__data/assets/pdf_file/0016/14047/Appendix-D-Coal-Seam-Gas-Water-and-Salt-Management-Strategy.pdf [Accessed: 5 September 2017]

[35] Although Surat CMA covers the area of current and planned CSG development in the Surat Basin and the Bowen Basin, CSG production in the Surat Basin was found to being more than four times higher compared to production in the Bowen Basin.

[36] Department of Natural Resources and Mines (2016). Surat Underground Water Impact Report 2016 – Summary.

  - water supply for irrigated crop production is dominated by groundwater resources that are largely unregulated and mostly unmetered. There is uncertainty over the long-term sustainability of current groundwater use in the region;
  - there is also uncertainty in relation to the management arrangements to apply to groundwater resources in the region, with the Moreton Water Plan currently under review. It is possible that as a result of this review, groundwater use in the Lockyer Valley will become subject to regulation, with users required to comply with volumetric entitlements that constrain usage at below current levels; and
  - growers source the remainder of their water from supplemented surface water resources, which have poor reliability and are not available to a significant proportion of growers;

- in terms of agricultural water use on the Darling Downs:
  - as in the Lockyer Valley, water for agricultural production on the Darling Downs is primarily sourced from groundwater resources, with supplementary supply accessed from surface water supplies;
  - there is considerable reliance on on-farm storage of water, which provides producers significant flexibility in managing water supplies;
  - in 2015-16, there were an estimated 706 agricultural businesses in the Darling Downs-Maranoa region with water use totalling 486,856 ML (noting that these figures will be greater than those for the region directly relevant for this demand assessment);
  - insufficient access to water supplies is a key constraint on the expansion of production for several crops on the Darling Downs. The significant on-farm storage capacity on the central Darling Downs, (estimated at around 300,000 ML in the Condamine Catchment upstream of Chinchilla), provides an indication as to the potential expansion of irrigation water use in the region; and
  - water use for intensive animal production is small relative to the volume of water used for irrigated crop production. The most significant source of potential demand for the NuWater project is likely to be feedlot operations.

5 Water market analysis

The prices at which water rights are traded in water markets can provide a useful guide as to the value of water in different regions (and users' capacity to pay). However, it is important to note that trading in Queensland's water markets remains relatively thin and thus the extent to which the prices at which water rights are traded can be used to draw conclusions in relation to the economic value of water is limited. This section summarises the water market trading data in the regions relevant to the NuWater project.

5.1 Lockyer Valley

As identified in section 4.1, there are two key WSS in the Lockyer Valley – the Central Lockyer Valley WSS, comprising of Lake Clarendon and the Bill Gunn Dam, and the Lower Lockyer Valley WSS, established following the construction of the Atkinson Dam. Trading in the Central Lockyer Valley WSS is currently limited to temporary allocations, whilst both temporary and permanent water trading is conducted in the Lower Lockyer Valley WSS, with DNRM managing and advising water users seeking to permanently trade water in the scheme.[37]

Table 7 summarises the permanent trading of supplemented surface water allocations in the Lower Lockyer Valley WSS over the past three financial years.

Table 7 Permanent trading of supplemented surface water allocations in the Lower Lockyer Valley

Year	Priority group	Number of transfers	Volume transferred (ML)	Weighted average price ($/ML)
2014-15	Medium	5	207	550
2015-16	Medium	11	518	403
2016-17	Medium	7	520	554

Source: Water Market Information – Permanent Water Trading Reports, Business Queensland (https://www.business.qld.gov.au/industries/mining-energy-water/water/water-markets/market-information)

The data in the above table shows that whilst the volume of permanent entitlements that has been traded has increased in the last two years, the volume of entitlements traded is still a small proportion of total water use in the WSS. The average price per ML is relatively low,[38] as is to be expected given the poor reliability of supplemented surface water allocations in the Lower Lockyer Valley WSS.

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[37] Whilst Seqwater plays a role in advising customers and facilitating temporary water trades in the scheme, it does not play a role in the trading of permanent water allocations.

[38] Prices have not been reported for several trades. This is potentially due to permanent transfers of water allocations being conducted between related parties or between two legal entities operating within the same agribusiness.

The volumes of temporary water trades in Central Lockyer Valley and Lower Lockyer Valley WSS from 2008/09 to 2015/16 are presented in Table 8. As previously stated, pricing data is not available for temporary water trades in Queensland.

Table 8 Temporary trading of water allocations, medium priority (ML)

Water Supply Scheme	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Central Lockyer Valley	0	6.14	0	0	15	0	30	55
Lower Lockyer Valley	63	396	23	82	202	131	393	325

Source: Network Service Plan — Central Lockyer Valley Scheme and Lower Lockyer Valley Scheme, Seqwater (http://www.seqwater.com.au/water-supply/irrigation)

The data presented in the above table shows that there is significantly more temporary trading activity in the Lower Lockyer Valley WSS, particularly in 2014/15 and 2015/16, noting that trading activity still represents a small proportion of total water use in the region.

5.2 Darling Downs

The two key WSS in the region relevant to the NuWater project are the Chinchilla Weir WSS and the Upper Condamine WSS, which contains Leslie Dam. Table 9 presents the data on permanent water trades for supplemented surface water allocations in the Chinchilla Weir WSS.

Table 9 Permanent trading of supplemented surface water allocations — Chinchilla Weir

Year	Priority group	Number of transfers	Volume transferred (ML)	Weighted average price ($/ML)
2011-12	Medium	2	278	-
2012-13	Medium	4	257	-
2013-14	Medium	1	20	1,300
2014-15	NA	-	-	-
2015-16	Medium	1	76	0
2016-17	Medium	2	76	1,000

Source: Water Market Information – Permanent Water Trading Reports, Business Queensland (https://www.business.qld.gov.au/industries/mining-energy-water/water/water-markets/market-information)

As shown by the data in the above table, trading activity in the Chinchilla Weir WSS is limited.

Table 10 presents the data on permanent water trades for supplemented and unsupplemented surface water allocations in the Upper Condamine WSS.

Table 10 Permanent trading of supplemented and unsupplemented surface water allocations — Upper Condamine WSS

	Priority group	Number of transfers	Volume transferred (ML)	Weighted average price ($/ML)
Supplemented surface water				
2012-13	Medium	7	1,094	904
	Risk-B	2	91	-
	Medium	5	220	1,866
2013-14	Risk-B	1	61	-
2014-15	Medium	4	2,681	1,059
2015-16	Medium	10	2,010	2,574
	Risk-A	6	1,680	-
	Risk-B	1	17	-
2016-17	Medium	6	463	3,378
	Risk-B	3	152	-
Unsupplemented surface water				
2013-14	CT2	1	24	313
2014-15	CG1	2	885	2,000
	CN2	2	3,375	-
	CT1	1	40	-
	CT2	3	60	2,099
	CT3	1	24	-
2015-16	CT2	1	24	292
	NB1	6	730	-
	CO1	1	165	261
	CH2	2	288	1,752
	CF2	1	10	-
	CH1	1	420	1,079
2016-17	CH1	3	1,725	1,650
	CH2	1	72	-
	CT2	1	24	1,250
	CI1	1	192	1,500
	CM2	1	150	-
	CG2	2	200	1,000
	CJ1	1	120	-
	CN2	1	95	2,200
	CG1	2	790	-

Source: Water Market Information – Permanent Water Trading Reports, Business Queensland (https://www.business.qld.gov.au/industries/mining-energy-water/water/water-markets/market-information)

The above table shows that water trading activity is far greater in the Upper Condamine WSS than the other WSS in the region relevant to the project. In 2015/16 and 2016/17, over 4,300 ML of supplemented surface water allocations and over 5,000 ML of unsupplemented surface water allocations were traded in the Upper Condamine WSS. In addition, the average price of some trades exceeded $3,000 per ML for supplemented allocations and $2,000 per ML for unsupplemented allocations. There is also significant trading activity in the temporary water market in the Upper Condamine WSS, as demonstrated in Table 11.

Table 11 Temporary trading of water allocations, medium priority (ML)

	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Chinchilla Weir	823	958	0	1158	640	1122	626	866
Upper Condamine	0	0	1,107	5,435	4,804	3,628	5,374	1,937

Source: SunWater Annual Reports (http://www.sunwater.com.au/about-sunwater/right-to-information/publication-scheme/annual-reports)

5.3 Conclusions

As stated above, the low level of trading activity in Queensland water markets limits the extent to which conclusions can be drawn in relation to the value of water allocations based on observed water trading data.

The key observations from the water trading data that is available for the WSS within the project area are:

- there is very limited trading activity in the Lockyer Valley, primarily due to the reliance of most water users on unsupplemented groundwater resources and the poor reliability of supplemented surface water allocations in the Lower Lockyer and Central Lockyer WSS; and
- both the volumes of permanent and temporary water entitlements being traded and the weighted average prices of traded permanent entitlements in the Upper Condamine WSS have increased in recent years, demonstrating the increasing value placed on water rights.

Despite the limited activity in water markets in the region, the price at which water allocations have been traded in recent years will impact on the price that growers will expect to pay for water rights from new water supply projects, such as the NuWater project.

6 Consultation with agricultural water users

This section summarises the engagement undertaken with agricultural water users (and representative bodies) and summarises the key findings and implications for the water demand assessment.

6.1 Engagement process

Initial discussions with peak industry groups and irrigator representatives, including:

- Central Downs Irrigators Limited
- Gowrie-Oakey Creek Irrigators
- Cotton Australia
- Lockyer Valley Growers
- AgForce.

The key findings and conclusions from this initial consultation were as follows:

- access to reliable water supply is crucial to the further expansion of agricultural production in the Lockyer Valley. There is a considerable amount of fallow and dryland land that could be used for higher value irrigated crop production should reliable water supply be made available;
- growers acknowledged that water to be made available from the project would be significantly more expensive than water that is currently used by growers. As such, water that is made available is likely to be used by growers that have established operations and on-farm water storage and irrigation infrastructure (as opposed to greenfields producers);
- whilst sufficient market demand may be a constraint on the production of some crops in the Lockyer Valley, there are sufficient opportunities available, both in domestic and export markets, for producers to diversify and expand production. Producers noted that they had recently rejected customer inquiries due to a lack of sufficient production (in part due to a lack of reliable water supply);
- growers in both the Lockyer Valley and on the Darling Downs acknowledged the interruptibility of the potential source of water supply however did not consider that this would materially affect demand for water or the economic value that could be derived from the use of the water. Growers noted that they currently operate using water supplies that are inherently unreliable and uncertain and also expressed the view that the considerable on-farm storage capacity to which growers

have access would provide a valuable resource in dealing with this interruptibility (particularly in relation to the Darling Downs);

- growers in both the Lockyer Valley and on the Darling Downs were strongly of the view that water availability is currently the key constraint on agricultural production in both regions. Growers expressed the view that water would be used for both increasing yields or protecting against yield losses on existing crops and also for expanding the area under irrigated crop production;
- on the Darling Downs, most growers expressed the view that water from the project would likely be used for the expansion of cotton production, however water would also be used for a range of other crops, including sorghum, chick peas, wheat and maize;[39]
- in the Lockyer Valley, growers expressed the view that water would be applied to a range of horticultural crops, likely to be determined by market factors on an ongoing basis;
- water quality requirements differed between producers in the two regions, with growers on the Darling Downs able to accept water of relatively low quality whilst growers in the Lockyer Valley required water quality levels to be sufficient for application to leafy vegetables (higher quality than water that can be used for production of cotton or fodder crops);
- producers in both regions noted requirements in relation to salinity levels, with growers on the Darling Downs able to accommodate slightly higher salinity levels compared to growers in the Lockyer Valley (1,000 parts per million compared to 600 parts per million);
- in terms of preferences regarding the nutrient content of water, growers on the Darling Downs expressed a strong interest in retaining as much of the nutrient content of the recycled wastewater as possible (particularly Phosphorus), whilst growers in the Lockyer Valley did not express a strong preference in relation to nutrient content and seemed more concerned with water quality levels;
- growers in both regions (in particular on the Darling Downs) considered there is significant unused on-farm storage capacity that could be used to take the water to be supplied from the project. Furthermore, growers require access to irrigation water all year, meaning the need to maintain constant supply is unlikely to cause major issues for growers in either region; and

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[39] Some growers also noted that additional water could be used to diversify into horticultural production (e.g. broccoli).

- increased water availability would open up significant opportunities for growers to access new marketing opportunities, particularly with export customers seeking strong commitments from growers for significant quantities of additional production. Securing access to a long-term 'reliable' water supply will provide growers with the confidence required to enter into these agreements.

6.2 Irrigator survey

A survey was provided to irrigators located in areas that could potentially be supplied with water from the NuWater project. The purpose of the survey was to identify those growers with an interest in accessing water from the project and to obtain information to inform the farm-level modelling to be undertaken both to inform the demand assessment and the financial-commercial and economic analysis of the project options. The areas investigated as part of the irrigator survey were as follows:

- details on current land use, crop production and land available for additional production;
- details on water supply, including current water resources, on-farm water storage capacity, recent purchases of water allocations, and details on current water use;
- details on the intended use of additional water, including for application to existing crops or new crops (and the crops on which additional water would be applied);
- requirements in relation to the level of reliability, timing of supply, water quality levels and preferences in relation to nutrient composition; and
- information on growers' willingness to pay for additional volumes of irrigation water and their level of demand at different price levels.

The survey template is attached to this report (see Attachment A). The sections below summarise the survey responses for both the Lockyer Valley and the Darling Downs.

6.2.1 Lockyer Valley survey responses

Only four survey responses were received from growers in the Lockyer Valley. The key findings from the survey responses were as follows:

- growers in the Lockyer Valley registered interest in receiving an additional 2,650 ML of water per annum;
- the primary use of additional volumes of water would be to increase the area of crop production;

- the main crops on which additional water would be applied include lettuce, cabbage, cauliflower and broccoli;
- the majority of growers expressed a strong preference for high quality water (i.e. A+ or PRW), given the stringent requirements of customers in relation to the quality of water that is applied to vegetables, which account for the majority of production in the region;
- the maximum salinity levels deemed acceptable by growers ranged from 300 to 1,200 parts per million. Growers were supportive of nutrient content being retained in the water, provided water quality levels could be maintained; and
- in relation to the potential interruptibility of supply, growers noted that the interruption of supply would necessitate a significant cut back in production. In addition, it was noted by one grower that the interruption of supply was likely to coincide with dry conditions in the region, which would be problematic for growers.

The survey included a question which asked growers to identify how their demand varied at different price points. The price levels provided ranged from $200 to $1,200 per ML per annum. The purpose of this question is to obtain an indication of the level of demand that would exist at different price points, given the significant cost associated with supplying water to growers, particularly those located on the Darling Downs.

Given the poor response to the survey in the region,[40] the responses to this question are not particularly useful in drawing any inferences about demand sensitivity across the Lockyer Valley. For example, one respondent indicated that even at a price of $1,200 per ML they would still demand 500ML, compared to 1,000ML at $200 per ML. However, another respondent's demand for additional water cut out at $400 per ML.

6.2.2 Darling Downs survey responses

A total of 34 survey responses were received from growers on the Darling Downs. The key findings were as follows:

- growers on the Darling Downs registered interest in receiving an additional 46,050 ML of water per annum;

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[40] Based on consultation with growers, the low response rate is attributed largely to the current review of the sustainable yield of groundwater aquifers in the Lockyer Valley and also confusion in relation to an alternative project proposal involving the construction of a pipeline from Wivenhoe Dam to water storages in the Lockyer Valley.

- additional water would be applied both to increase the area of production of key crops grown in the region in addition to water being applied to increase yields on existing cropped areas;
- the majority of survey respondents identified cotton as the main crop for which additional water would be used, with other crops including maize, sorghum, chickpeas and wheat;
- growers expressed flexibility with regards to the quality of water supplied by the project, however salinity was of concern, with most growers expressing a preference for maximum salinity rates of between 300 to 900 parts per million;
- most growers expressed a preference for nutrients being retained in the water that would be supplied by the project; and
- in relation to the potential interruptibility of supply, the majority of Darling Downs survey respondents stated that the interruptibility of supply would not impact on their demand, primarily due to the fact that their production systems are designed to deal with variable water supply (e.g. ability to vary irrigation application rates and store water in on-farm dams). However, several growers noted that the greater the potential for interruptions to supply, the lower the value of the water, and some growers, particularly those currently operating under dryland cropping systems, noted that interruptibility may impact on the viability of necessary infrastructure investments.

In terms of the sensitivity of demand to price, Table 12 shows the total demand in the region at each price point.

Table 12 Demand for additional water from Darling Downs growers at specified price points

Price ($/ML/year)	Total demand by respondents
Current water price/cost	46,050 ML
200	38,700 ML
400	18,400 ML
600	7,350 ML
800	2,750 ML
1000	1,100 ML
1200	300 ML

Source: Responses to irrigator survey.

As demonstrated in Table 12, demand falls away significantly at the $600 per ML level and above, with demand of less than 20 per cent of that registered at a price of $200 per ML.

6.3 Grower consultation days

Two open grower consultation days were held as part of the consultation process:

- in the Lockyer Valley, at the Lockyer Valley Cultural Centre in Gatton on 21 August 2017; and
- on the Darling Downs, at the Cecil Plans Hall in Cecil Plains and at Mary's Commercial Hotel in Dalby.

The purpose of the grower consultation days was to:

- assist growers with the completion of the grower questionnaire;
- discuss issues associated with the demand assessment and the feasibility study in general;
- identify key inputs and assumptions for the farm-level modelling to be undertaken as part of the demand assessment, including the cost of crop production (broken down into pre-harvest, irrigation, harvest and post-harvest growing costs), crop yields and revenues; and
- discuss the on-farm impacts of increased water availability, including increasing yields on existing crop production and underpinning the expansion of irrigated crop production.

The following sections contain summaries of the key findings from the open grower consultation days.

6.3.1 Lockyer Valley

The key findings from the Lockyer Valley grower consultation day were as follows:

- the consultation day was attended by around 15 growers, with a wide range of crops produced including broccoli, cauliflower, lettuce, lucerne, potatoes, onions, cabbages, shallots, sweet corn, carrots, green beans, pumpkins, etc.;
- all growers stated that additional water would be used to plant additional areas of crops, as areas are determined based on expectations in relation to future water availability (i.e. there is minimal scope to vary irrigation application rates for vegetable crops, hence growers will only plant an area if they are confident that they will have the water available to produce the crop);
- if additional water was to be made available, several growers stated that they would continue to produce on their current area of land, however would plant two crops

per year as opposed to the one crop per year they are currently producing (due to water constraints). This would increase asset utilisation of their existing on-farm irrigation infrastructure;

- growers noted that should their groundwater access be subject to a regulated allocation at some point in the future, demand for water from the project would increase significantly, as growers would require access to additional volumes of water simply to maintain their current levels of production;
- several growers considered vegetable production in the Lockyer Valley to be constrained by market demand, in particular from SEQ, however some growers expressed the view that there are significant export opportunities that could be accessed were growers to have the necessary level of certainty around access to sufficient water volumes (and hence levels of production);
- all growers have stringent requirements in relation to water quality levels, predominantly driven by customer preferences. Whilst growers had greater flexibility in terms of salinity, most growers expressed a preference for salinity levels at or below 600 parts per million; and
- there was significant variation in terms of growers' willingness to pay for water, with some growers of the view that water would need to be priced at a relatively low level (i.e. $100 per ML per annum) for there to be significant uptake in the Lockyer Valley whilst other growers stated they would have material demand at significantly higher prices (i.e. up to $1,000 per ML per annum).

6.3.2 Darling Downs

The key findings from the Darling Downs grower consultation day were as follows:

- the consultation day was attended by around 40 growers, with crops produced including cotton, lucerne, sorghum, maize, other fodder crops and small areas of vegetable crops, such as broccoli;
- the majority of growers were seeking additional water to increase their areas of crop production,[41] whilst some growers, in particular cotton growers, were seeking additional water to increase their crop yields;

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[41] This includes growers who were looking to expand production by planting additional crops on the same area of land (i.e. moving from producing one crop per year to two crops per year).

- growers communicated that the annual nature of crop production means that they typically plant crop areas based on their projected water availability (as opposed to maintaining the same area of crop and varying irrigation application rates);
- growers acknowledged the significant cost associated with developing the necessary water transport infrastructure and also the pumping costs associated with delivering recycled wastewater to the Darling Downs. Growers held differing views on the appropriate price of the recycled wastewater, with views ranging from $100 to $600 per ML per annum;
- growers noted that there is significant on-farm storage capacity on the Darling Downs and that the total volume of storage capacity far exceeds the water that is able to be harvested from overland flows or groundwater resources (i.e. there is spare capacity in on-farm storages on the Darling Downs to accommodate the water from the project);
- the majority of growers did not perceive market access to be a constraint on the expansion of agricultural production on the Darling Downs, noting the significant opportunities available in export markets that growers would be able to take advantage off with more certainty in terms of water availability and production levels. Some growers of broadacre fodder crops were of the view that increased production in the region would lead to a reduction in prices and hence on-farm returns;
- growers expressed differing views in terms of preferences in relation to the delivery of water to farms, with some growers, particularly those already harvesting water allocations from watercourses, expressing the view that the recycled wastewater should be delivered via existing watercourses to minimise delivery costs,[42] whilst other growers were of the view that water should be delivered to the farm gate via a reticulated distribution system. A proportion of growers noted that a mixed delivery system may be appropriate; and
- several growers noted the potential value associated with the retention of nutrients (i.e. nitrogen and in particular phosphorus) in the recycled wastewater. All growers were concerned with minimising salinity levels in the water. The majority of growers had relatively minimal concerns in relation to water quality levels.

6.4 Key findings

The key findings from the consultation undertaken with growers are as follows:

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[42] It is important to note that some growers were of the view that

- whilst little inference can be drawn from the survey responses in the Lockyer Valley, we have identified considerable potential demand on the Darling Downs;
- in terms of the intended use of water from the project by growers on the Darling Downs, the majority of water is expected to be applied to cotton crops, both existing and new crops, with water also to be applied to other broadacre crops produced in the region, including corn, sorghum, wheat and chickpeas. Survey responses were not sufficient to provide an indication as to the likely use of additional volumes of water by producers in the Lockyer Valley;
- consultation with growers in the Lockyer Valley confirmed that water would primarily be applied to increase the area of crop production in the region. However, survey responses from growers on the Darling Downs indicate that around 65 per cent of water would be applied to increase yields on existing cropped areas, with the remainder to be applied to expand the area under crop production;
- the poor response rate in the Lockyer Valley can be attributed, at least in part, to the uncertainly regarding the future regulatory arrangements for the use of groundwater resources in the region.[43] As noted in section 4.1.1, the sustainability of current groundwater use in the Lockyer Valley is currently under review, with the potential for future groundwater use to be subject to regulation. This has the potential to significantly alter the level of demand for water from the project in the Lockyer Valley;
- there are significant differences in terms of the water quality levels required by growers in the Lockyer Valley and on the Darling Downs. Whilst growers in the latter are flexible in terms of the quality of the water to be supplied by the project, growers in the Lockyer Valley have relatively stringent quality requirements;
- the majority of growers stated that the potential for water supply to be interrupted as a result of the WCRWS infrastructure being required for urban water supply would not impact on their demand, however several growers noted that supply interruptions would have a negative impact on on-farm returns and thus the value of the water rights (and hence the price that growers would be willing to pay for water from the project); and
- demand for water from growers on the Darling Downs is highly sensitive to price. In particular, the level of demand declines significantly at prices above $600 per ML.

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[43] Growers consulted with also communicated confusion in relation to an alternative project proposal involving the construction of a pipeline from Wivenhoe Dam to water storages in the Lockyer Valley.

7 Modelling the on-farm returns from irrigation water

This section sets out the results of the modelling of the on-farm returns from the use of additional irrigation water for irrigated crop production in the Lockyer Valley and on the Darling Downs, in addition to setting out the key modelling parameters and assumptions underpinning the analysis.

7.1 Crops modelled

Crops were included in the farm-level modelling exercise based on:

- a review of available information in relation to crop production and water use within the regions; and
- the outcomes of consultation with producers (including responses to grower questionnaires and discussions during grower consultation days).

This assessment was undertaken for both the Lockyer Valley and the Darling Downs regions. Based on the outcomes of this assessment, the on-farm returns were modelled for the following crops:

- for the Lockyer Valley:
    - lettuce
    - broccoli
    - onions
    - carrots
    - cabbages
    - cauliflowers[44]
- for the Darling Downs:
    - cotton
    - maize
    - sorghum
    - wheat
    - chickpeas.

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[44] On-farm returns were not modelled for potatoes (despite accounting for a significant proportion of total water use in the Lockyer Valley and being identified as a crop produced by several growers consulted with) due to the lack of information available in terms of the yield, irrigation application rate, revenues and costs of production of the crop in the region.

7.2 Data and information sources

The process for gathering data and information to be used in developing the farm-level crop models was as follows:

- review of available information on crop production and water use in the Lockyer Valley and on the Darling Downs and available gross margin analyses to obtain estimates on growing costs, crop yields, irrigation application rates, and crop prices;[45]
- consultation with growers, both through targeted consultation with key stakeholders, responses to the grower questionnaire, and one-on-one consultation with growers at the grower consultation day; and
- refinement of key inputs and assumptions through further consultation with key stakeholders.

7.3 Beneficial uses of irrigation water

There are two means by which growers derive value from the use of additional irrigation water – application to existing area under crop and the expansion of the area of production. These uses and the value that is derived are assessed in the following sections.

7.3.1 Application to existing cropped area

Additional irrigation water could be used to derive additional revenue from the production of existing irrigated crops. This could occur through either:

- increased yield or product quality by increasing irrigation application rates; or
- the avoidance of the loss of yield or product quality in 'dry' years when crops are exposed to 'moisture stress' (i.e. growers can maintain yield and product quality by applying additional volumes of irrigation water in dry years to maintain sufficient moisture levels).

Based on consultation with growers, it is considered unlikely that growers in the Lockyer Valley would apply additional water to existing cropped area. Vegetable crop producers in the Lockyer Valley stated that due to the stringent quality requirements for crops to be saleable, decisions on the area of crop to plant are made on a periodic basis taking into account future water availability. As such, growers vary their areas of crop

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[45] 'Agricultural Gross Margin Calculator'; Ag Margins (Queensland Government); See: http://agmargins.net.au/.

production based on their expected future water availability, rather than maintaining the same area of production and varying irrigation application rates. Hence, additional water supplied to growers in the Lockyer Valley would be applied to expand areas under crop production rather than increasing yields (or avoiding yield losses) on existing cropped area.

The different crops produced on the Darling Downs mean that growers are more likely to apply additional water to existing crops to increase yields. The nature of the production of broadacre crops such as cotton, maize, sorghum and wheat means that growers have greater capacity to increase yields by increasing irrigation application rates. As previously stated, of the 46,050 ML of demand identified on the Darling Downs, growers reported that around 65 per cent would be applied to increase yields on existing crops (including cotton, maize, sorghum, wheat and chickpeas).

The return derived from the use of additional water to increase yields on existing crops will vary based on a range of factors, including:

- current irrigation application rates;
- impact of farming practices on crop yield;
- volume of additional irrigation water to be applied per hectare;
- yield response to an increase in the irrigation application rate; and
- grower costs incurred (a high-cost grower will derive a lower return from applying additional water to increase yields on an existing cotton crop).

When considering the likely uses of water to be supplied from the project, it is important to take into account that the water from the project will be of significantly higher cost relative to water that is currently available to growers, both in the Lockyer Valley and on the Darling Downs. This may impact on the viability of the application of water for some uses, particularly the application of additional volumes to increase yields on existing crops.[46]

The table below provides a summary of the extent to which additional volumes of irrigation water would be applied to existing crops for each crop produced on the Darling Downs. The assessment was based on information obtained from growers, both from responses received to the grower survey and through discussions at the grower consultation day.

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[46] Noting that this will depend on the farm gate price received for the crop and also the yield response to an increase in the irrigation application rate.

Table 13 Likelihood of additional water being applied to existing cropped area on the Darling Downs

Crop	Likelihood of application to existing crops	Discussion
Cotton	High	Growers reported significant variation in terms of irrigation application rates for cotton, indicating that growers have substantial flexibility in terms of the volume of water that is applied to crops. A significant majority of growers on the Darling Downs who indicated that additional water would be applied to existing crops identified cotton as one of the crops to which additional water would be applied.
Maize	Medium	Several growers on the Darling Downs indicated additional water would be applied to existing maize crops. Survey respondents also varied significantly in terms of their current irrigation application rates for maize.
Chickpeas	Medium	Several Darling Downs growers indicated that additional water would be applied to existing chickpea crops. The relatively low volumes of irrigation water currently being applied to chickpea crops by the survey respondents indicates scope to increase yields by increasing irrigation application rates.
Sorghum	Low	Sorghum is commonly grown as a dryland crop throughout Queensland, including on the Darling Downs. A small proportion of Darling Downs survey respondents stated that additional water would be applied to existing sorghum crops.
Wheat	Medium	Several Darling Downs survey respondents indicated that additional water would be applied to existing wheat crops during the winter months. The relatively low volumes of irrigation water currently being applied to wheat crops by the survey respondents indicates scope to increase yields by increasing irrigation application rates.

Source: Based on survey responses and one-on-one consultation with growers.

7.3.2 Expansion of area under crop production

An increase in the volume of water available to growers will result in an increase in the area under crop production both in the Lockyer Valley and on the Darling Downs. Growers of a range of crops in both regions have communicated that water is the primary constraint on the expansion of crop production, with there being arable land currently under-utilised, including being utilised for a lower value purpose, in both regions.

However, it is important to note that there are a range of factors other than access to water that can constrain the expansion of crop production. These factors include:

- availability of suitable land;
- the fixed costs associated with the large-scale expansion of operations (e.g. machinery, on-farm water storages, land preparation, expansion of on-farm irrigation infrastructure); and
- market factors (i.e. the scope for producers to access sufficient demand to enable the expansion of production, either due to the lack of sufficient demand or issues with accessing the market).

Availability of suitable land

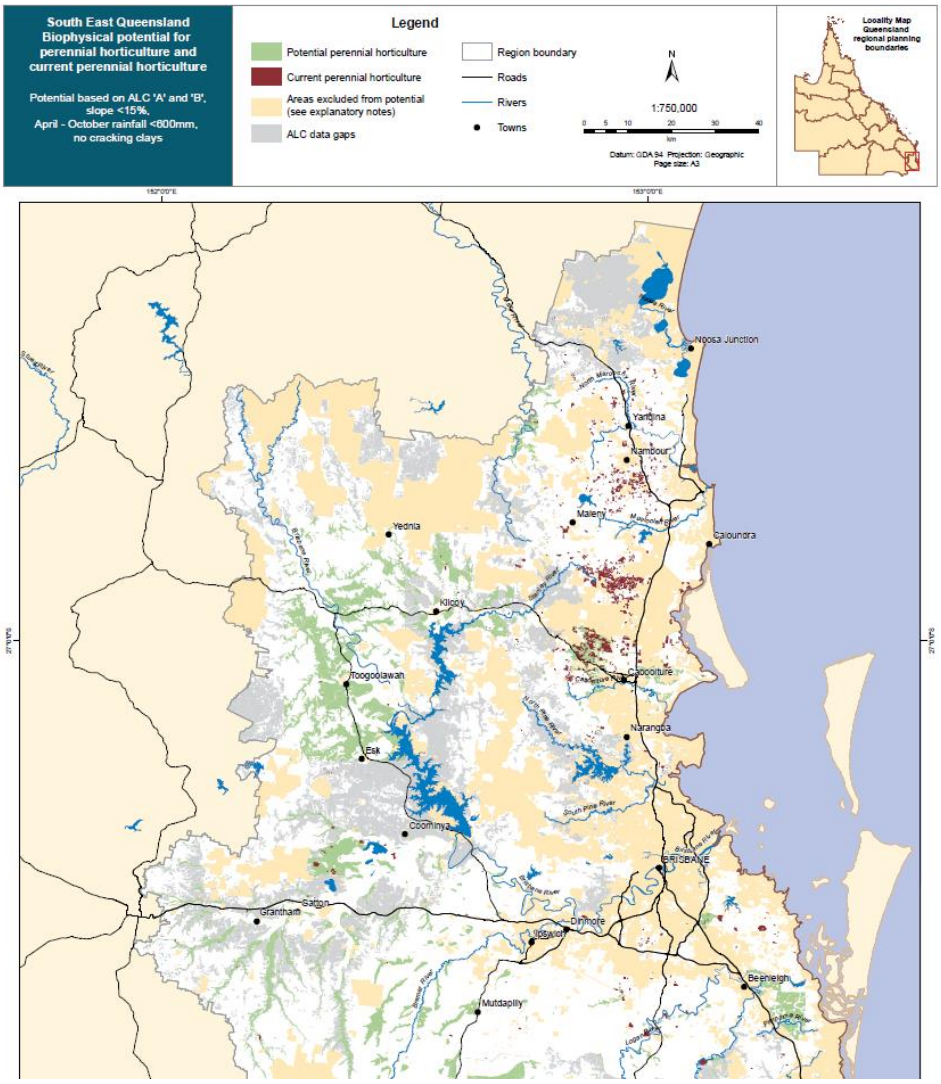
The Queensland Government periodically undertakes audits of agricultural land in different regions of Queensland. The purpose of these audits is to document current agricultural land uses and also to assess the potential for the expansion of agricultural production into new areas.

Throughout the grower consultation process, growers, particularly on the Darling Downs, expressed the view that water was a key constraint on the expansion of agricultural production. It is important to note that this view was almost universal across growers on the Darling Downs, whilst some growers in the Lockyer Valley were of the view that the most arable land was already being utilised and that additional available land was relatively marginal in terms of the potential for horticultural production. The following sections summarise the key findings from the most recent Queensland Agricultural Land Audit for the Lockyer Valley and Darling Downs regions.

Lockyer Valley

As discussed in section 3.1.1, the Lockyer Valley is currently under relatively intensive irrigated crop production, predominantly horticultural crops. Noting that some growers communicated throughout the consultation process that the most suitable land in the Lockyer Valley is already under irrigated crop production, the most recent Agricultural Land Audit indicates that there are still significant areas of land deemed suitable for intensive horticultural production that are not being used for this purpose (see figure below). This indicates that land is unlikely to be a constraint on the expansion of irrigated crop production in the Lockyer Valley (noting that it is likely that the most arable land is already under production).

Figure 5 Area of current and potential crop production in South East Queensland



Source: Queensland Agricultural Land Audit.

Darling Downs

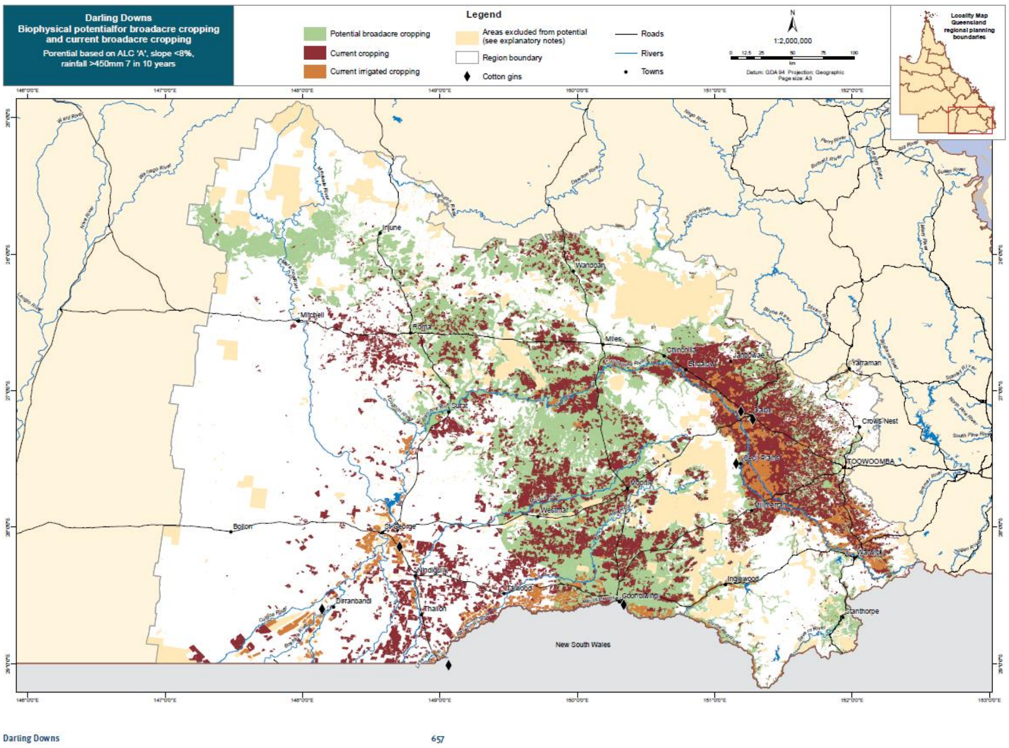
The outcomes of the audit for the Darling Downs region demonstrated that whilst broadacre cropping accounts for a significant proportion of total land use in the region, a significant proportion of ‘potential’ cropping land is currently used for grazing. The 2006 Queensland Land Use Mapping Program has previously identified that around 4.2 million hectares of land on the Darling Downs is suitable for broadacre crop production, with around 2.4 million hectares being used for this purpose.

The land audit also showed that whilst horticultural production currently accounts for a very small proportion of land use on the Darling Downs, there is significant potential for expansion, with large areas of land identified as suitable for horticultural production.

The land audit supports the views expressed by growers throughout the consultation process that crop production on the Darling Downs has been focused in areas where water supplies allow for land to be irrigated and that the ability to access water supplies for irrigation is a key constraint on the expansion of crop production.

Figure 6 shows the areas of land on the eastern Darling Downs that is suitable for broadacre crop production and the areas of land that are currently being used for irrigated and dryland crop production.

Figure 6 Area of current and potential broadacre cropping on the Darling Downs



Data source: Queensland Agricultural Land Audit.

The figure shows that a significant proportion of broadacre crop production in the region is dryland production. This indicates there is significant potential for growers to move to higher value irrigated crop production. There are also significant areas of land suitable for broadacre crop production that are currently being used for other, lower value purposes.

An increase in the value of crops produced using additional irrigation water could occur as a result of growers shifting from lower value to higher value crops. For example, a grower on the Darling Downs could move from growing dryland lucerne to irrigated cotton were they to have access to additional irrigation water. Whilst this would be modelled as an expansion in area of crop production, it would also be necessary to take into account the loss of value derived from the production of the lower value crop – it would only be the difference that would constitute the gain in value as a result of the application of irrigation water.

Market demand

Market demand factors are likely to be a constraint on increased agricultural production in the Lockyer Valley, according to several growers consulted. This is because SEQ consumers are the primary market for horticultural products from the Lockyer Valley. There were differing opinions from growers in terms of the potential for growers to access export markets. Some growers felt this was a significant opportunity for expansion that could be accessed with sufficient level and certainty of water supply, whilst other growers were of the view that Australian horticultural producers are too high cost to compete with other producers in global markets and, consequently, export markets were purely opportunistic and could not be relied upon.

For the Darling Downs, export markets make up a far larger proportion of total demand, particularly in relation to cotton and chickpeas. Therefore, market factors are far less likely to be a constraint on the expansion of production for growers in this region. However, some growers did note that market demand was a constraint on increased production for fodder crop production such as maize and sorghum.

Fixed costs of expansion

Due to the high cost of water that would be supplied by the NuWater project relative to the water resources currently available to growers in both the Lockyer Valley and on the Darling Downs, it is anticipated that the supply of water from the project would be limited to growers with existing operations. Thus, fixed costs such as machinery, equipment and infrastructure are unlikely to represent barriers to the uptake of water from the project, as growers would use water from the project for incremental expansion of their current operations.[47] This was confirmed through consultation with Darling Downs growers.

A small proportion of Darling Downs survey respondents are currently producing under dryland cropping systems and stated that they would move to irrigated systems were they able to secure access to water from the NuWater project (at an acceptable water price). For these growers, the fixed costs associated with moving to an irrigated

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[47] It is acknowledged that for some growers to use water from the NuWater project it may be necessary for growers to invest in additional on-farm water storages. This is to be considered in the economic analysis of the shortlisted options.

production system (e.g. irrigation infrastructure, pumping equipment, and on-farm storages and water delivery systems) are more likely to represent a barrier to the uptake of water from the project. The on-farm returns derived from water supplied by the NuWater project for these growers will be lower than the returns derived from growers with established irrigated cropping operations.

Overview of potential for expansion of crop production

In summary, for vegetable crop producers in the Lockyer Valley, market factors and water availability are considered to be the key constraints on the expansion of crop production. Whilst several growers acknowledged that the majority of the most arable land in the region was currently under crop production, the majority of growers consulted with considered there to be available land on which to expand. This view is supported by the outcomes of the most recent Agricultural Land Audit.

Growers' views on the extent to which market factors are a constraint on the expansion of production varied, with some growers expressing the view that there was limited scope for growth in most crops, both in domestic and export markets, whilst other growers considered there to be significant opportunities for expansion into export markets, particularly for crops such as cabbages and broccoli.

On the Darling Downs, there was strong consensus across the growers consulted with that water availability is the primary constraint on the expansion of crop production. Land availability was not considered to be a constraint (consistent with the most recent Agricultural Land Audit) whilst the extent to which market factors constrain the expansion of production were considered to vary across crops. For instance, for crops such as cotton and chickpeas which are primarily grown for export markets, market factors were not considered to be a significant constraint, whereas for crops such as sorghum and maize, market factors are more likely to constrain production.

Opportunity cost of expanding crop production

In estimating the on-farm return from the use of additional water to expand crop production, it is necessary to take into account the opportunity cost associated with the value derived from the current use of the land (i.e. value derived from the use of the land if the project does not proceed).[48]

Based on consultation with growers, it is understood that land that would be used for the expansion of crop production is either land that is currently either not used for crop

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[48] Failure to account for the on-farm return derived from the current use of land would result in the on-farm return from the use of water from the project being overstated.

production; is sitting fallow as part of the crop rotation; or is currently used for dryland production of lower value crops such as sorghum. The average gross margin derived from the use of land for dryland sorghum production is approximately $400 per hectare.[49] Based on the outcomes of the consultation with growers, it has been assumed that, on average, the opportunity cost of developing new land is approximately $200 per hectare (i.e. 50 per cent of the gross margin derived from dryland sorghum production).

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[49] AG Margins – Sorghum (Rainfed) Darling Downs 2016.

8 Modelling results

This section sets out the modelling results for each of the crops identified in the preceding section.

8.1 Lockyer Valley crops

The following sections assess the on-farm returns from the use of water from the NuWater project to expand production of horticultural crops in the Lockyer Valley. As noted in section 7.3.1, the limited flexibility available to horticultural producers in relation to the water required to produce crops of saleable quality makes it unlikely that material volumes of water would be applied to increase yields or product quality on existing crops (i.e. crops that would be planted in the absence of additional water being supplied to growers). This was confirmed through consultation with growers. As such, for horticultural crops produced in the Lockyer Valley, the modelling has focused on estimating the on-farm returns from the use of additional water to expand the areas of crop production.

8.1.1 Lettuce

Lettuce is the main vegetable crop produced in the Lockyer Valley. It has previously been estimated that the Lockyer Valley accounts for approximately 70 per cent of Queensland's lettuce production,[50] with the value of lettuce production from the region exceeding $30 million per annum.[51] In addition, the quantity of lettuce produced in the Lockyer Valley increased by around 28 per cent between 2000/01 and 2010/11.[52]

Whilst lettuce produced in the Lockyer Valley is primarily supplied into domestic markets, Australian lettuce growers are supplying customers in several export markets such as Singapore, China, Indonesia and South Korea, with further opportunities for expansion in the region, such as Malaysia.[53] However, acknowledging these opportunities, market access may constitute a constraint on the expansion of lettuce production in the Lockyer Valley. As noted in section 7.3.2, land availability is unlikely to represent a constraint on the expansion of lettuce production in the Lockyer Valley.

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[50] Australian Bureau of Statistics (2008).

[51] Australian Bureau of Statistics (2012).

[52] AEC (2013). Economic analysis and social impact assessment of the Lockyer Valley Recycled Water Scheme. Final Report.

[53] AusVeg market snapshots.

Table 14 sets out the key operating characteristics and costs of lettuce production in the Lockyer Valley. This is based on a review of available data and information obtained from consultation with lettuce growers.

Table 14 Parameters for lettuce production

Parameter	Measure	Estimate
Yield	cartons/hectare[a]	3,333
Irrigation application rate	ML/hectare	4.0
Revenue		
Price	$/carton	$16.39
Operating revenue	$/hectare	$54,614
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$8,604
Irrigation costs	$/hectare	$504
Harvesting and post-harvest costs	$/hectare	$30,923
Total variable growing costs	**$/hectare**	**$40,031**
Gross margin per hectare	**$/hectare**	**$14,583**
Gross margin per ML	**$/ML**	**$3,314**[b]

a Cartons have a capacity of 62L.

b This includes an allowance of 10% for water security requirements.

Source: Various.

Based on the parameters set out in the above table, the gross margin for each additional hectare of lettuce produced in the Lockyer Valley is estimated at $14,583. At an average irrigation application rate of 4 ML per hectare, this equates to an on-farm return of $3,314 per ML per annum.[54] Taking into account the opportunity cost of land to be used for the expansion of lettuce production results in an on-farm return of $3,223 per ML per annum.

8.1.2 Broccoli

Broccoli is one of the highest value agricultural commodities produced in the Lockyer Valley. The production of broccoli in the Lockyer Valley has expanded significantly in recent years. From 2000/01 to 2010/11, the quantity of broccoli produced in the region increased by 77 per cent from 5,390 tonnes to 9,529 tonnes.[55] Based on consultation with

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[54] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for growers' water security requirements (i.e. Return per ML has been calculated based on an irrigation application rate of 4.4 ML per hectare).

[55] AEC (2013). Economic analysis and social impact assessment of the Lockyer Valley Recycled Water Scheme. Final Report.

growers from the Lockyer Valley, this total has continued to increase in the following years.

As noted in the preceding section, market access is likely to be a constraint on the expansion of production for several horticultural crops produced in the Lockyer Valley, due to the significant proportion of total production that is supplied into domestic markets. However, the most recent *Australian Horticultural Update* reported increasing demand for broccoli in both domestic and export markets, with a positive outlook for broccoli prices.[56] Significant tonnages of broccoli are currently exported into Singapore, South Korea and Thailand, with opportunities for growth in Indonesia and Japan.[57]

The table below sets out the key operating characteristics and costs of broccoli production in the Lockyer Valley. Some producers on the Darling Downs are also producing small areas of broccoli crops. This is based on a review of available data and information obtained from consultation with broccoli growers.

Table 15 Parameters for broccoli production

Parameter	Measure	Estimate
Yield	cartons/hectare[a]	1,700
Irrigation application rate	ML/hectare	3.0
Revenue		
Price	$/carton	$21.08
Operating revenue	$/hectare	$35,842
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$8,218
Irrigation costs	$/hectare	$378
Harvesting and post-harvest costs	$/hectare	$23,299
Total variable growing costs	**$/hectare**	**$31,895**
Gross margin per hectare	**$/hectare**	**$3,947**
Gross margin per ML	**$/ML**	**$1,196[b]**

a Cartons contain an average of 8 kilograms.

b This includes an allowance of 10% for water security requirements.

Source: Various.

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[56] Australian Horticultural Update – August 2017.

[57] AusVeg market snapshots.

Based on the parameters in the above table, the gross margin for each additional hectare of broccoli is estimated at $3,947. Based on an average irrigation application rate of 3 ML per hectare, this equates to an on-farm return of $1,196 per ML.[58]

Taking into account the opportunity cost of land to be used for the expansion of broccoli production results in an on-farm return of $1,075 per ML.

8.1.3 Onions

In 2010/11, it was estimated that onion production in the Lockyer Valley totalled around 11,240 tonnes, a 19 per cent increase compared to 2000/01.[59] The region accounts for over 50 per cent of total onion production in Queensland.

Whilst produced primarily for supply into domestic markets, there is also evidence of potentially significant demand for onions in export markets,[60] with the ability of growers in the Lockyer Valley to plant onion crops from February through to June providing significant flexibility in terms of the varieties that are produced and marketing opportunities that are available to growers.[61] Onions produced in Australia are currently exported to Indonesia, Japan and the UAE, with opportunities to increase supply into Singapore.[62] As such, market access is not considered a significant constraint on the incremental expansion of onion production in the Lockyer Valley.

The table below sets out the key operating characteristics and costs of onion production in the Lockyer Valley. This is based on a review of available data and information obtained from consultation with onion growers.

Table 16 Parameters for onion production

Parameter	Measure	Estimate
Yield	20kg bag/hectare	2,000
Irrigation application rate	ML/hectare	5.0
Revenue		
Price	$/bag	$20.35
Operating revenue	$/hectare	$40,700

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[58] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for growers' water security requirements (i.e. Return per ML has been calculated based on an irrigation application rate of 3.3 ML per hectare).

[59] AEC (2013).

[60] See: 'How Lockyer veggies could feed two nations'; 24 February 2017; https://www.qt.com.au/news/lockyer-valley-veggie-harvest-has-capacity-to-feed/3147176/; Emma Clarke; DOA: 30 August 2017.

[61] https://www.daf.qld.gov.au/plants/fruit-and-vegetables/vegetables/onions

[62] AusVeg market snapshots.

Parameter	Measure	Estimate
Farm operating costs		
Pre-harvest costs (insert details)	\$/hectare	\$5,381
Irrigation costs	\$/hectare	\$711
Harvesting and post-harvest costs	\$/hectare	\$22,218
Total variable growing costs	**\$/hectare**	**\$28,310**
Gross margin per hectare	**\$/hectare**	**\$12,390**
Gross margin per ML	**\$/ML**	**\$2,253**[a]

a This includes an allowance of 10% for water security requirements.

Source: Various.

Based on the parameters in the above table, the gross margin for each additional hectare of onions produced in the Lockyer Valley is estimated at \$12,390. Based on an average irrigation application rate of 5 ML per hectare, this equates to an on-farm return of \$2,253 per ML per annum.[63]

Taking into account the opportunity cost of land to be used for the expansion of onion production results in an on-farm return of \$2,180 per ML per annum.

8.1.4 Carrots

Carrots are another major vegetable crop produced in the Lockyer Valley. Carrot production in the Lockyer and Fassifern Valleys has previously been estimated at around 30,590 tonnes per annum, the majority of total carrot production in Queensland.[64] As with most vegetable crops grown in the Lockyer Valley, carrots are primarily produced for domestic markets, however Australian producers export material tonnages of carrot into Singapore, Japan, Malaysia, South Korea, Thailand and the UAE.[65]

Table 17 sets out the key operating characteristics and costs of carrot production in the Lockyer Valley. This is based on a review of available data and information obtained from consultation with carrot growers.

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[63] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for growers' water security requirements (i.e. Return per ML has been calculated based on an irrigation application rate of 5.5 ML per hectare).

[64] https://www.daf.qld.gov.au/plants/fruit-and-vegetables/vegetables/vegetable-production-in-south-east-queensland

[65] AusVeg market snapshots.

Table 17 Parameters for carrot production

Parameter	Measure	Estimate
Yield – Grade 1	20kg Ctns/hectare	1,425
Yield – Grade 2	20kg Bags/hectare	475
Irrigation application rate	ML/hectare	4.0
Revenue		
Price - Grade 1	$/20kg Ctn	$17.87
Price - Grade 2	$/20kg Bag	$10.01
Operating revenue	$/hectare	$30,219
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$4,504
Irrigation costs	$/hectare	$504
Harvesting and post-harvest costs	$/hectare	$10,277
Total variable growing costs	**$/hectare**	**$15,285**
Gross margin per hectare	**$/hectare**	**$14,933**
Gross margin per ML	**$/ML**	**$3,394**[a]

a This includes an allowance of 10% for water security requirements.

Source: Various.

Based on the parameters in the above table, the gross margin for each additional hectare of carrots produced in the Lockyer Valley is estimated at $14,933. At an average irrigation application rate of 4 ML per hectare, this equates to an on-farm return of $3,394 per ML per annum.[66]

Taking into account the opportunity cost of land to be used for the expansion of carrot production results in an on-farm return of $3,303 per ML per annum.

8.1.5 Cabbage

The production of cabbages has grown significantly in the Lockyer Valley in recent years. It has previously been estimated that the region accounts for over 60 per cent of Queensland's total production of cabbages.[67] Several growers consulted with over the duration of the project produced cabbages and stated that additional water would be applied to expand cabbage production in the region. Several growers noted the significant export potential for cabbages. In particular, Singapore and Japan represent significant opportunities for increased cabbage exports.[68]

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[66] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for growers' water security requirements (i.e. Return per ML has been calculated based on an irrigation application rate of 4.4 ML per hectare).

[67] Australian Bureau of Statistics (2008).

[68] AusVeg market snapshots.

Table 18 sets out the key operating characteristics and costs of cabbage production in the Lockyer Valley. This is based on a review of available data and information obtained from consultation with cabbage growers.

Table 18 Parameters for cabbage production

Parameter	Measure	Estimate
Yield	No/hectare	26,000
Irrigation application rate	ML/hectare	4.0
Revenue		
Price	$/each	$1.40
Operating revenue	$/hectare	$36,400
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$6,013
Irrigation costs	$/hectare	$450
Harvesting and post-harvest costs	$/hectare	$23,797
Total variable growing costs	**$/hectare**	**$30,260**
Gross margin per hectare	**$/hectare**	**$6,140**
Gross margin per ML	**$/ML**	**$1,395**[a]

a This includes an allowance of 10% for water security requirements.

Source: Various.

Based on the parameters in the above table, the gross margin for each additional hectare of onions produced in the Lockyer Valley is estimated at $6,140. Based on an average irrigation application rate of 4 ML per hectare, this equates to an on-farm return of $1,395 per ML per annum.[69]

Taking into account the opportunity cost of land to be used for the expansion of cabbage production results in an on-farm return of $1,305 per ML.

8.1.6 Cauliflower

Similar to cabbages, cauliflower production in the Lockyer Valley has increased significantly in recent years. From 2000/01 to 2010/11, total production of cauliflower from the Lockyer Valley increased by almost 150 per cent, from around 5,430 tonnes to 13,455 tonnes per annum.[70] Several of the growers consulted with identified cauliflowers as a major production crop. In addition, growers considered there to be significant

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[69] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for growers' water security requirements (i.e. Return per ML has been calculated based on an irrigation application rate of 4.4 ML per hectare).

[70] AEC (2013). Economic analysis and social impact assessment of the Lockyer Valley Recycled Water Scheme. Final Report.

potential growth in the market for cauliflowers grown in the Lockyer Valley, including in export markets. According to AusVeg, there are opportunities to increase exports of cauliflower into Asian markets, in particular Singapore and Japan.[71]

Table 19 sets out the key operating characteristics and costs of cauliflower production in the Lockyer Valley. This is based on a review of available data and information obtained from consultation with cauliflower growers.

Table 19 Parameters for cauliflower production

Parameter	Measure	Estimate
Yield	Ctns/hectare	2,666
Irrigation application rate	ML/hectare	4.0
Revenue		
Price	$/Ctns	$26.67
Operating revenue	$/hectare	$71,096
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$8,561
Irrigation costs	$/hectare	$504
Harvesting and post-harvest costs	$/hectare	$36,942
Total variable growing costs	**$/hectare**	**$46,007**
Gross margin per hectare	**$/hectare**	**$25,089**
Gross margin per ML	**$/ML**	**$5,702**[a]

a This includes an allowance of 10% for water security requirements.

Source: Various.

Based on the parameters in the above table, the gross margin for each additional hectare of cauliflower produced in the Lockyer Valley is estimated at $25,089. At an average irrigation application rate of 4 ML per hectare, this equates to an on-farm return of $5,702 per ML per annum.[72]

Taking into account the opportunity cost of land to be used for the expansion of cauliflower production results in an on-farm return of $5,611 per ML.

8.1.7 Summary of returns in the Lockyer Valley

In summary, the on-farm returns from the use of water to expand crop production in the Lockyer Valley are as follows:

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[71] AusVeg.

[72] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for growers' water security requirements (i.e. Return per ML has been calculated based on an irrigation application rate of 4.4 ML per hectare).

- $3,223 per ML per annum for lettuce production
- $1,075 per ML per annum for broccoli production
- $2,180 per ML per annum for onion production
- $3,303 per ML per annum for carrot production
- $1,305 per ML per annum for cabbage production
- $5,611 per ML per annum for cauliflower production.

8.2 Darling Downs crops

The following sections assess the on-farm returns from the use of water from the NuWater project to expand production of broadacre crops on the Darling Downs. Unlike the vegetable crops grown in the Lockyer Valley, growers on the Darling Downs have the capacity to increase yields on crops by applying additional volumes of water. As a result, in accordance with the survey responses received from Darling Downs growers, the on-farm returns for broadacre crops produced on the Downs have been estimated based on both the application of additional water to existing crops to increase yields and the use of additional water to expand the area of crop production.

8.2.1 Cotton

Cotton is one of the most significant agricultural commodities produced on the Darling Downs. In 2010/11, the total value of cotton production in the region was estimated at $361.3 million, approximately 20 per cent of the total value of agricultural production on the Darling Downs. This accounts for around 47 per cent of total cotton production in Queensland.[73] Cotton is predominantly produced for major export markets and is produced under both irrigated and dryland cropping systems.

Almost 80 per cent of survey respondents from the Darling Downs identified cotton as one of the main crops that is currently produced. Irrigation application rates varied considerably across the respondents (from 1 ML to 6 ML per hectare), with an average rate of 3.4 ML per hectare. Respondents stated that additional water would be used both to increase yields on existing crops and to expand their area of cotton production.

At the grower consultation day, the majority of cotton growers expressed the view that there is significant potential for the expansion of cotton production on the Darling Downs, with significant opportunities for growth in several export markets. Growers

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[73] Australian Bureau of Statistics (2012).

also noted that the ability to guarantee supply into export markets is critical and that this can only be achieved with reliable access to additional water supplies. Growers that identified the expansion of the area of cotton production as an intended use of water from the project stated that increased cotton plantings could be either at the expense of other crops (e.g. dryland sorghum) or as a result of a reduction in the use of single or double skip row plantings.[74]

Table 20 sets out the key metrics for irrigated cotton production on the Darling Downs. These metrics are averages derived from publicly available gross margin data, survey responses received from cotton growers, and the outcomes of consultation at the grower consultation days.[75]

Table 20 Operating metrics, revenues and costs of irrigated cotton production on the Darling Downs

Parameter	Measure	Estimate
Yield – lint	Bales/hectare	10.5
Yield – seed	Tonnes/ha	3.6
Irrigation application rate[a]	ML/hectare	5.5
Revenue		
Price - Lint	$/bale	$500
Price _ Seed	$/tonne	$190
Operating revenue	$/hectare	$5,934
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$1,184
Irrigation costs	$/hectare	$424
Harvesting and post-harvest costs	$/hectare	$1,093
Total variable growing costs	**$/hectare**	**$2,698**
Gross margin per hectare	**$/hectare**	**$3,237**
Gross margin per ML	**$/ML**	**$535[b]**

a It is noted that the irrigation application rate in this table is significantly higher than the average irrigation application rate reported by survey respondents (3.4 ML per hectare). This is attributable to several respondents applying lower than optimal volumes of irrigation water due to constrained water supply.

b This includes an allowance of 10% for on-farm storage losses.

Note: Where available, growing costs provided by growers have been used in this analysis instead of those available in gross margin information published by DAF. DAF gross margins appear to consistently over estimate pre-harvest growing costs.

Source: Various.

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[74] Skip row planting is the practice of skipping rows, typically either every second or third row, to maximise yields, fibre quality or to reduce water usage.

[75] It is important to note that the metrics and estimates set out in the table are not intended to represent current farming and irrigation practices, but rather the production systems that would be applied by growers if additional water was to be made available from the NuWater project.

Application to established crops

Consultation was undertaken with cotton growers to determine the average yield response of cotton to increases in irrigation application rates (i.e. the magnitude of the increase in cotton yields and revenues as a result of a given increase in the irrigation rate). The outcomes of this consultation are as follows:

- the average irrigation application rate would increase by 2.0 ML per hectare, from 3.5 ML to 5.5 ML per hectare;
- average yields would increase from 7 bales per hectare to 10.5 bales per hectare as a result of the increased irrigation application rate; and
- gross margin per hectare would increase from $1,836 to $3,237. This represents an increase of 76 per cent as a result of a 57 per cent increase in the irrigation application rate.

Based on the above, the annual on-farm return from the use of additional water to increase yields on existing crops is estimated at $637 per ML.[76]

Expansion of crop production

The expansion of the area of cotton production was the most commonly identified intended use of additional water, both in the survey responses and at the grower consultation days. Over 90 per cent of cotton growers consulted with stated that additional water would be used to expand their area of cotton production (as stated above, this includes the use of additional land for cotton production or increasing the intensity of crop production on land currently under crop by moving from skip row cotton to solid cotton planting).

As noted above, neither market demand or land availability are likely to represent a constraint on the production of cotton on the Darling Downs. Australian cotton producers account for a small proportion of global cotton production (4.2 of 106.5 million bales).[77] In addition, all cotton growers consulted with expressed the view that total cotton production from the Darling Downs could increase significantly without adversely affecting grower returns.

The on-farm return from the use of water for the expansion of cotton production is determined based on parameter estimates set out in the above table. Based on these parameters, the on-farm return from the use of each additional ML of water to expand

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[76] This estimate has been calculated including an allowance of 10% for on-farm storage losses.

[77] https://apps.fas.usda.gov/psdonline/circulars/cotton.pdf

crop production is estimated at $3,237 per hectare and $535 per ML (based on an irrigation application rate of 5.5 ML per hectare).

Taking into account the opportunity cost of land to be used for the expansion of cotton production, this results in an additional on-farm return of $502 per ML.[78]

8.2.2 Maize

Maize is produced on the Darling Downs predominantly for use as a fodder crop for livestock feed (maize can also be used for corn ethanol, corn starch or syrup and for fresh consumption). Total production of maize on the Darling Downs was estimated at just under 100,000 tonnes in 2010/11, which represents almost 60 per cent of total production in Queensland.[79]

Around 45 per cent of survey respondents from the Darling Downs identified maize as one of their main crops. The average irrigation application rate for these growers is 3.1 ML per hectare. Respondents stated that additional water would be used both to increase yields on existing maize crops and also to expand the area of maize production.

Table 21 sets out the key metrics for irrigated maize production on the Darling Downs. These metrics are averages derived from publicly available gross margin data, survey responses received from maize growers, and the outcomes of consultation at the grower consultation days.[80]

Table 21 Operating metrics, revenues and costs of irrigated maize production on the Darling Downs

Parameter	Measure	Estimate
Yield	Tonnes/hectare	10.0
Irrigation application rate[a]	ML/hectare	4.3
Revenue		
Price	$/tonne	$300
Operating revenue	$/hectare	$3,000
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$583
Irrigation costs	$/hectare	$341
Harvesting and post-harvest costs	$/hectare	$311

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[78] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for on-farm storage losses (evaporation and seepage).

[79] Australian Bureau of Statistics (2012).

[80] It is important to note that the metrics and estimates set out in the table are not intended to represent current farming and irrigation practices, but rather the production systems that would be applied by growers if additional water was to be made available from the NuWater project.

Parameter	Measure	Estimate
Total variable growing costs	**$/hectare**	**$1,234**
Gross margin per hectare	**$/hectare**	**$1,766**
Gross margin per ML	**$/ML**	**$373**[b]

a It is noted that the irrigation application rate in this table is significantly higher than the average irrigation application rate reported by survey respondents (3.1 ML per hectare).This is attributable to several respondents applying lower than optimal volumes of irrigation water due to constrained water supply.

b This includes an allowance of 10% for on-farm storage losses.

Note: Where available, growing cost data provided by growers have been used in this analysis instead of those available in gross margin information published by DAF. DAF gross margins appear to consistently over estimate pre-harvest growing costs.

Source: Various.

Application to established crops

Application to increase yields on existing crops was the dominant use of additional water identified by maize growers, with around 80 per cent stating that water would be used for this purpose. Based on consultation with maize growers, the following parameters have been applied to estimate the on-farm return from the use of additional water to increase yields on existing maize crops:

- the average irrigation application rate would increase by 1.2 ML per hectare, from 3.1 ML to 4.3 ML per hectare;
- average yields would increase from 8 tonnes per hectare to 11 tonnes per hectare as a result of the increased irrigation application rate; and
- gross margin per hectare would increase from $1,219 to $1,766. This represents an increase of 45 per cent as a result of an increase of a 39 per cent increase in the irrigation application rate.

Based on the above, the annual on-farm return from the application of additional water to increase yields for existing maize crops is estimated at $416 per ML.[81]

Expansion of crop production

Around 67 per cent of maize growers indicated that they intended to apply additional water to expand production of maize crops. As with the other crops produced on the Darling Downs, the availability of suitable land is unlikely to constrain the expansion of maize production. However, market factors are likely to be a more significant constraint on the expansion of maize production than is the case for other broadacre crops, particularly those predominantly produced for export markets such as cotton and chickpeas.

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[81] This estimate has been calculated including an allowance of 10% for on-farm storage losses.

The on-farm return from the use of water to expand the area of maize production is determined based on the parameter estimates set out in the above table. Based on these parameters, the return from each additional ML of water used to expand maize production is estimated at $1,766 per hectare and $373 per ML (based on an irrigation application rate of 4.3 ML per hectare).

Taking into account the opportunity cost[82] of land to be used for the expansion of irrigated maize production results in an on-farm return of $331 per ML.[83]

8.2.3 Chickpeas

Chickpea production on the Darling Downs has increased significantly in recent years in response to strong increases in prices available in major export markets such as India. Pulse Australia, the peak industry body, has previously estimated that annual production of chickpeas on the Darling Downs has totalled 140,000 hectares in recent years, an increase of well over 200 per cent on previous production levels.[84]

Around 36 per cent of survey respondents on the Darling Downs identified chickpeas as one of their major crops. Current irrigation application rates were relatively low, with an average of 1.2 ML per hectare. Whilst chickpea growers identified both increased application to existing crops and the expansion of the area of chickpea production as intended uses of additional water, the former was the more commonly identified use.

Table 22 sets out the key metrics for irrigated chickpea production on the Darling Downs. These metrics are averages derived from publicly available gross margin data, survey responses received from chickpea growers, and the outcomes of consultation at the grower consultation days.[85]

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[82] As with cotton production, the opportunity cost has been calculated based on the returns derived from the production of dryland sorghum on the Darling Downs.

[83] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for on-farm storage losses (evaporation and seepage).

[84] 'Chickpea prices push huge crop on Darling Downs'; 11 July 2015; The Chronicle; See: https://www.thechronicle.com.au/news/chickpea-prices-push-huge-crop/2702079/; Amy Lyne; DOA: 30 August 2017.

[85] It is important to note that the metrics and estimates set out in the table are not intended to represent current farming and irrigation practices, but rather the production systems that would be applied by growers if additional water was to be made available from the NuWater project.

Table 22 Operating metrics, revenues and costs of irrigated chickpea production on the Darling Downs

Parameter	Measure	Estimate
Yield	Tonnes/hectare	3.0
Irrigation application rate[a]	ML/hectare	2.5
Revenue		
Price	$/tonne	$700
Operating revenue	$/hectare	$2,100
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$240
Irrigation costs	$/hectare	$198
Harvesting and post-harvest costs	$/hectare	$96
Total variable growing costs	**$/hectare**	**$534**
Gross margin per hectare	**$/hectare**	**$1,566**
Gross margin per ML	**$/ML**	**$569**[b]

a It is noted that the irrigation application rate in this table is significantly higher than the average irrigation application rate reported by survey respondents (1.2 ML per hectare). This is attributable to several respondents applying lower than optimal volumes of irrigation water due to constrained water supply.

b This includes an allowance of 10% for on-farm storage losses.

Note: Where available, growing cost data provided by growers have been used in this analysis instead of those available in gross margin information published by DAF. DAF gross margins appear to consistently over estimate pre-harvest growing costs.

Source: Various.

Application to established crops

Around 42 per cent of chickpea growers indicated that additional water would be used to increase yields on existing chickpea crops.[86] Based on consultation with chickpea growers, the following parameters have been applied to estimate the on-farm return from the use of additional water to increase yields on existing chickpea crops:

- the average irrigation application rate would increase by 0.8 ML per hectare, from 1.7 ML to 2.5 ML per hectare;
- average yields would increase from 1.9 tonnes per hectare to 3 tonnes per hectare as a result of the increased irrigation application rate; and
- gross margin per hectare would increase from $892 to $1,566. This represents an increase of 75 per cent as a result of an increase of a 47 per cent increase in the irrigation application rate.

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[86] In addition, around 10 per cent indicated they would increase their area of other legume crops, such as soy beans and mung beans.

Based on the above, the annual on-farm return from the application of additional water to increase yields for existing chickpea crops is estimated at $766 per ML.[87]

Expansion of crop production

Around 33 per cent of chickpea growers indicated they would use additional water to expand chickpea production. As with cotton, market demand and the availability of suitable land are unlikely to constrain the expansion of chickpea production on the Darling Downs. Production of the crop has increased significantly in recent years due to growing global demand and increasing export prices, with several growers indicating that demand and profitability is expected to increase in the future. The need to deliver significant tonnages of chickpeas to supply major customers in export markets means it is important that growers are able to guarantee a certain level of supply over a period of several years.

The on-farm return from the use of water to expand the area of chickpea production is determined based on the parameter estimates set out in the above table. Based on these parameters, the return from the expansion of chickpea production is estimated at $1,566 per hectare and $569 per ML (based on an irrigation application rate of 2.5 ML per hectare).[88]

Taking into account the opportunity cost of land to be used for the expansion of chickpea production results in an on-farm return of $497 per ML.

8.2.4 Sorghum

Sorghum is produced on the Darling Downs, which accounts for over 60 per cent of total sorghum production in Queensland, for use as a fodder crop for livestock production. In 2010/11, the region's production of sorghum was estimated at around 788,000 tonnes.[89]

Around 24 per cent of Darling Downs survey respondents identified sorghum as a major crop currently being produced. Current irrigation application rates provided by survey respondents for sorghum production were relatively low, averaging 1.3 ML per hectare. Whilst sorghum growers identified both increased application to existing crops and the

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[87] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for on-farm storage losses (evaporation and seepage).

[88] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for on-farm storage losses (evaporation and seepage).

[89] Australian Bureau of Statistics (2012).

expansion of the area under sorghum production as intended uses of additional water, the latter was the more commonly identified use.

Table 23 sets out the key characteristics for the production of irrigated sorghum on the Darling Downs. These estimates are averages derived from publicly available gross margin data, survey responses received from sorghum producers, and estimates provided at the grower consultation days.[90]

Table 23 Operating metrics, revenues and costs of irrigated sorghum production on the Darling Downs

Parameter	Measure	Estimate
Yield	Tonnes/hectare	9.0
Irrigation application rate[a]	ML/hectare	3.8
Revenue		
Price	$/tonne	$200
Operating revenue	$/hectare	$1,800
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$375
Irrigation costs	$/hectare	$216
Harvesting and post-harvest costs	$/hectare	$103
Total variable growing costs	**$/hectare**	**$780**
Gross margin per hectare	**$/hectare**	**$1,020**
Gross margin per ML	**$/ML**	**$268[b]**

a It is noted that the irrigation application rate in this table is significantly higher than the average irrigation application rate reported by survey respondents (1.3 ML per hectare). This is attributable to several respondents applying lower than optimal volumes of irrigation water due to constrained water supply.

b This includes an allowance of 10% for on-farm storage losses.

Note: Where available, growing cost data provided by growers have been used in this analysis instead of those available in gross margin information published by DAF. DAF gross margins appear to consistently over estimate pre-harvest growing costs.

Source: Various.

Application to established crops

Around 40 per cent of sorghum producers indicated that additional water would be applied to increase yields on existing sorghum crops. Based on consultation with growers, the following parameters have been applied to estimate the on-farm return from the use of additional water for this purpose:

- the average irrigation application rate would increase by 1.0 ML per hectare, from 2.8 ML to 3.8 ML per hectare;

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[90] It is important to note that the metrics and estimates set out in the table are not intended to represent current farming and irrigation practices, but rather the production systems that would be applied by growers if additional water was to be made available from the NuWater project.

- average yields would increase from 8 tonnes to 9 tonnes per hectare as a result of the increased irrigation application rate; and
- gross margin per hectare would increase from $1,020 to $910 tonnes per hectare. This represents an increase of 11 per cent as a result of an increase of 36 per cent in the irrigation application rate.

Based on the above, the annual on-farm return from the application of additional water to increase yields for existing sorghum crops is estimated at $100 per ML.[91]

Expansion of crop production

Around 75 per cent of sorghum producers indicated they intended to use additional water to expand their area of sorghum production. Whilst the availability of suitable land is unlikely to constrain an increase in sorghum production, the level of demand for additional sorghum production is likely to represent a constraint. This was confirmed through consultation with growers.

The on-farm return from the use of water to expand the area of sorghum production is determined based on the parameter estimates set out in the above table. Based on these parameters, the return from the expansion of sorghum production is estimated at $1,020 per hectare and $268 per ML (based on an irrigation application rate of 3.8 ML per hectare).[92]

Taking into account the opportunity cost of land used for the expansion of irrigated sorghum production results in an on-farm return of $196 per ML.

8.2.5 Wheat

Wheat is a major winter cereal crop produced on the Darling Downs. Total wheat production in the region was estimated at around 735,000 tonnes in 2010/11, accounting for approximately 50 per cent of total production in Queensland. The total value of wheat production on the Darling Downs was estimated at $182.5 million in 2010/11.[93] Several growers consulted with identified wheat as their dominant winter crop.

Whilst a significant proportion of the wheat produced on the Darling Downs is grown in dryland systems, a significant number of growers are also applying irrigation water

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[91] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for on-farm storage losses (evaporation and seepage).

[92] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for on-farm storage losses (evaporation and seepage).

[93] Australian Bureau of Statistics (2012).

to wheat crops. Around 20 per cent of survey respondents on the Darling Downs identified wheat as a major crop that is currently produced. Current irrigation application rates are relatively low, averaging 1.4 ML per hectare. The vast majority of wheat growers identified both the increased application to existing crops and expansion of the area of wheat production as intended uses of additional water.

Table 24 sets out the key metrics for irrigated wheat production on the Darling Downs. These metrics are averages derived from publicly available gross margin data, survey responses received from wheat growers, and the outcomes of consultation at the grower consultation days.[94]

Table 24 Operating metrics, revenues and costs of irrigated wheat production on the Darling Downs

Parameter	Measure	Estimate
Yield	Tonnes/hectare	6.0
Irrigation application rate[a]	ML/hectare	2.5
Revenue		
Price	$/tonne	$320
Operating revenue	$/hectare	$1,920
Farm operating costs		
Pre-harvest costs (insert details)	$/hectare	$193
Irrigation costs	$/hectare	$198
Harvesting and post-harvest costs	$/hectare	$96
Total variable growing costs	**$/hectare**	**$487**
Gross margin per hectare	**$/hectare**	**$1,433**
Gross margin per ML	**$/ML**	**$521**[b]

a It is noted that the irrigation application rate in this table is significantly higher than the average irrigation application rate reported by survey respondents (1.4 ML per hectare). This is attributable to several respondents applying lower than optimal volumes of irrigation water due to constrained water supply.

b This includes an allowance of 10% for on-farm storage losses.

Note: Where available, growing cost data provided by growers have been used in this analysis instead of those available in gross margin information published by DAF. DAF gross margins appear to consistently over estimate pre-harvest growing costs.

Source: Various.

Application to established crops

All of the survey respondents who identified wheat as a major crop stated that additional water would be used to increase yields on existing wheat crops. Based on consultation with wheat growers, the following parameters have been applied to estimate the on-farm return from the use of additional water for this purpose:

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[94] It is important to note that the metrics and estimates set out in the table are not intended to represent current farming and irrigation practices, but rather the production systems that would be applied by growers if additional water was to be made available from the NuWater project.

- the average irrigation application rate would increase by 1.1 ML per hectare, from 1.4 ML to 2.5 ML per hectare;
- average yields would increase from 3.75 tonnes per hectare to 6.0 tonnes per hectare as a result of the increased irrigation application rate; and
- gross margin per hectare would increase from $833 to $1,433. This represents an increase of 72 per cent as a result of an increase of 79 per cent increase in the irrigation application rate.

Based on the above, the annual on-farm return from the application of additional water to increase yields for existing wheat crops is estimated at $496 per ML.[95]

Expansion of crop production

All of the wheat growers consulted with indicated they would use additional water to expand their area of wheat production. Land availability and market access are not considered to be constraints on the expansion of wheat production on the Darling Downs, with strong demand in both domestic and export markets.[96]

The on-farm return from the use of water to expand the area of wheat production is determined based on the parameter estimates set out in the above table. Based on these parameters, the return from the expansion of wheat production is estimated at $1,433 per hectare and $521 per ML (based on an irrigation application rate of 2.5 ML per hectare).[97]

Taking into account the opportunity cost of land to be used for the expansion of irrigated wheat production results in an on-farm return of $448 per ML.

8.2.6 Summary of returns from water use on the Darling Downs

Table 25 summarises the on-farm returns estimated for each of the crops on which additional water would be applied on the Darling Downs.

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[95] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for on-farm storage losses (evaporation and seepage).

[96] 'Australian grain exports surge'; Queensland Country Life; 10 March 2017; See: http://www.queenslandcountrylife.com.au/story/4521361/record-large-grain-exports/; DOA: 12 October 2017.

[97] Noting that in calculating this estimate, an allowance of 10 per cent of the irrigation application rate has been included to account for on-farm storage losses (evaporation and seepage).

Table 25 Summary of on-farm returns for crop production on the Darling Downs

Crop	On-farm returns from application to existing crops	On-farm returns from expansion of cropping area
Cotton	$637 per ML	$502 per ML
Maize	$416 per ML	$331 per ML
Chickpeas	$766 per ML	$497 per ML
Sorghum	$100 per ML	$196 per ML
Wheat	$496 per ML	$448 per ML

Source: Synergies modelling.

9 Water demand for other uses

In addition to irrigated crop producers in the Lockyer Valley and on the Darling Downs, the following producers were also identified as potential sources of demand for the NuWater project:

- intensive animal producers in the region, including feedlot operators, chicken meat producers and processors, egg producers, pig producers, and dairy farmers; and
- CSG producers, to satisfy future 'make good' requirements.

This section sets out the outcomes of the assessment of these potential sources of water demand and their implications for the NuWater project.

9.1 Intensive animal producers

Consultation was undertaken with both peak body representatives of producers of intensive animal products (see section 6). The key findings from consultation with industry representatives and producers in the intensive animal production are set out in Table 26.

Table 26 Summary of outcomes of consultation with intensive animal producers

Sector	Summary of outcomes
Chicken meat producers and processors	• Access to a reliable water supply is a fundamental requirement for chicken production and chicken meat processing • Chicken meat processors and producers indicated that reliability of water supply was critical and thus at this stage it was not possible to include chicken meat processors or producers in the demand profile for the project.
Egg producers	• Egg producers primarily require water for drinking water for hens, with other uses including cleaning, cooling and potentially irrigation • Annual drinking water requirements are estimated at 75 litres per egg-laying hen. Based on an estimate of 3.7 million hens in the Darling Downs, this equates to an annual water requirement of around 275 ML per annum. • Reliability requirements prevent egg producers from being considered in the demand profile for the project at this stage.
Pig producers	• Water is primarily used for drinking water for pigs, in addition to stock water for wash down purposes. • Overall water requirements for pig producers are estimated at 75 L per sow per day (27,375 L per sow per annum). • There are also significant water requirements associated with feed requirements of pigs. • Reliability requirements prevent pig producers from being considered in the demand profile for the project at this stage.
Dairy farmers	• Around 20 dairy producers located in the Lockyer Valley, with more located on the Darling Downs • Typically, water is used for relatively low value purposes, being fodder crop production, with smaller volumes also used as stock water • Majority of dairy producers are currently paying between $30 and $50 per ML to access water in both regions – it is unlikely that producers would be able to pay prices exceeding $100 per ML

Sector	Summary of outcomes
	• Dairy producers are unlikely to have stringent water quality requirements, as water is primarily being used to grow fodder crops.
Feedlot operators	• Water is used for drinking water for cattle in addition to for stock purposes including feed processing, cleaning yards and equipment and washing down cattle • Total water requirements for feedlot operations are estimated at 24 ML per 1000 head of cattle. The majority of this water needs to be of sufficient quality to enable cattle to drink the water • Feedlot operators can either grow their own crops for silage (e.g. oats, barley, lucerne, corn or wheat) or purchase cattle feed from crop producers in the region • Stakeholder advised that feedlot developers were struggling to secure developmental approval in the region surrounding Toowoomba, partly due to issues in relation to water availability • Reliability requirements prevent feedlot operators from being included in the demand profile for the project at this stage.

Source: Davis, R. & Watts, P. (2016). Feedlot Design and Construction: 4. Water requirements; Australian Pork (2016). Fact Sheet: Water Supply to Pigs; 'Queensland pig industry'; Department of Agriculture and Fisheries; https://www.daf.qld.gov.au/animal-industries/pigs/about-the-industry/in-queensland; DOA: 11 October 2017;

In summary:

- noting the issues with reliability of supply, of the intensive animal sectors, feedlot operators are likely to represent the most significant potential source of demand for water from the project, both in terms of the total level of water use and strength of water demand. However, due to the issues with reliability of supply, feedlot operators have not been included in the demand profile for the project at this time;
- dairy farmers are unlikely to represent a potential source of demand for the NuWater project, primarily due to the low value uses of water by dairy farmers and also dairy farmers' relatively low willingness to pay for water; and
- whilst water is an important input for pig producers, egg producers, and chicken meat producers and processors, the volume of water required by producers in these industries in small relative to other water uses (including feedlot operators and irrigated crop producers).

It is recommended that as part of the next stage of the project assessment, further investigation be undertaken of the potential for water to be supplied to intensive animal producers, particularly feedlot operators on the Darling Downs (noting the need to gain greater clarity around the reliability of supply from the project over the long term).

9.2 'Make good' requirements for CSG producers

As discussed in section 4.2.2, the extraction of water from coal seams for CSG production on the Darling Downs can adversely impact on the groundwater resources used by agricultural producers. In accordance with the *Water Act 2000*, CSG producers can be required to 'make good' on these impacts, potentially by supplying an alternative water source to affected users.

Whilst the lack of certainty in terms of the volume and timing of CSG producers' requirements for 'make good' water means that this source of demand cannot be included in the demand profile for the project, it should be noted that were the project to proceed, water could be supplied to CSG producers to satisfy these requirements. Whether this demand materialises will be subject to the extent of CSG producers' 'make good' requirements and the alternative water supply options available to meet these requirements.

9.3 Implications for the NuWater project

Consultation with industry representatives and key stakeholders and a review of publicly available information indicates that, based on the current scope of the project, it is not possible to include intensive animal producers or CSG producers in the demand profile for the NuWater project. For intensive animal producers, this is largely attributable to the importance of reliability of water supply to the feasibility of operations, whilst for CSG producers, the key constraint is uncertainty in relation to the timing and magnitude of producers' 'make good' water requirements.

Noting this, it is recommended that as part of the Detailed Business Case, further investigation be undertaken of the potential for water to be supplied to intensive animal producers, particularly in relation to feedlot operators on the Darling Downs. Whilst CSG producers may become a source of demand in the future, it is not appropriate for these producers to be included in the demand profile for the project, given the uncertainty regarding the timing and volume of CSG producers' 'make good' requirements.

10 Key findings and implications

This section presents the key findings from the water demand assessment and the implications for the feasibility study.

10.1 Crop production

10.1.1 Lockyer Valley

There is significant uncertainty in relation to the future water supply arrangements for agricultural production in the Lockyer Valley. As discussed in section 4.1.1, the future availability of groundwater resources in the Lockyer Valley, which accounts for over 70 per cent of total water use for horticultural production in the region, is highly uncertain.

Demand for water from the NuWater project in the Lockyer Valley is likely to be sensitive to the future management of the groundwater resources in the region. The two potential scenarios are:

- management arrangements remain unchanged, with groundwater use not subject to regulation and groundwater use remaining unmonitored; or
- the revision of the Moreton Water Plan results in volumetric water entitlements being implemented for the Lockyer Valley, placing limitations on the volumes of water that growers are able to extract from groundwater aquifers.

Under the first of the above scenarios, based on consultation with growers in the Lockyer Valley, demand for additional water from the NuWater project would be relatively marginal relative to current water use in the region. Several growers consulted with indicated they were satisfied with their current access to water resources and would only seek water from the project in the event that constraints were placed on their ability to access groundwater.

Whilst the poor survey response rate in the Lockyer Valley (only four survey responses were received with total demand of 2,650 ML identified) makes it difficult to draw conclusions in relation to the quantum of future demand for water relevant to the NuWater project, it is considered that a reasonable range for demand for additional water for the Lockyer Valley under the scenario in which access to groundwater resources remains unchanged is 5,000 to 10,000 ML per annum. Based on estimates of total water use for agricultural production in the Lockyer Valley of around 60,000 ML per annum, this would represent an increase in water use (and hence agricultural production) of between 8 and 17 per cent.[98]

Under the second of the scenarios outlined above (i.e. groundwater use becoming regulated and subject to volumetric allocations), there is likely to be significantly higher demand for water from the project, as growers will require additional water in order to maintain current production levels (i.e. 'replacement water'). This was confirmed through consultation with growers from the Lockyer Valley. Based on this consultation, demand under this scenario is estimated at between 20,000 ML and 30,000 ML per annum (up to 50 per cent of current water use).

Due to the limited responses to the irrigator surveys, it is necessary to rely on the modelling results generated in terms of the on-farm returns derived from the production of key vegetable crops in the Lockyer Valley to identify the crops for which additional water is likely to be applied (and the economic value that will be generated from this production). Noting that were additional water to be supplied to growers the water would be applied to a wide variety of crops (including niche crops),[99] based on the results of the modelling undertaken, it is considered that the on-farm returns derived from the production of broccoli, lettuce, onions, carrots, cabbage and cauliflower are representative of the types of crops to which additional water would be applied.

The average on-farm return from the use of water to expand production of the above costs is $2,783 per ML per annum (see section 8.1). This estimate represents the basis on which the return to be derived from the use of water for irrigated crop production in the Lockyer Valley is to be assessed in the economic analysis.

10.1.2 Darling Downs

The stronger response rate to the irrigator survey from growers on the Darling Downs (34 responses identifying total demand of over 46,000 ML) and more extensive one-on-one consultation with Darling Downs growers provides a clearer picture of the demand for additional water from growers in this region and the most probable uses of the water.

As set out in section 8.2, the key crops to which additional water would be applied by Darling Downs growers are cotton, maize, chickpeas, sorghum and wheat. Of these crops, sorghum has been excluded from the demand profile for the NuWater project,

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[98] It should be noted that growers expressed differing views throughout the consultation process in relation to the scope for horticultural production in the Lockyer Valley to increase significantly. Some growers expressed the view that market constraints would constrain the expansion of most crops whilst other growers considered there to be significant opportunity for expansion, particularly in export markets.

[99] During consultation, growers stated that they would be responsive to market forces in deciding which crops on which to apply additional water.

due to the lower on-farm returns derived from the production of this crop relative to competing crops, in particular cotton. Given these results, and the high cost of water from the NuWater project relative to water that is currently available to Darling Downs growers, it was considered appropriate to exclude sorghum production from the demand profile.

Table 27 sets out, based on the survey responses and the estimated on-farm returns for each crop and use, the proportion of demand for additional water for crop production on the Darling Downs accounted for by each crop and intended use. The table also sets out the subsequent volume of water use attributable to each crop and use, based on a total demand of 46,050 ML per annum.

Table 27 Breakdown of water use for crop production on the Darling Downs

Crop	Water use on existing crops		Water use for expansion of crop area	
	% of total demand	ML	% of total demand	ML
Cotton	47.4	21,828	22.3	10,269
Maize	6.4	2,947	4.3	1,980
Chickpeas	3.6	1,658	6.7	3,085
Wheat	7.1	3,270	2.4	1,105

Source: Based on survey responses from Darling Downs growers and results of modelling of on-farm returns from water use.

The above table shows that growers on the Darling Downs would seek to apply the majority (around 70 per cent) of the water to be supplied from the NuWater project to either increase yields on existing cotton crops or to expand the area under cotton production. Whilst it is noted that this is not consistent with the constant delivery of water to growers all year round (as will be the case for the NuWater project), it is considered that the ability of the majority of growers on the Darling Downs to store significant volumes of water in on-farm storages will enable higher volumes to be applied during peak growing periods, with lesser volumes applied to winter crops such as wheat and chickpeas.[100]

It is also important to note that this demand assessment has been conducted at a relatively preliminary stage of the feasibility assessment for the NuWater project. Given the scale of broadacre crop production on the Darling Downs and the estimates generated for the on-farm returns from the use of additional water for crop production in the region, it is anticipated that actual demand for additional irrigation water would be significantly greater than the 46,050 ML identified in the survey responses.

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[100] It should also be noted that in estimating the on-farm returns from the use of additional water by growers on the Darling Downs, an additional 10 per cent has been added to the irrigation water required to account for on-farm storage losses (i.e. evaporation and seepage).

It is recommended that as part of the Detailed Business Case for the project, a more formal Expression of Interest (EOI) process be undertaken whereby growers are provided with a more detailed prospectus for the project. This would also provide an opportunity to seek commitments from growers in relation to the volume of water they would seek access to and the price growers would be willing to pay for the water.

10.2 Intensive animal production

Consultation was undertaken with industry representatives to understand the potential demand for water from intensive animal producers. The sectors considered in this assessment were chicken meat producers and processors; egg producers; pig producers; dairy farmers; and feedlot operators. Whilst the uncertainty over the reliability of supply from the project prevented intensive animal producers from being included in the demand profile for the project, it is important to note that water availability is considered a constraint on the expansion of these activities in the region, particularly in relation to chicken meat producers and processors and feedlot operators.

On this basis, it is recommended that further investigations be undertaken as part of the development of the Detailed Business Case for the project once further clarity has been obtained in terms of the future reliability of supply. Based on the consultation undertaken, feedlot operators on the Darling Downs are considered the most likely source of demand from the intensive animal production industry.

10.3 Industrial water demand

In relation to industrial water demand, the ‘make good’ water requirements of CSG producers was identified as the most likely source of demand. Due to the nature of these ‘make good’ requirements, in particular the uncertainty with regards to the timing and magnitude of the ‘make good’ requirements, this potential source of demand has not been included in the demand profile for the project. However, it is noted that there is scope for water to be supplied to CSG producers to meet these ‘make good’ requirements in the future.

10.4 Overall demand and findings

Based on responses to the irrigator survey and consultation with growers both in the Lockyer Valley and on the Darling Downs, the following demand has been identified for crop production for the NuWater project:

- for the Darling Downs, survey respondents identified total demand of 46,050 ML. Given the preliminary stage of this feasibility study, the relatively small proportion of growers on the central Darling Downs that responded to the irrigator survey, and the results of the crop modelling, it is concluded that actual demand on the Darling Downs is significantly greater than 46,050 ML; and

- for the Lockyer Valley, limited conclusions can be drawn from the survey responses from growers. However, based on a review of available documentation on water use in the region, consultation with growers and the results of the crop modelling, the following demand scenarios have been defined:
  - 7,500 ML per annum under the continuation of current groundwater management arrangements; and
  - 25,000 ML per annum under the scenario in which groundwater resources become regulated and subject to volumetric allocations.

The shortlisted options that have been identified for the NuWater project involve total water supply of up to 84,680 ML of per annum. Based on the outcomes of the demand assessment, the expected breakdown of water demand under these shortlisted options is set out in Table 28.

Table 28 Overview of demand for crop production from the NuWater project

Scenario	Lockyer Valley water demand	Darling Downs water demand
Maintenance of existing groundwater management arrangements in the Lockyer Valley	7,500 ML per annum for the expansion of crop production, with the crop mix to be determined by changing market factors.	77,180 ML per annum for broadacre crop production (primarily cotton) on the Darling Downs, including increasing yields on existing crops and new crop production. It is expected that the proportions in Table 27 would be broadly reflective of the breakdown of demand.
Groundwater resources in the Lockyer Valley to be subject to regulation and volumetric entitlements	25,000 ML per annum for crop production in the Lockyer Valley, including the expansion of production and potentially maintaining pre-existing levels of production. It is expected that water would be applied to a range of crops, with the mix to be determined by changing market factors.	59,680 ML per annum for broadacre crop production (primarily cotton) on the Darling Downs, including increasing yields on existing crops and new crop production. It is expected that the proportions in Table 27 would be broadly reflective of the breakdown of demand.

Note: Where a shortlisted option involves less than 84,680 ML of water being made available, Darling Downs demand will be lowered in accordance with the level of total water supply.

Source: Based on the outcomes of the demand assessment and crop modelling results.

In terms of intensive animal production, it is not possible to attribute demand to producers. However, there is the potential that should the project progress to the next stage of investigation, continued consultation with intensive animal producers may reveal demand from some producers. Based on discussions to date, the most likely sources of demand from intensive animal producers are likely to be chicken meat producers and processors and feedlot operators.

In terms of industrial demand, the only potential industrial water user identified as a potential customer for the NuWater project were CSG producers on the Darling Downs. Whilst there is the potential for water to be supplied to CSG producers to meet their ‘make good’ requirements, the uncertainty over the timing and magnitude of these requirements means that CSG producers have not been included in the demand profile for the project.

A Grower questionnaire

Preamble

Queensland Farmers' Federation (QFF) has recently secured funding under the National Water Infrastructure Development Fund (NWIDF) to undertake a feasibility study into utilising recycled water from south-east Queensland sources to improve water supply for irrigated agriculture and related activities in the region.

The Western Corridor Recycled Water Scheme and associated treatment plants have the capacity to deliver a considerable quantity of water to both boost existing production and unlock potential agricultural enterprises in the Lockyer Valley, Darling Downs and adjacent areas.

There are considerable capital and operating costs associated with delivering recycled water to the region. As such, it is anticipated that the cost of delivering this water to farms in the study area will be substantially higher than the current cost of accessing water and this should be considered when responding to the following questionnaire. The ultimate level of charging that will apply to this new water supply is to be investigated as part of this feasibility study.

Having regard to the above, you are requested to respond to the following questionnaire only if you consider there is a reasonable likelihood that you would consider purchasing some of this recycled water were it to become available in your area.

QUESTIONNAIRE

Property details

Property Owner/manager: __________________________________

Property Address: __________________________________

Land Availability

Total area of property: _________ ha

Total area suitable for cropping: _________ ha

Total area suitable for irrigation: _________ ha

Land Use

Current (average of last 2 or 3 years) Land Use

Irrigated cropping:

Crop 1 _________________ Area[1]: _________ha

Crop 2 _________________ Area[1]: _________ha

Crop 3 _________________ Area[1]: _________ha

Crop 4 _________________ Area[1]: _________ha

Crop 5 _________________ Area[1]: _________ha

1. Note:- these areas are total areas and include any multiple cropping on the same block.

Water supply

Current water resources

Groundwater nominal allocation: _______ Ml, licence conditions, etc

Groundwater announced allocation: _______ Ml, percent current period

Supplemented nominal allocation: _______ Ml

Supplemented announced allocation: _______ Ml, percent current period

Unsupplemented allocation: _______ Ml, harvesting conditions, etc

On-farm water storage capacity

Total farm Dam Capacity: _______ ML, ha, m^3, etc (*please specify*)

Pumping capacity into farm dams: _______ Ml/hr, m^3/hr (*please specify*)

Recent water purchases

Have you purchased any temporary or permanent water allocations over the past three years? If so, please specify the volumes purchased and prices at which the trades were made.

____

____

____

____

____

Water Use and irrigation method

Water use on crops referred to in section 1.3.1 (ave. of last 2 or 3 years)

Crop 1 ________Ml Applic. rate: _________ Ml/ha Method:__________

Crop 2 ________Ml Applic. rate: _________ Ml/ ha Method:__________

Crop 3 ________Ml Applic. rate: _________ Ml/ ha Method:__________

Crop 4 ________Ml Applic. rate: _________ Ml/ ha Method:__________

Crop 5 ________Ml Applic. rate: _________ Ml/ ha Method:__________

(CP – Centre Pivot. HS – hand shift. LM – Lateral Move. DRIP. SI - Surface Irrigation. O – Other)

Estimated total water use: _____________ Ml/annum

Future water supply, demand and Use

Future Water Supplies

Are you planning to undertake any alteration on your property that will materially change (increase or decrease) the quantity of water available to you for irrigation purposes (e.g. purchase land with available water resources, undertake on-farm activities to reduce water losses, etc)? If so, could you please provide details of that alteration and the quantity of water involved.

YES/NO

____

____

____

____

____

Future Water Use

Are you planning to undertake any alteration on your property that will materially change (increase or decrease) the quantity of water you use for irrigation purposes (e.g. changes in cropping mix, installation of new irrigation infrastructure)? If so, could you please provide details of that alteration and the quantity of water involved.

YES/NO

____

____

____

____

____

Demand for recycled Water

If recycled water was to be made available at a cost comparable to your current cost of accessing irrigation water, would you be prepared to nominate a quantity of water which you would like to purchase in the future?

YES/NO

If yes, please provide an indication as to the quantity of water you would require (assume water would be equivalent reliability as a High Priority allocation).

___________ Ml

Use of recycled water

If possible, please provide an indication of the breakdown between water that would be applied to existing cropped areas (i.e. to increase yield or to reduce potential yield or quality losses in below average rainfall years) and water that would be used to expand the area of crop production.

For use on existing cropped areas: ___________ %

For use on new cropping areas: ___________ %

Application to existing crops

Where water is to be applied to existing cropping areas, please provide an indication as to how much total water you would now apply and the revenue you would expect to derive from the increased application to the targeted crops.

Crop ___________________

Application Rate __________ Ml/ha

Additional revenue from this crop __________ %

Crop ___________________

Application Rate __________ Ml/ha

Additional revenue from this crop __________ %

Crop ___________________

Application Rate __________ Ml/ha

Additional revenue from this crop __________ %

Expansion of cropping area

For water that is to be used to expand your area of crop production, please identify the crops on which you would focus and provide an indication of the area of additional planting and water application rate.

Crop 1 ___________________

Area irrigated: _________ ha

Application Rate: _________ Ml/ha

Crop 2 ___________________

Area irrigated: _________ ha

Application Rate: _________ Ml/ha

Crop 3 ___________________

Area irrigated: _________ ha

Application Rate: _________ Ml/ha

Level of reliability and timing requirements

The primary purpose of the Western Corridor Recycled Water Scheme is to supplement drinking water supplies in Wivenhoe Dam in the event the dam storage falls below a certain level. It should be noted that in the event of Wivenhoe Dam falling to below this level, recycled wastewater from the Scheme would need to be diverted for indirect potable reuse (i.e. the water would no longer be available for irrigation use). This could result in recycled water becoming unavailable for irrigation use for several years. The timing of this interruption will depend primarily on climatic conditions and also alternative supply arrangements. This aspect, and the likelihood of an interruption to supply occurring over certain timeframes, is to be explored with Seqwater and Queensland Urban Utilities as part of this study.

Does the potential for future supply interruption alter your demand for water from the project? If so, please describe the impact.

____

____

____

____

Timing of Supply

Could you please detail any specific requirements in relation to the time at which the project would need to supply water to your farm (i.e. do supply requirements vary throughout the year and if so by what magnitude)?

____

____

____

____

____

Water quality and nutrient composition

In terms of water quality, the eventual composition and purity of the water is yet to be determined, however we consider that it will be of a standard adequate for most agricultural applications.

Please specify the maximum level of salinity at which you would be able to apply water to your crops _______________ (***please specify unit of measurement***)

Please provide details of any specific requirements you have in terms of water quality.

____

____

____

____

Please specify any preferences regarding the nutrient content of the recycled water supply (i.e. Nitrogen and Phosphorus).

____

____

____

Willingness to pay for water

As stated previously, the capital and operating costs of delivering recycled water to the region will be considerable. As such, the prices that will be charged for this water will be higher than those currently charged for locally sourced water. The following requires you to specify how your demand for recycled water alters over a range of specified prices. The prices used in this comparison are annual charges per megalitre that cover both the up-front capital and ongoing costs of operating and maintaining the infrastructure and delivering the water.

Total charge ($/ML/yr)	**Estimated Demand (ML per annum)**
Current Water price	_______ Ml (see sect. 1.6.3)
200	_______ Ml
400	_______ Ml
600	_______ Ml

800	_______ Ml
1000	_______ Ml
1200	_______ Ml

Appendix D – Long List Options Review

QFF NuWater Project Feasibility Study

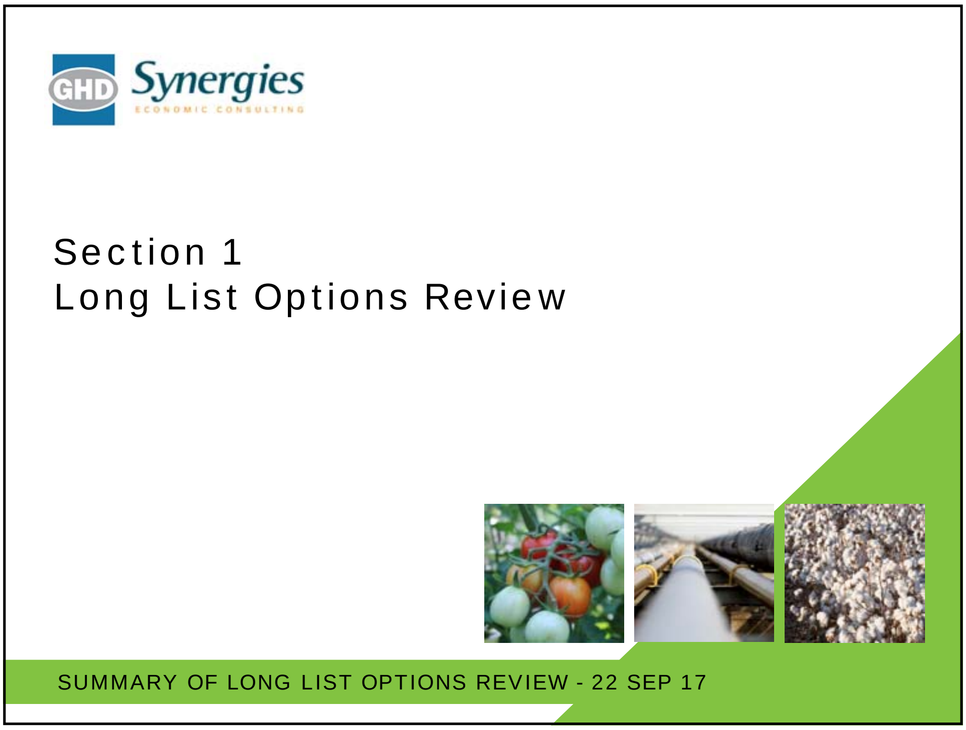
SUMMARY OF LONG LIST OPTIONS REVIEW - 22 SEP 17

Long List Options Review – Contents

This summary document aims to provide an overview of the process to determine the short list of options from the long list of options identified in the Options Identification Workshop Report.

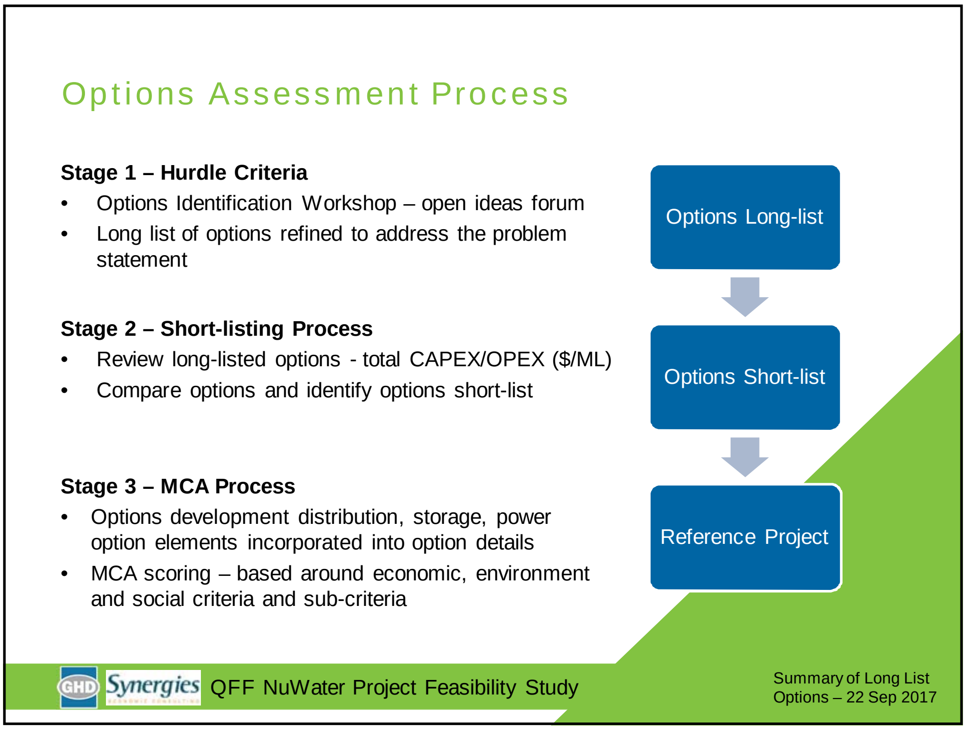
This document has been presented in the following format.

Section	Description
1	Summarise the Long List Options Review, as presented at the NPMC Meeting 13 Sep 2017
2	Present the Long List Options Review Sensitivity Analysis, completed 19-20 Sep 2017
3	Describe the Short List Options



Section 1
Long List Options Review

SUMMARY OF LONG LIST OPTIONS REVIEW - 22 SEP 17



Options Assessment Process

Stage 1 – Hurdle Criteria

- Options Identification Workshop – open ideas forum
- Long list of options refined to address the problem statement

Stage 2 – Short-listing Process

- Review long-listed options - total CAPEX/OPEX ($/ML)
- Compare options and identify options short-list

Stage 3 – MCA Process

- Options development distribution, storage, power option elements incorporated into option details
- MCA scoring – based around economic, environment and social criteria and sub-criteria

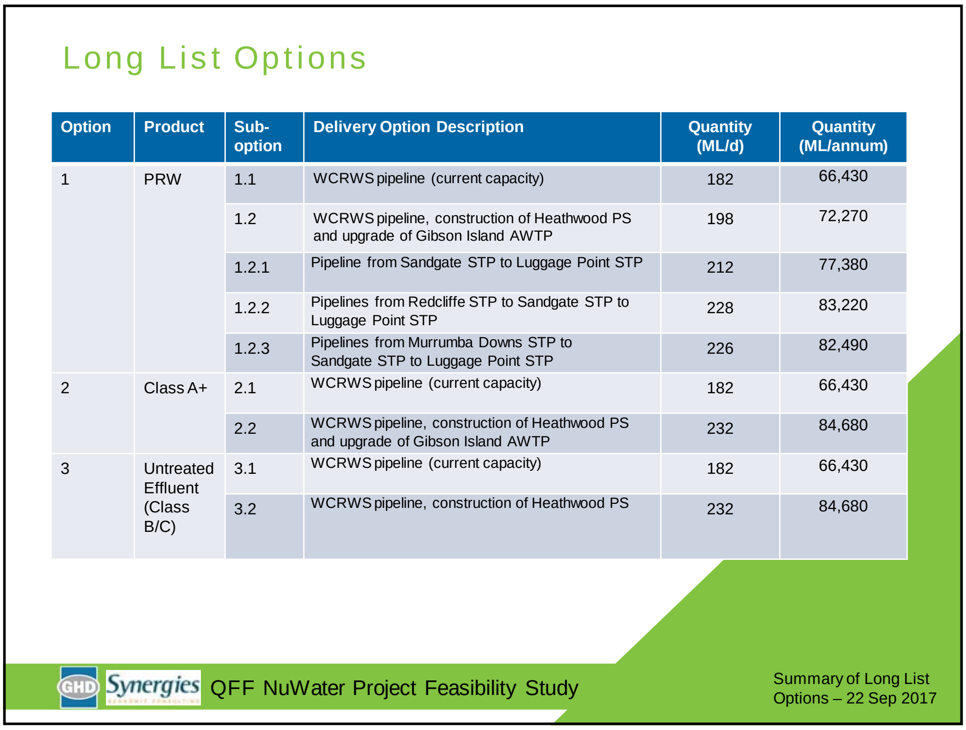
Options Long-list

Options Short-list

Reference Project

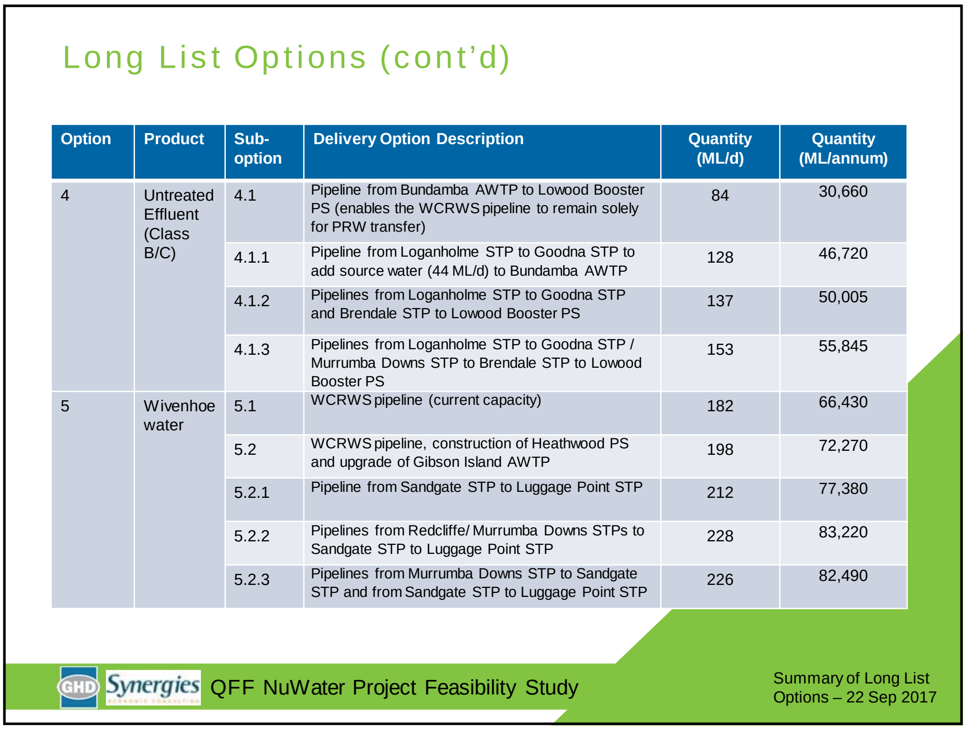
QFF NuWater Project Feasibility Study

Summary of Long List Options – 22 Sep 2017



Long List Options

Option	Product	Sub-option	Delivery Option Description	Quantity (ML/d)	Quantity (ML/annum)
1	PRW	1.1	WCRWS pipeline (current capacity)	182	66,430
		1.2	WCRWS pipeline, construction of Heathwood PS and upgrade of Gibson Island AWTP	198	72,270
		1.2.1	Pipeline from Sandgate STP to Luggage Point STP	212	77,380
		1.2.2	Pipelines from Redcliffe STP to Sandgate STP to Luggage Point STP	228	83,220
		1.2.3	Pipelines from Murrumba Downs STP to Sandgate STP to Luggage Point STP	226	82,490
2	Class A+	2.1	WCRWS pipeline (current capacity)	182	66,430
		2.2	WCRWS pipeline, construction of Heathwood PS and upgrade of Gibson Island AWTP	232	84,680
3	Untreated Effluent (Class B/C)	3.1	WCRWS pipeline (current capacity)	182	66,430
		3.2	WCRWS pipeline, construction of Heathwood PS	232	84,680



Long List Options (cont'd)

Option	Product	Sub-option	Delivery Option Description	Quantity (ML/d)	Quantity (ML/annum)
4	Untreated Effluent (Class B/C)	4.1	Pipeline from Bundamba AWTP to Lowood Booster PS (enables the WCRWS pipeline to remain solely for PRW transfer)	84	30,660
		4.1.1	Pipeline from Loganholme STP to Goodna STP to add source water (44 ML/d) to Bundamba AWTP	128	46,720
		4.1.2	Pipelines from Loganholme STP to Goodna STP and Brendale STP to Lowood Booster PS	137	50,005
		4.1.3	Pipelines from Loganholme STP to Goodna STP / Murrumba Downs STP to Brendale STP to Lowood Booster PS	153	55,845
5	Wivenhoe water	5.1	WCRWS pipeline (current capacity)	182	66,430
		5.2	WCRWS pipeline, construction of Heathwood PS and upgrade of Gibson Island AWTP	198	72,270
		5.2.1	Pipeline from Sandgate STP to Luggage Point STP	212	77,380
		5.2.2	Pipelines from Redcliffe/ Murrumba Downs STPs to Sandgate STP to Luggage Point STP	228	83,220
		5.2.3	Pipelines from Murrumba Downs STP to Sandgate STP and from Sandgate STP to Luggage Point STP	226	82,490

Long List Options (cont'd)

Option	Product	Sub-option	Delivery Option Description	Quantity (ML/d)	Quantity (ML/annum)
6	Separate Systems	6.1	Wivenhoe Water / WCRWS pipeline (current capacity)	116	42,340
		6.2	Pipeline from Bundamba AWTP to Lowood Booster PS	84	30,660

- Options 6.1 and 6.2 were added to examine the option of providing separate systems delivering water catered to the different water quality requirements of Darling Downs (DD) and Lockyer Valley (LV)
- Options 6.1 and 6.2 should be considered as a single option (Option 6) to more fully address the project objectives/problem statements

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Option Elements

Comparative Option Elements

- Water quality / water product
- Delivery infrastructure for source water
- Wastewater treatment requirements
- Delivery infrastructure for product water

Common Option Elements [1]

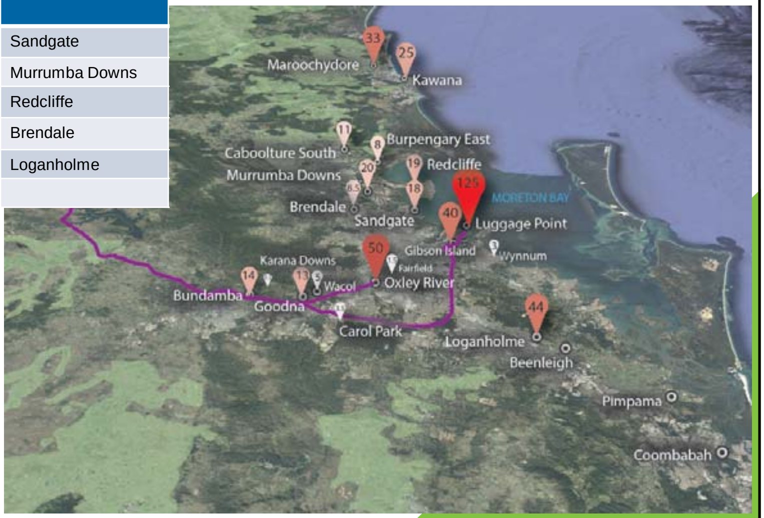
- Distribution infrastructure for product water
- Centralised and decentralised (on-farm) storage
- Power consumption and supply

[1] Common option elements have not been included in the Long List Options Review. These will be defined and refined based on the Short List Options and outcomes of the demand survey.

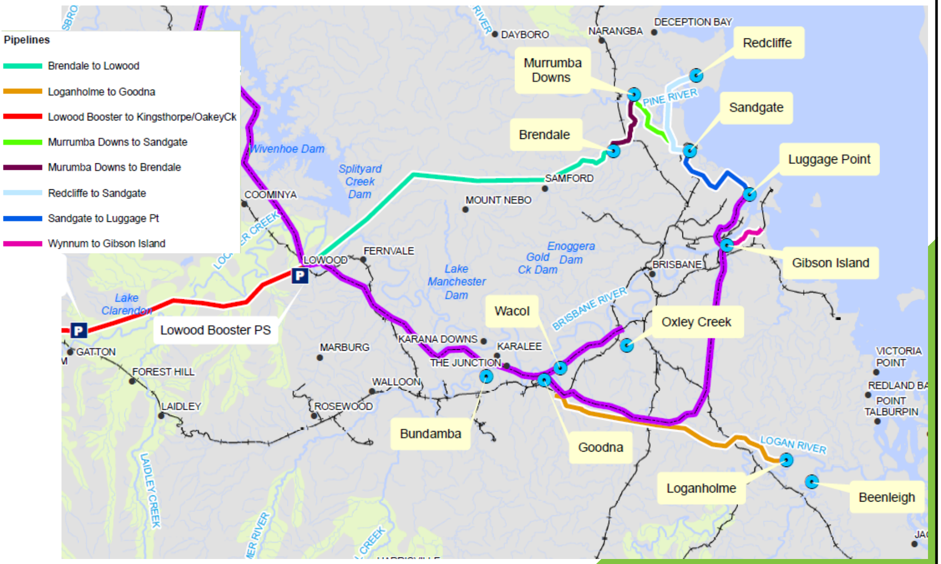
Option Elements – Source Alternatives

STPs connected to WCRWS	Other STPs
Luggage Point	Sandgate
Gibson Island	Murrumba Downs
Oxley Creek	Redcliffe
Wacol	Brendale
Goodna	Loganholme
Bundamba	

AWTPs
Luggage Point
Gibson Island
Bundamba



Option Elements – Delivery Alternatives



Option Elements – Delivery Alternatives

Pipeline from Lowood Booster PS to top of Toowoomba Range: Indicative Hydraulic Grade Line

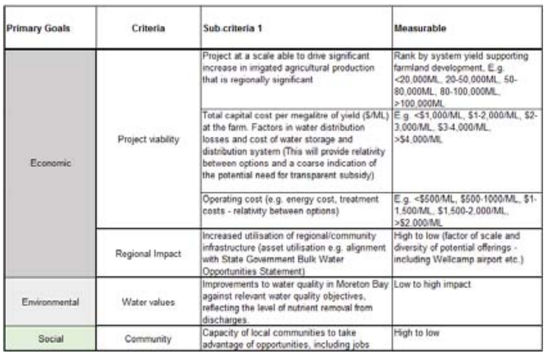
Comparative CAPEX and OPEX estimates

Option	Quality/ Product	Sub-option	Delivery	Quantity (ML/d)	Quantity (ML/a)	CAPEX ($M)	CAPEX ($/ML)	OPEX ($M/Yr)	OPEX ($/ML)
1	PRW	1.1	WCRWS pipeline (current capacity)	182	66,430	$814	$12,260	$120	$1,814
		1.2	WCRWS pipeline + construction of Heathwood PS and upgrade of Gibson Island AWTP	202	73,774	$949	$12,857	$137	$1,859
		1.2.1	Pipeline from Sandgate STP to Luggage Point STP	217	79,161	$1,053	$13,297	$149	$1,884
		1.2.2	Pipelines from Redcliffe STP to Sandgate STP and from Sandgate STP to Luggage Point STP	232	84,680	$1,159	$13,683	$157	$1,851
		1.2.3	Pipelines from Murrumba Downs STP to Sandgate STP and from Sandgate STP to Luggage Point STP	230	84,085	$1,146	$13,632	$156	$1,852
2	Class A+	2.1	WCRWS pipeline (current capacity)	182	66,430	$751	$11,306	$98	$1,476
		2.2	WCRWS pipeline + construction of Heathwood PS and upgrade of Gibson Island AWTP	232	84,680	$900	$10,628	$128	$1,507
3	Class B/C (as produced)	3.1	WCRWS pipeline (current capacity)	182	66,430	$948	$14,271	$97	$1,462
		3.2	WCRWS pipeline + construction of Heathwood PS	232	84,680	$1,072	$12,657	$125	$1,482
4	Class B/C (as produced) No WCRWS Infrastructure	4.1	Pipeline from Bundamba AWTP to Lowood Booster PS	84	30,660	$673	$21,959	$34	$1,103
		4.1.1	Pipeline from Loganholme STP to Goodna STP	128	46,720	$1,063	$22,753	$49	$1,058
		4.1.2	Pipelines from Loganholme STP to Goodna STP and Brendale STP to Lowood Booster PS	137	49,823	$1,166	$23,403	$58	$1,170
		4.1.3	Pipelines from Loganholme STP to Goodna STP and Murrumba Downs STP to Brendale STP to Lowood Booster PS	153	55,827	$1,309	$23,440	$65	$1,167
5	Wivenhoe (raw) water	5.1	WCRWS pipeline (current capacity)	182	66,430	$830	$12,488	$125	$1,886
		5.2	WCRWS pipeline, construction of Heathwood PS and upgrade of Gibson Island AWTP	202	73,774	$965	$13,084	$142	$1,930
		5.2.1	Pipelines from Sandgate STP to Luggage Point STP	217	79,161	$1,165	$14,713	$155	$1,954
		5.2.2	Pipelines from Redcliffe STP to Sandgate STP and from Sandgate STP to Luggage Point STP	232	84,680	$1,272	$15,023	$163	$1,926
		5.2.3	Pipelines from Murrumba Downs STP to Sandgate STP and from Sandgate STP to Luggage Point STP	230	84,085	$1,260	$14,979	$162	$1,926
6	Separate Systems	6.1	WCRWS pipeline (current capacity)- PRW to Lockyer Valley	116	42,340	$379	$8,951	$54	$1,281
		6.2	Pipeline from Bundamba AWTP to Lowood Booster PS - Class B/C to Darling Downs	84	30,660	$521	$16,977	$21	$695

Does not include:- Power supply, distribution costs, storage costs except for Class A+ where storage is included for Lockyer Valley to levelise options.

Multi-Criteria Analysis (MCA) Criteria – Short list assessment scoring

- Initial scoring (as presented at NPMC meeting) was undertaken on a qualitative basis, scoring each option against alignment with the criteria (1-5).
- Preferred options from this analysis indicated the preferred options were Option 2.2, Option 3.2 and Option 6 (combining Option 6.1 and 6.2)
- A sensitivity analysis was subsequently performed on the options, with a range of variables modified to review the impact on scoring and preferred options.



Primary Goals	Criteria	Sub criteria 1	Measurable
Economic	Project viability	Project at a scale able to drive significant increase in irrigated agricultural production that is regionally significant	Rank by system yield supporting farmland development. E.g. <20,000ML, 20-50,000ML, 50-80,000ML, 80-100,000ML, >100,000ML
		Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system (This will provide relativity between options and a coarse indication of the potential need for transparent subsidy)	E.g. <$1,000/ML, $1-2,000/ML, $2-3,000/ML, $3-4,000/ML, >$4,000/ML
		Operating cost (e.g. energy cost, treatment costs - relativity between options)	E.g. <$500/ML, $500-1000/ML, $1-1,500/ML, $1,500-2,000/ML, >$2,000/ML
	Regional Impact	Increased utilisation of regional/community infrastructure (asset utilisation e.g. alignment with State Government Bulk Water Opportunities Statement)	High to low (factor of scale and diversity of potential offerings - including Wellcamp airport etc.)
Environmental	Water values	Improvements to water quality in Moreton Bay against relevant water quality objectives, reflecting the level of nutrient removal from discharges.	Low to high impact
Social	Community	Capacity of local communities to take advantage of opportunities, including jobs	High to low

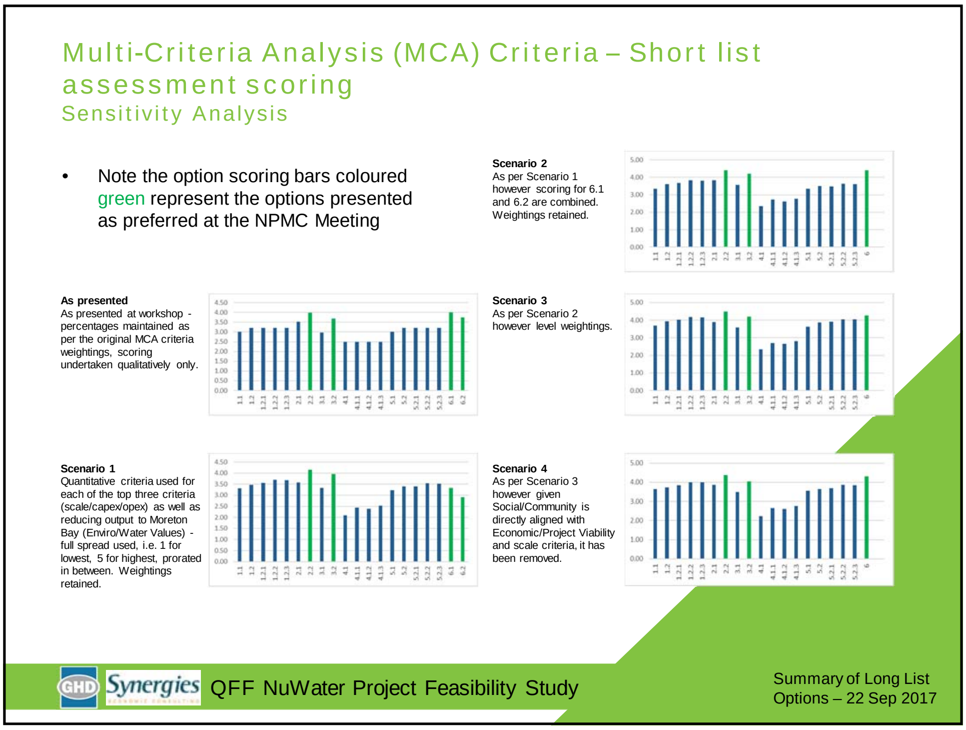
Synergies QFF NuWater Project Feasibility Study

Summary of Long List Options – 22 Sep 2017

Synergies ECONOMIC CONSULTING

Section 2
Sensitivity Analysis

SUMMARY OF LONG LIST OPTIONS REVIEW - 22 SEP 17



Multi-Criteria Analysis (MCA) Criteria – Short list assessment scoring

Sensitivity Analysis

- Note the option scoring bars coloured green represent the options presented as preferred at the NPMC Meeting

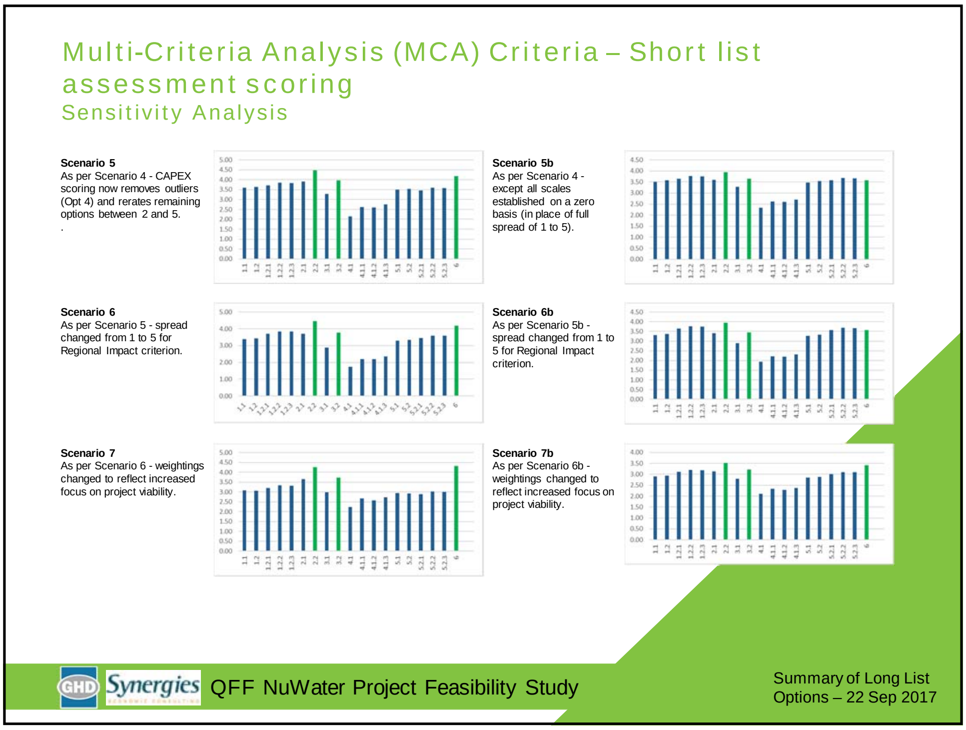
As presented
As presented at workshop - percentages maintained as per the original MCA criteria weightings, scoring undertaken qualitatively only.

Scenario 1
Quantitative criteria used for each of the top three criteria (scale/capex/opex) as well as reducing output to Moreton Bay (Enviro/Water Values) - full spread used, i.e. 1 for lowest, 5 for highest, prorated in between. Weightings retained.

Scenario 2
As per Scenario 1 however scoring for 6.1 and 6.2 are combined. Weightings retained.

Scenario 3
As per Scenario 2 however level weightings.

Scenario 4
As per Scenario 3 however given Social/Community is directly aligned with Economic/Project Viability and scale criteria, it has been removed.



Multi-Criteria Analysis (MCA) Criteria – Short list assessment scoring

Sensitivity Analysis

Scenario 5
As per Scenario 4 - CAPEX scoring now removes outliers (Opt 4) and rerates remaining options between 2 and 5.
.

Scenario 6
As per Scenario 5 - spread changed from 1 to 5 for Regional Impact criterion.

Scenario 7
As per Scenario 6 - weightings changed to reflect increased focus on project viability.

Scenario 5b
As per Scenario 4 - except all scales established on a zero basis (in place of full spread of 1 to 5).

Scenario 6b
As per Scenario 5b - spread changed from 1 to 5 for Regional Impact criterion.

Scenario 7b
As per Scenario 6b - weightings changed to reflect increased focus on project viability.

Multi-Criteria Analysis (MCA) Criteria – Short list assessment scoring

Sensitivity Analysis – Ranking Summary

- The options were ranked in each scenario and totalised for all scenarios, with the lowest total score representing the most preferred, etc. Refer below.
- The sensitivity analysis supported the presented preferred options. A PRW option (Option 1.2.2) has been added as it scored equivalent to other preferred options.
- The four preferred options will be progressed to the short list and undergo further development for comparison and selection of the preferred option and Reference Project.

Scenario	**Option**																		
	1.1	1.2	1.2.1	1.2.2	1.2.3	2.1	2.2	3.1	3.2	4.1	4.1.1	4.1.2	4.1.3	5.1	5.2	5.2.1	5.2.2	5.2.3	6
As presented	14	6	6	6	6	5	2	16	4	17	17	17	17	14	6	6	6	6	2
Scenario 1	14	9	6	3	4	5	1	13	2	20	18	19	17	15	10	11	7	8	14
Scenario 2	15	10	7	5	6	4	2	11	3	19	17	18	16	14	12	13	8	9	1
Scenario 3	13	9	8	4	5	11	1	15	3	19	17	18	16	14	12	10	6	7	2
Scenario 4	13	10	9	4	5	6	1	15	3	19	17	18	16	14	12	11	7	8	2
Scenario 5	10	8	7	5	6	4	1	15	3	19	17	18	16	13	12	14	9	11	2
Scenario 6	12	11	6	3	4	7	1	15	5	19	17	18	16	14	13	10	8	9	2
Scenario 7	8	9	7	5	6	4	2	12	3	19	17	18	16	13	14	15	10	11	1
Scenario 5b	13	11	7	2	3	8	1	15	6	19	17	18	16	14	12	10	4	5	9
Scenario 6b	13	11	6	2	3	10	1	15	9	19	17	18	16	14	12	8	4	5	7
Scenario 7b	12	11	7	4	5	6	1	15	3	19	17	18	16	14	13	10	8	9	2
TOTAL	137	105	76	**43**	53	70	**14**	157	**44**	208	188	198	178	153	128	118	77	88	**44**

QFF NuWater Project Feasibility Study

Summary of Long List Options – 22 Sep 2017

Section 3
Short List Options

SUMMARY OF LONG LIST OPTIONS REVIEW - 22 SEP 17

Short List Options

The short listed options are summarised in the table below and described in the following slides.

Option	Product Option	Sub-Option	Description	Quantity (ML/Day)	Quantity (ML/annum)
A	1 – PRW	1.2.2	WCRWS pipeline + construction of Heathwood PS and upgrade of Gibson Island AWTP, including pipelines from Redcliffe STP to Sandgate STP and from Sandgate STP to Luggage Point STP	232	84,680
B	2 – Class A+	2.2	WCRWS pipeline + construction of Heathwood PS and upgrade of Gibson Island AWTP	232	84,680
C	3 – Class B/C (as produced)	3.2	WCRWS pipeline + construction of Heathwood PS	232	84,680
D	6 – PRW (LV) / Class B/C (DD)	6.1	WCRWS pipeline (current capacity)	116	42,340
		6.2	Pipeline from Bundamba AWTP to Lowood Booster PS	84	30,660

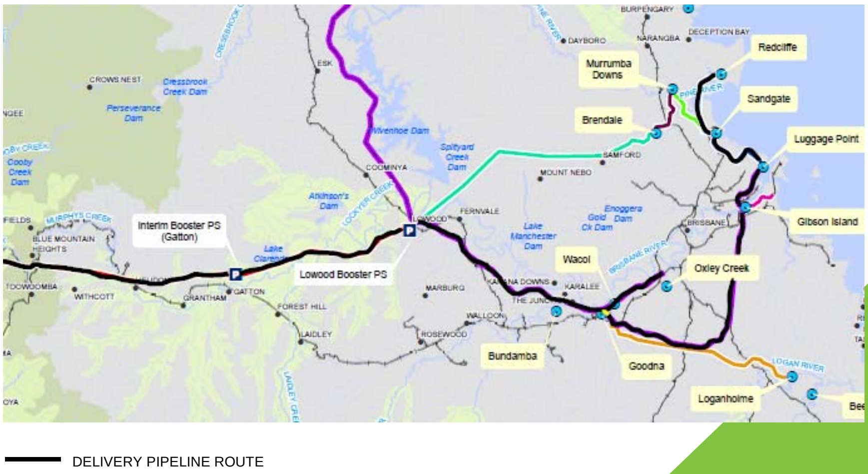
Short List Options – Option A

Option	Product Option	Sub-Option	Description	Quantity (ML/Day)	Quantity (ML/annum)
A	1 – PRW	1.2.2	WCRWS pipeline + construction of Heathwood PS and upgrade of Gibson Island AWTP, including pipelines from Redcliffe STP to Sandgate STP and from Sandgate STP to Luggage Point STP	232	84,680

Key Option A elements:

- PRW water delivered to both Darling Downs and Lockyer Valley
- Full use of WCRWS – AWTPs and pipeline
- Pipelines from Redcliffe STP to Luggage Point STP via Sandgate STP to provide additional source water (treatment plant effluent)
- Increased transfer of source water from Luggage Point to Gibson Island
- Gibson Island AWTP upgrade
- Construction of Heathwood PS (part of WCRWS)

Short List Options – Option A



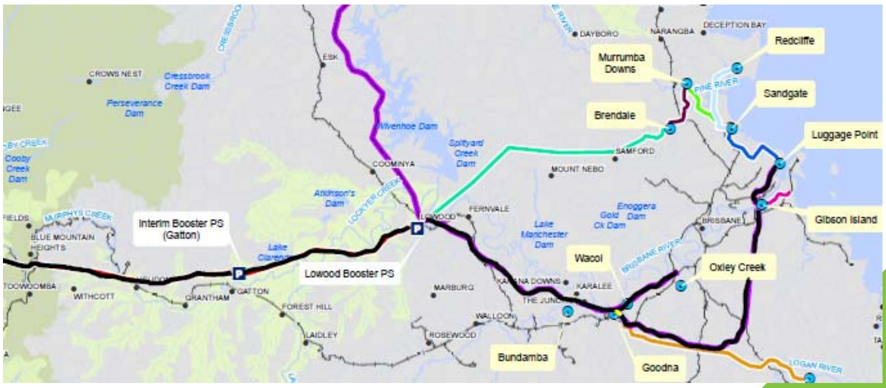
Short List Options – Option B

Option	Product Option	Sub-Option	Description	Quantity (ML/Day)	Quantity (ML/annum)
B	2 – Class A+	2.2	WCRWS pipeline + construction of Heathwood PS and upgrade of Gibson Island AWTP	232	84,680

Key Option B elements:

- Class A+ water delivered to both Darling Downs and Lockyer Valley
- Partial use of WCRWS – AWTPs, full use of WCRWS pipeline
- Increased transfer of source water from Luggage Point to Gibson Island
- Gibson Island AWTP upgrade
- Construction of Heathwood PS (part of WCRWS)
- New storage dams (12GL total) in Lockyer Valley

Short List Options – Option B



▬ DELIVERY PIPELINE ROUTE

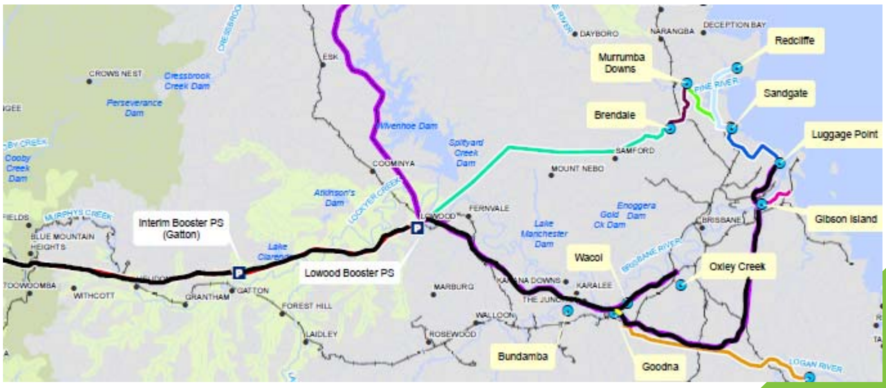
Short List Options – Option C

Option	Product Option	Sub-Option	Description	Quantity (ML/Day)	Quantity (ML/annum)
C	3 – Class B/C (as produced)	3.2	WCRWS pipeline + construction of Heathwood PS	232	84,680

Key Option C elements:

- Class B/C water delivered to both Darling Downs and Lockyer Valley, includes end of pipe treatment to Class A+ for Lockyer Valley
- Full use of WCRWS pipeline, bypass of AWTPs
- Increased transfer of source water from Luggage Point to Gibson Island
- Construction of Heathwood PS (part of WCRWS)
- New storage dams (12GL total) in Lockyer Valley

Short List Options – Option C



▬ DELIVERY PIPELINE ROUTE

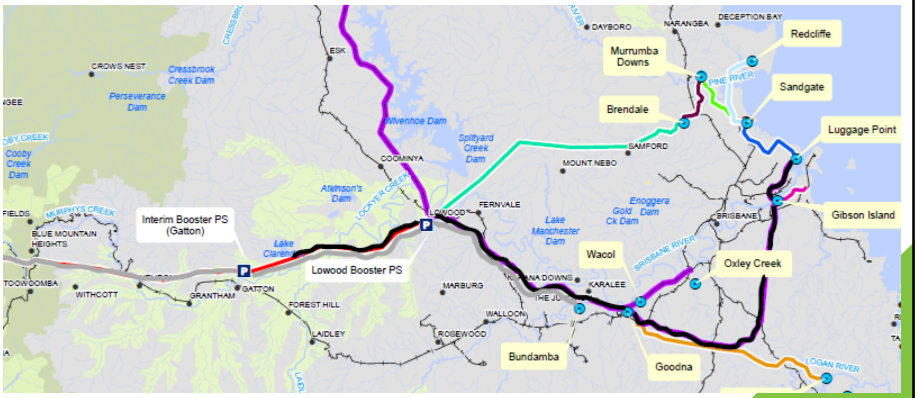
Short List Options – Option D

Option	Product Option	Sub-Option	Description	Quantity (ML/Day)	Quantity (ML/annum)
D	6 – PRW (LV) / Class B/C (DD)	6.1	WCRWS pipeline (current capacity)	116	42,340
		6.2	Pipeline from Bundamba AWTP to Lowood Booster PS	84	30,660

Key Option D elements:

- PRW water delivered to Lockyer Valley
- Part use of WCRWS – AWTPs (Luggage Point STP, Gibson Island STP) and pipeline (not full capacity)
- Separate pipeline delivers PRW water from Lowood Booster PS to Lockyer Valley
- Class B/C water delivered to Darling Downs
- Bypass of Bundamba AWTP (source water is Bundamba, Goodna, Wacol and Oxley Ck STPs)
- Separate pipeline delivers Class B/C water from Lowood Booster PS to Darling Downs

Short List Options – Option D



LOCKYER VALLEY (PRW) DELIVERY PIPELINE ROUTE

DARLING DOWNS (CLASS B/C) DELIVERY PIPELINE ROUTE

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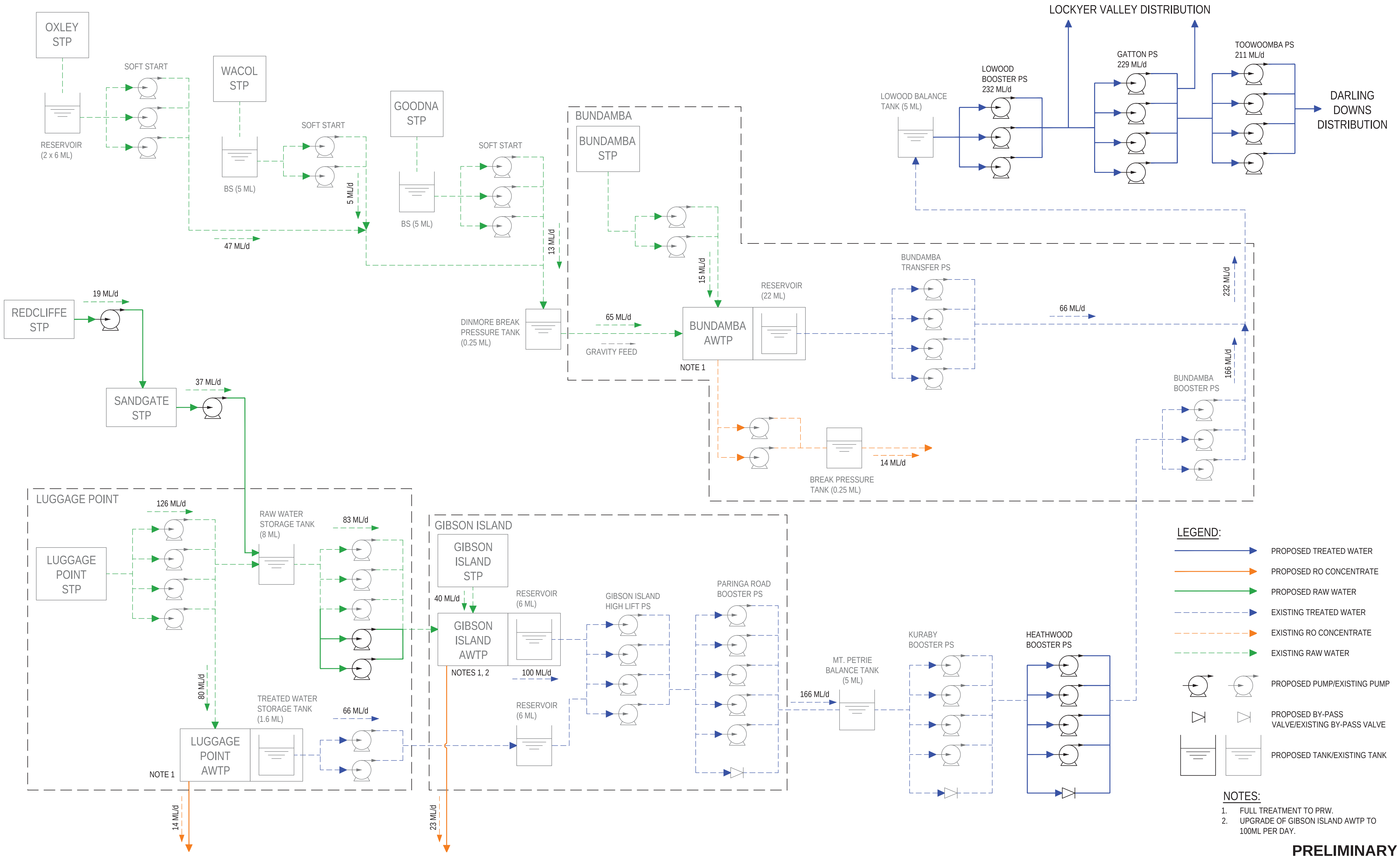
Appendix E – Process Flow Diagrams



NOTES:
1. FULL TREATMENT TO PRW.
2. UPGRADE OF GIBSON ISLAND AWTP TO 100ML PER DAY.

PRELIMINARY

No	Revision	Drawn	Job Manager	Project Director	Date
UR	UNDER REVISION				

Note: * indicates signatures on original issue of drawing or last revision of drawing

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Designer K.WALDUCK
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Design Check
Approved (Project Director)
Date
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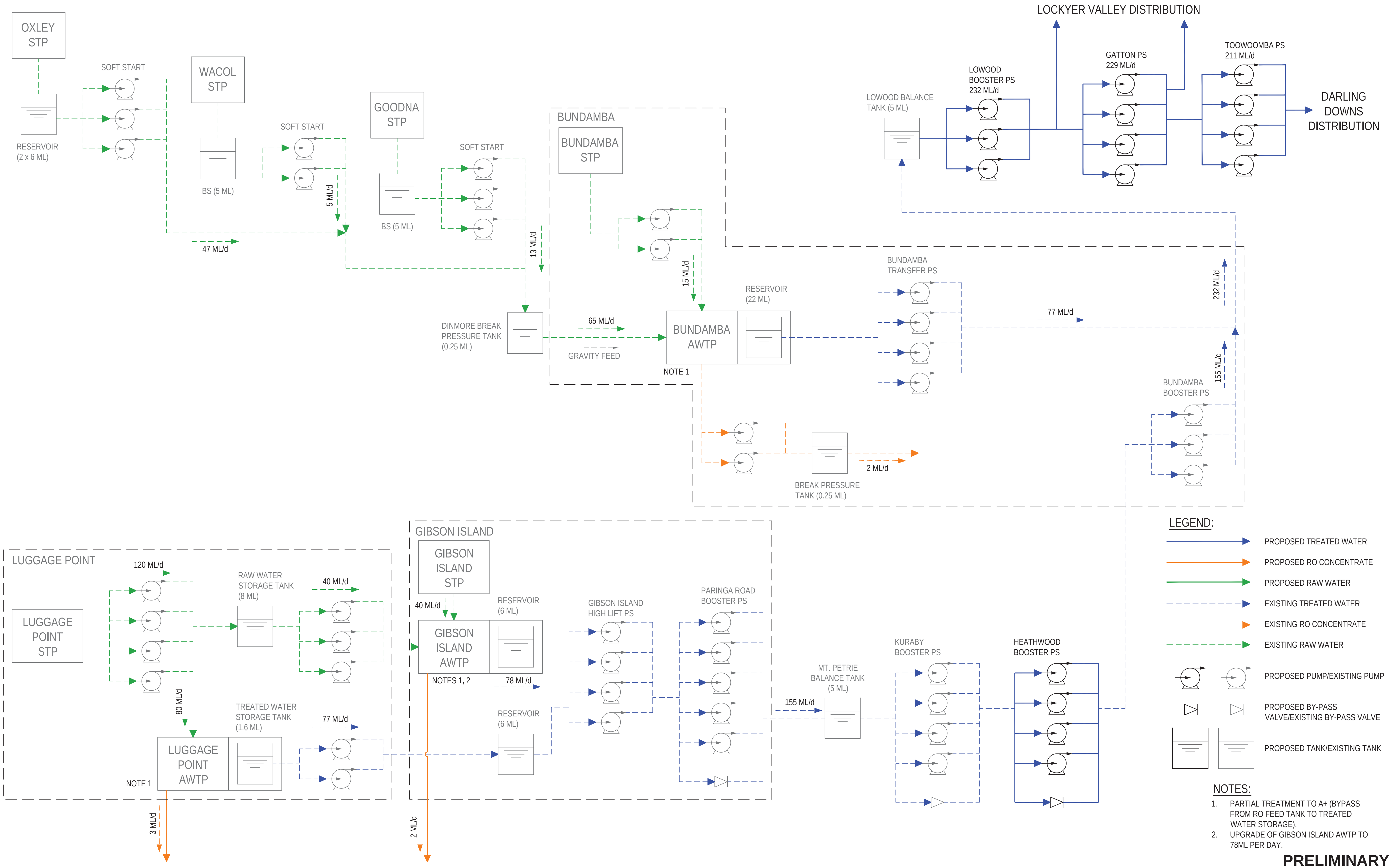
Client **QUEENSLAND FARMERS FEDERATION**
Project **NUWATER PROJECT FEASABILITY STUDY**
Title **OPTION A**
PROCESS FLOW DIAGRAM

Original Size A1
Drawing No: **41-30968-J001**
Rev: UR

Plot Date: 22 November 2017 - 4:29 PM Plotted by: Kirsty Eldridge Cad File No: G:\41\30968\CADD\Drawings\41-30968-J001.dwg



NOTES:

1. PARTIAL TREATMENT TO A+ (BYPASS FROM RO FEED TANK TO TREATED WATER STORAGE).
2. UPGRADE OF GIBSON ISLAND AWTP TO 78ML PER DAY.

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Client **QUEENSLAND FARMERS FEDERATION**
Project **NUWATER PROJECT FEASABILITY STUDY**
Title **OPTION B**
PROCESS FLOW DIAGRAM
Original Size **A1**
Drawing No: 41-30968-J002
Rev: UR

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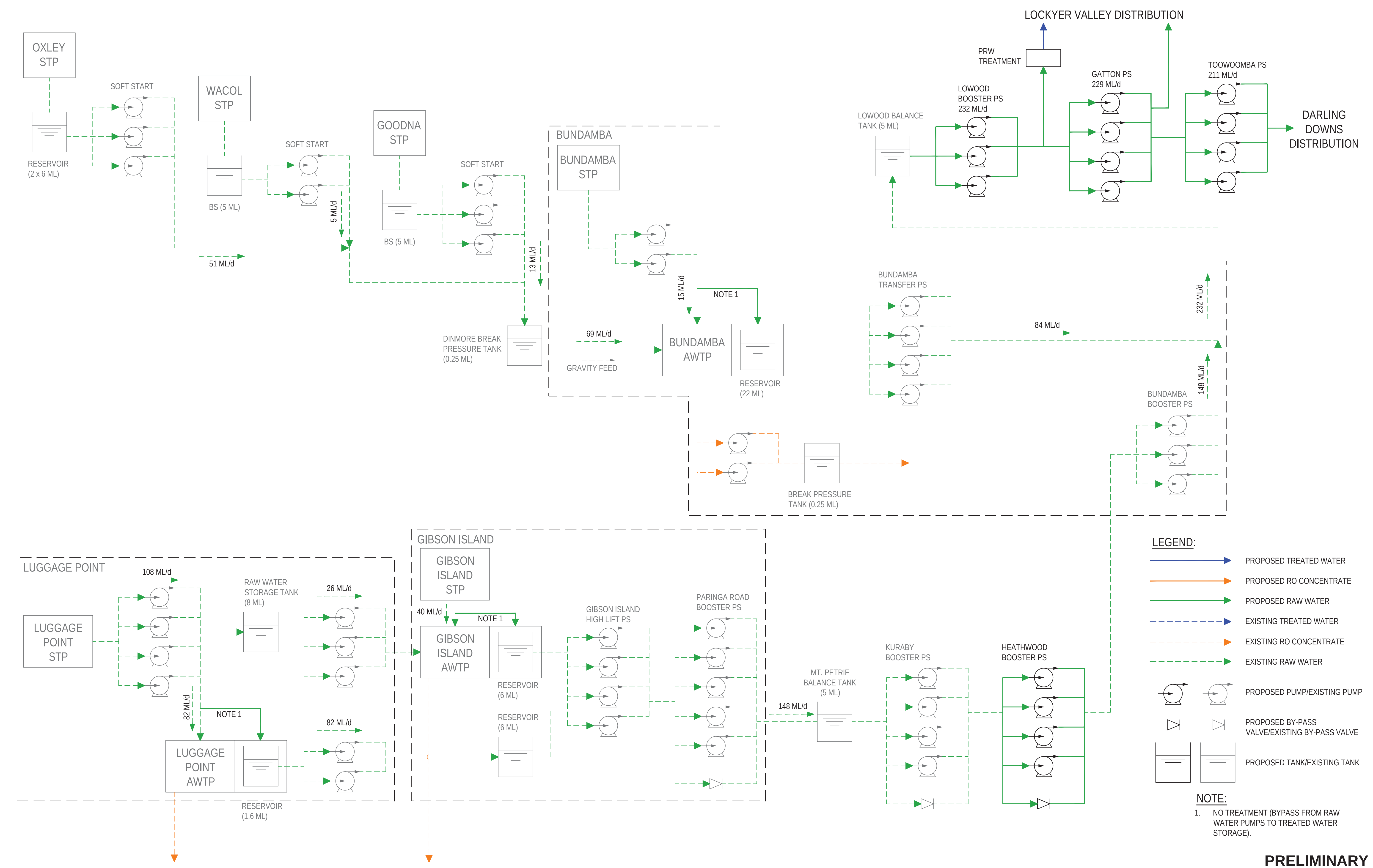

NOTE:

1. NO TREATMENT (BYPASS FROM RAW WATER PUMPS TO TREATED WATER STORAGE).

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Client **QUEENSLAND FARMERS FEDERATION**
Project **NUWATER PROJECT FEASABILITY STUDY**
Title **OPTION C**
PROCESS FLOW DIAGRAM

Original Size **A1**
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Rev: **UR**

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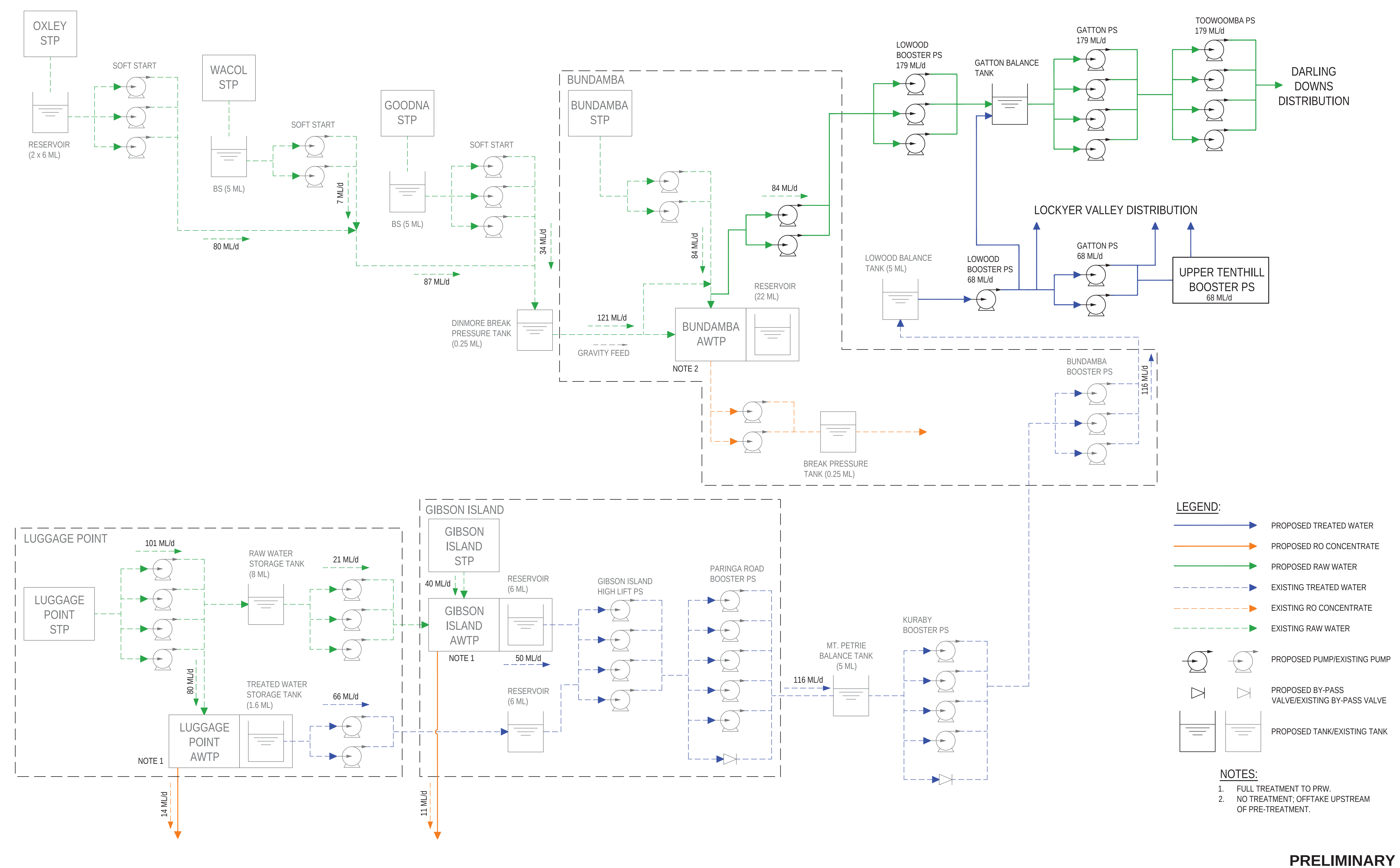

NOTES:

1. FULL TREATMENT TO PRW.
2. NO TREATMENT; OFFTAKE UPSTREAM OF PRE-TREATMENT.

PRELIMINARY

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Client **QUEENSLAND FARMERS FEDERATION**
Project **NUWATER PROJECT FEASABILITY STUDY**
Title **OPTION D**
PROCESS FLOW DIAGRAM
Original Size **A1**
Drawing No: 41-30968-J004
Rev: UR

Plot Date: 22 November 2017 - 4:33 PM Plotted by: Kirsty Eldridge Cad File No: G:\41\30968\CADD\Drawings\41-30968-J004.dwg

Appendix F – Cost estimation

Appendix F1	GHD Long list Options – Basis of Cost Estimate
Appendix F2	NuWater Feasibility Study Indicative Estimate Report (WT Partnership, November 2017)

Appendix F1 GHD Long list Options – Basis of Cost Estimate

F1.1 Cost Estimation Process

The cost estimation process supporting the evaluation of the long list options was undertaken including a range of sources including:

- Seqwater advised cost allowances for WCRWS recommissioning and operational costs
- GHD cost database information and other industry sources for typical supply and construction unit rates for treatment, pumping, storage and linear infrastructure
- Information drawn from previous relevant reports
- Typical operational cost estimates, including treatment consumables, energy and regular operations and maintenance allowances for identified infrastructure.

It is noted that the intent of the cost estimates was to provide a comparative assessment of the options using a common estimate basis, thereby focusing on relative differences between options rather than the total option cost. As such, some common option elements (i.e. distribution networks, transmission and power supply) were left undefined at this stage of the investigation.

Further description of the basis of cost estimates used for this stage of options assessment has been included below.

F1.1.1 WCRWS restart and operational forecast

Seqwater has provided costs associated with restarting the WCRWS up to 180 ML/d, including operational costs over the 2-year restart period. These costs have been pro-rated depending on the quality of water required i.e. PRW, Class A^+ or Class B/C. These costs are inclusive of energy and network costs, therefore these costs have been included for all options that use any of the WCRWS infrastructure.

F1.1.2 AWTP capacity upgrade

Additional costs have been included for options where an upgrade of the Gibson Island AWTP is required; and are based on GHD costs. No additional costs have been included for modifications to the AWTPs for Class A^+ or B/C uses. These costs will be considered in the next stage of estimate development.

F1.1.3 Class A^+ treatment plant

All recycled water used in the Lockyer Valley is required to be of Class A^+ quality or higher. As such, end of pipe treatment (to Class A^+) has been included for options using Class B/C water; and are based on previous GHD experience.

F1.1.4 Concentrate treatment costs

While Bundamba AWTP has nutrient removal in place, Gibson Island and Luggage Point AWTPs do not. To ensure a net reduction of nutrients from Moreton Bay occurs, additional costs have been included to treat these streams. These costs have been estimated based on previous GHD experience.

The same cost basis has been used for PRW reject as well as reject from Class A^+, due to the level of estimate developed at this stage.

F1.1.5 Bulk water pipelines

The WCRWS includes pipelines and pump stations to transfer PRW from the AWTPs at Luggage Point, Gibson Island and Bundamba to Lake Wivenhoe for Indirect Potable Reuse; refer to Section 3.3 (Volume 1). No additional capital expenditure has been included for Western Corridor infrastructure.

Additional bulk water pipelines, for either additional source water or downstream of Lowood Booster PS, have been sized based on selected flows at a velocity of 1.7 m/s and GIS information. Seqwater rates have been used as the basis with which to cost the bulk piping.

F1.1.6 Pump stations

Pump station costs have been based on Seqwater rates and have been sized based on 60% efficiency and total head calculations using relevant information from GIS or as provided by QUU or Seqwater.

F1.1.7 Storage

Storage rates are based on 1 GL storages, requiring approximately 42,000 cubic metres of earthworks.

Storage has only been included for Option 2, which is based on the use of Class A^+ water. Storage has been included for this option due to insufficient storage capacity as Lockyer Valley does not have sufficient storage capacity for this quality of water.

F1.1.8 Reticulation and distribution

A reticulation and distribution network has been developed in and around both the Lockyer Valley and the Darling Downs regions for direct distribution of water to farmers. Given the commonality of systems across all options, the evaluation of this element was held over to the short list options review.

F1.1.9 Indirect costs

Indirect cost allowances include design, project management and contingency have been based on typical rates for high level estimates, refer to Table F1-1.

Table F1-1 Indirect costs

Indirect Cost	Percentage of CAPEX (%)
Design	10
Project Management (owner's cost)	15
Contingency	30

F1.1.10 Operating costs

WCRWS (treatment + pumping)

Operating costs for the WCRWS are based on figures provided by Seqwater, pro-rated depending on the quality of water required i.e. PRW, Class A$^+$ or Class B/C. These costs include pumping as well as treatment, therefore all options using any of the WCRWS infrastructure will incur costs.

Class A+ end-of-pipe treatment

Operating costs associated with a Class A$^+$ quality end-of-pipe treatment plant are based on WCRWS Class A$^+$ costs as outlined in F1.1.3, reduced by 10%. This reduction is to take into account the pumping costs associated with the WCRWS cost, whilst acknowledging that due to the remoteness compared to the existing AWTPS and the economy of scale achieved by the AWTPs, the operating costs may not substantially differ.

Concentrate

Bundamba AWTP has nutrient removal in place; these costs are assumed to be included within the WCRWS operational costs provided by Seqwater. Gibson Island and Luggage Point AWTPs do not have any nutrient removal process in place, therefore an operating cost has been assumed, based on GHD experience. The same cost basis has been used for PRW reject as well as reject from Class A$^+$, due to the level of estimate developed at this stage.

Pipelines

Pipeline operating costs have been calculated at 0.25% of the capital costs, as per Seqwater rates. This includes allowances for operations and maintenance.

Pump stations

Pump station operating costs relating to maintenance have been calculated at 2% of the capital costs, while general operation costs have been calculated based on the power requirements, as per Seqwater rates.

Appendix F2 NuWater Feasibility Study Indicative Estimate Report (WT Partnership, November 2017)

WT PARTNERSHIP

wtpartnership.com.au

28 March 2018

GHD
145 Ann Street
BRISBANE QLD 4000

Attention: James Skene

Dear Sir

NU WATER FEASABILITY STUDY – INDICATIVE ESTIMATE REPORT

Please find attached our Final Indicative Estimate Report for this project based on GHD's concept design information.

Should you have any further queries, please do not hesitate to contact the undersigned.

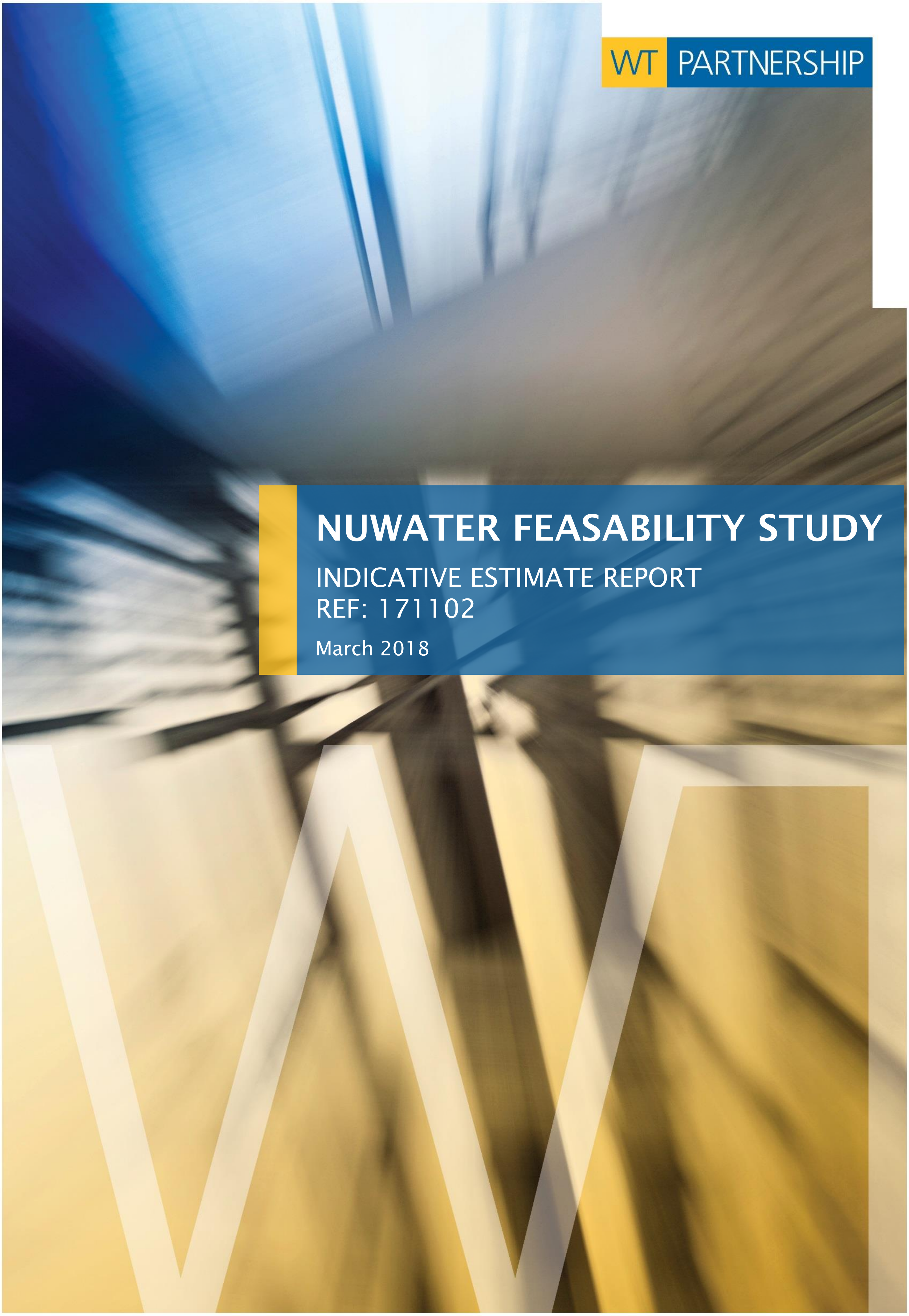
Yours faithfully
WTP AUSTRALIA PTY LTD

JON MANDER-JONES
Queensland Lead Infrastructure

Encl

WTP Ref: 171517

WT PARTNERSHIP



NUWATER FEASABILITY STUDY

INDICATIVE ESTIMATE REPORT
REF: 171102

March 2018

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CONTENTS

APPENDICES

1 CONTACT

DETAIL	DESCRIPTION
NAME OF COMPANY/TRADING NAME	WTP Australia Pty Ltd
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DOCUMENT STATUS	NAME	DATE
PREPARED BY:	Phillip Wilson	28 March 2018
REVIEWED BY:	Luke Hare	28 March 2018
e-SIGNATURE APPROVED	Jon Mander-Jones ☒	28 March 2018

REVISION NO.	REVISION DATE	DRAFT / FINAL
0	28 March 2018	Final

This “Feasibility Cost Estimate Report” has been prepared expressly for GHD and NWIDF. WT Partnership (WTP) accepts no liability to any other third party who may without written consent from WTP rely on its contents. WTP has relied in part on information supplied to it from the Principal, Superintendent, Contractor and Project Consultants and whilst all reasonable skill and care has been exercised to validate its accuracy and authenticity, WTP is unable to provide any guarantee in that regard. WTP will not be liable to any party for any loss arising as a result of any such information subsequently being found to be inaccurate or lacking authenticity.

2 INTRODUCTION

WT Partnership (WTP) has been commissioned by GHD to provide an Indicative Construction Cost Estimate for the proposed pipeline and associated pump stations included in the Western Corridor Recycled Water Scheme.

We understand the purpose of the project is to test the viability of using recycled water from the South-East Queensland Western Corridor Recycled Water Scheme, as irrigation water to the agriculture and industry west of Brisbane on both sides of the Great Dividing Range (including, but not limited to the Lockyer Valley, Darling Downs, Ripley Valley). This estimate is provided to inform GHD and Queensland Farmers' Federation (QFF) the indicative construction cost of the proposed options.

WTP understands that GHD has completed a high level concept design which indicates the location and magnitude of the proposed systems.

This report covers the methodology, assumptions and outcomes from the development of the project estimate.

3 EXECUTIVE SUMMARY

The Estimate Summary of costs is contained in the table below:

ITEM	OPTION A	OPTION B	OPTION C	OPTION D
Establishment	$ 2,529,400	$ 1,779,400	$ 1,779,400	$ 2,529,400
Treatment	$ 231,643,879	$ 139,229,595	$ 57,070,569	$ 124,786,001
Pipelines	$ 615,606,000	$ 531,217,942	$ 531,217,942	$ 572,632,712
Pump Stations	$ 62,071,758	$ 51,388,159	$ 51,250,400	$ 64,530,211
Storage	Nil	$ 2,520,000	$ 2,520,000	Nil
Crossings	$ 121,216,000	$ 16,860,000	$ 16,860,000	$ 22,580,000
Power	$ 295,990,000	$ 292,990,000	$ 292,990,000	$ 328,611,000
Indirect Costs	$ 890,468,215	$ 694,110,014	$ 638,971,168	$ 747,498,447
TOTAL	**$ 2,219,525,252**	**$ 1,730,095,110**	**$ 1,592,659,479**	**$ 1,863,167,771**

4 METHODOLOGY

4.1 DOCUMENTS REVIEWED

This estimate is based on the following documents:

- Options Component Summary
- Short Options Scope of Works – Option A
- Proposed Pump Station General Arrangements
- Plant Layout – Tie-Ins
- Plant Layout – P&IDs
- Power Supply & Distribution Options
- Options Bill of Quanities
- Vendor Budget Estimates

4.2 ESTIMATE PROCESS

The cost estimates are based on the drawings and information supplied, using the quantities provided by GHD.

Escalation has not been applied and the estimates are priced in November 2017 dollars.

The estimates have been developed using the following process.

Design Intent

- Understand the designer's intent
- Understand the context, location and existing infrastructure
- Estimator input from WTP

Develop method of work

- Identify plant and equipment required for each process
- Define the labour and staff required for each process
- Obtain material availability and lead times

Production rate appraisal

- Consider ground conditions
- Review risks, terrain, water table and geotechnical information
- Decide production rate for the plant/crew selected
- Estimate time and cost from these parameters for each process

WTP has prepared the cost estimates using information from a combination of industry standard rates, budget vendor estimates, construction tenders and other sources. The estimates have been produced solely for the analysis of the short-listed options and the accuracy therein is to Class 4 standard, approximately -30% to +50%. They are sufficient for this purpose and should not be used for budgeting. The scope of the works is not fully defined and WTP cannot guarantee the accuracy of the estimates as the project progresses.

4.3 PRINCIPALS COSTS

Principals costs mainly include project initiation, concept design, preliminary and detailed design, project management and supervision, and project close out and finalisation. These costs have been estimated as a percentage of the Construction Cost at 15%.

Other principal's costs are the land acquisition.

PUP costs are estimated in the construction cost as work item.

4.4 LAND ACQUISITION

WT Partnership has incorporated the supplied Land acquisition costs by GHD.

Disclaimer: WT Partnership are not Licenced Land Valuers and cannot take responsibility for land value costs.

5 SCOPE OF WORKS

5.1 PROJECT SCOPE

This estimate has been prepared to provide GHD / QFF with an indication of construction costs for the options proposed. The key elements of the estimates for Options A, B, C & D include:

- Project Establishment
- Treatment / WCRWS
- Pipelines – Transfer, Delivery & Distribution
- Pump Stations – Transfer & Delivery
- Storage
- Crossings – Road, Rail & Water
- Power Supply

6 ASSUMPTIONS

The following assumptions apply to our indicative construction cost estimates:

- All quantities and rates are indicative based on our understanding of scope of works required. All estimates should be reviewed and updated upon receipt of further design information
- Costs, where based on historical data have been escalated to 2017 at 3.0% pa
- From Gibson Island to Toowoomba the pipeline route will follow existing corridors providing an unconstrained environment for maximum productivity.
- In the highly constrained urban areas from Sandgate to Gibson Island a reduced rate of production and modified method of construction has been adopted
- Groundwater and rock is expected to be encountered during excavation in certain areas and the implications have been factored in
- Pipeline rates include allowance for 1 scour valve and 1 air valve assembly per km
- Budget estimates for pipe and pumps have been sourced from relevant suppliers and adopted into our estimate
- A 42% contingency allowance has been included for unmeasurable and unidentified scope required to provide a complete and working system. Additional allowances for client held contingencies etc should be made by others, if required
- Footprint sizes for pump station buildings with undefined limits have been factored from known constants
- WTP has utilised the Western Corridor Recycle Water Scheme (WCRWS) Restart Forecast costs provided by SEQ Water for each option within its estimates of the Water Treatment Plant works

7 EXCLUSIONS

The following items are excluded from our indicative construction cost estimate:

- Planning and approval fess
- Land purchase fees
- Removal of spoil
- Council and Authority Fees, if required
- Latent ground conditions and works associated with the remediation of contaminated ground
- Diversion of existing services
- Escalation costs beyond the estimate date
- Finance costs and holding charges
- GST

8 RISK

As the project is at the feasibility phase (1% and 15%), a Strategic Contingency for the project has been included within the typical ranges between 40% to 70% for this level of definition.

This contingency was defined using a method developed from the Qld Government TMR Project Cost Estimating Manual 7th. This process is used by the Qld Government in developing contingencies for large scale and high value infrastructure projects. This process yielded a result of 42% of the project cost. The risk analysis work sheet is included here as Appendix B and its assessment criteria outlined below:

- Project Scope Definition
- Risks and Risk Analysis
- Constructability
- Key Dates
- Information and Definition
- Length of the Project
- Scalability

Source 'Best Practice cost estimation in land transport infrastructure projects'. Australasian Transport Research Forum 2010 proceedings.

9 PROJECT PROGRAM

For the purposes of developing an indicative construction program a start date of May 2020 has been used.

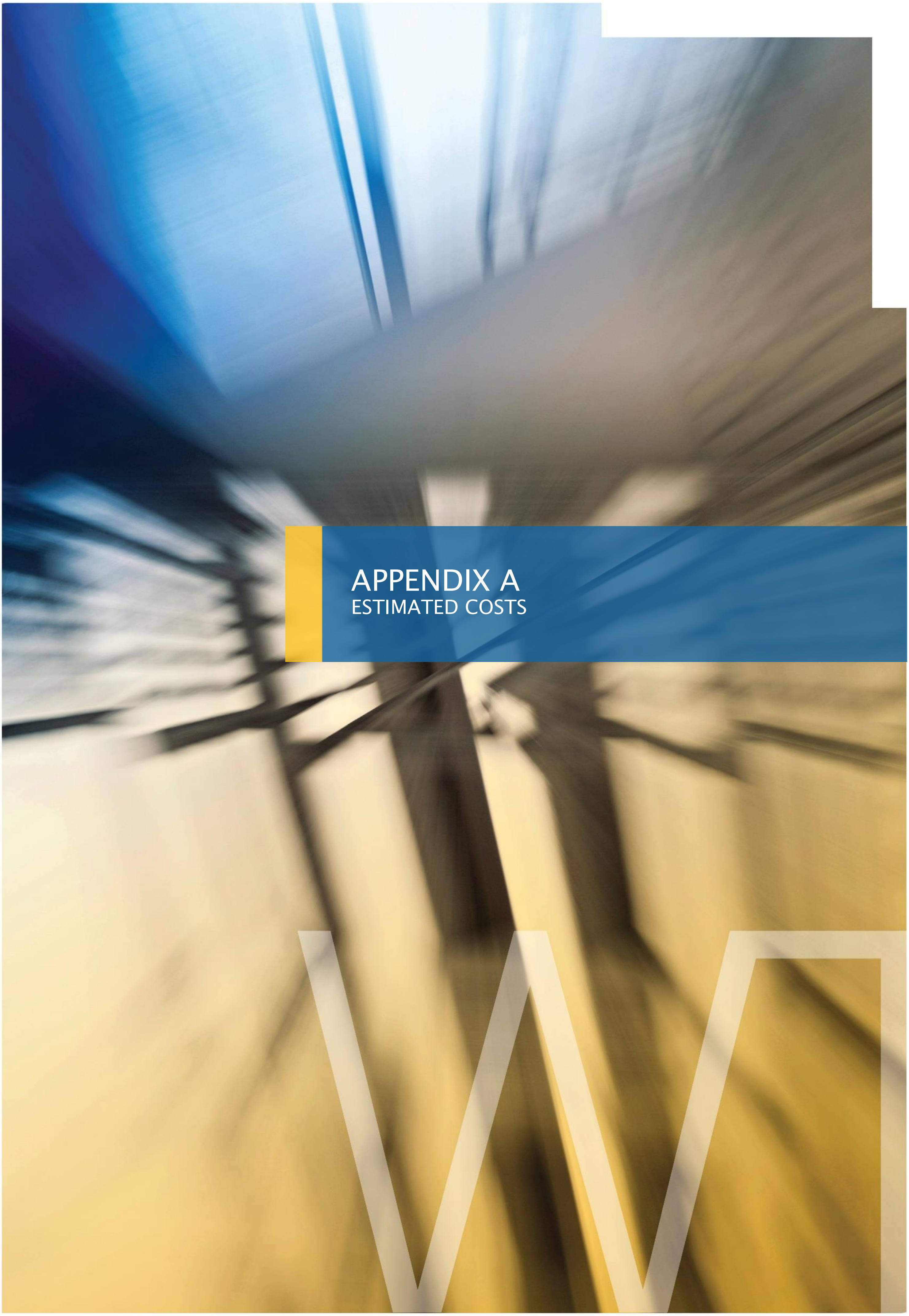
The draft Project Program has been developed for Option A only. Though as it can be assumed all short-listed options will follow similar sequencing, the indicative total duration for each option can be factored from this using the estimated project cost as a basis. The indicative duration for each option is outlined below:

- Option A – 40 Months
- Option B – 31 Months
- Option C – 29 Months
- Option D – 34 Months

The draft Project Program and Cash Flow for Option A, is included as Appendix C.

10 BENCHMARKING

In developing and compiling the estimates, benchmarking of unit rate prices was conducted of similar works in SEQ particularly with respect to pipelines and pump stations, including the application of cost/capacity factors where applicable.



APPENDIX A

ESTIMATED COSTS

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: A

Project Capital Estimate
Option A

Quality/product: PRW
Treatment: Fully recommission WCRWS AWTPs
Delivery: Pipelines from Redcliffe STP to Sandgate STP and from Sandgate STP to Luggage Point STP
Quantity (ML/d): 232
Quantity (ML/a): 84680

Item	Description	Qty	Unit	Rate	Amount	Comments
1	**PROJECT ESTABLISHMENT**					
1.1	Planning Period (10 People)	3	months	$ 259,800	$ 779,400	
1.2	Site office establishment	7	item	$ 250,000	$ 1,750,000	
	Subtotal				**$ 2,529,400**	
2	**TREATMENT/WCRWS**					
2.1	Water	1	item	$ 217,980,071	$ 217,980,071	
2.2	Concentrate	1	item	$ 13,663,807	$ 13,663,807	
	Subtotal				**$ 231,643,879**	
3	**PIPELINES**					
3.1	**Transfer**					
3.1.1	Redcliffe STP to Sandgate STP	13,900	m	$ 2,141	$ 29,755,069	DN508 MSCL Pipe
3.1.2	Sandgate STP to Luggage Point STP	14,000	m	$ 2,371	$ 33,199,551	DN610 MSCL Pipe
3.1.3	Luggage Point STP to Gibson Island STP	9,900	m	$ 2,165	$ 21,433,439	DN900 HDPE PN8
3.2	**Delivery**					
3.2.1	Lowood Booster PS to Gatton (interim booster PS) - DN1575 MSCL	25,161	m	$ 3,444	$ 86,656,509	DN1575 MSCL pipe
3.2.2	Gatton (interim booster PS) to Toowoomba Range (bottom) - DN1575 MSCL	22,733	m	$ 3,444	$ 78,294,281	DN1575 MSCL pipe
3.2.3	Gatton (interim booster PS) to Toowoomba Range (bottom) - DN1500 MSCL	15,509	m	$ 3,225	$ 50,013,891	DN1500 MSCL pipe
3.2.4	Toowoomba Range (bottom) to Toowoomba Range (top) - DN1500 MSCL	4,858	m	$ 3,225	$ 15,666,225	DN1500 MSCL pipe
3.3	**Distribution - Lockyer Valley**					
3.3.1	DN150 PVC-M PN16 Distribution Pipework	14,250	m	$ 234	$ 3,337,885	
3.3.2	DN200 PVC-M PN16 Distribution Pipework	3,403	m	$ 275	$ 934,342	
3.3.3	DN250 PVC-M PN16 Distribution Pipework	3,484	m	$ 332	$ 1,155,545	
3.3.4	DN300 PVC-M PN16 Distribution Pipework	2,295	m	$ 394	$ 903,305	
3.3.5	DN375 PVC-M PN16 Distribution Pipework	9,806	m	$ 524	$ 5,134,273	
3.3.6	DN502 MSCL Distribution Pipework	-			$ -	
3.3.7	DN559 MSCL Distribution Pipework	-			$ -	
3.3.8	DN648 MSCL Distribution Pipework	-			$ -	
3.3.9	DN711 MSCL Distribution Pipework	-			$ -	
3.3.10	DN762 MSCL Distribution Pipework	-			$ -	
3.3.11	DN800 MSCL Distribution Pipework	-			$ -	
3.3.12	DN813 MSCL Distribution Pipework	-			$ -	
3.3.13	DN914 MSCL Distribution Pipework	-			$ -	
3.3.14	DN960 MSCL Distribution Pipework	-			$ -	
3.3.15	DN1125 MSCL Distribution Pipework	-			$ -	
3.3.16	DN1290 MSCL Distribution Pipework	-			$ -	
3.3.17	DN1404 MSCL Distribution Pipework	-			$ -	
3.3.18	DN1422 MSCL Distribution Pipework	-			$ -	
3.3.19	DN1440 MSCL Distribution Pipework	-			$ -	
3.3.20	DN1500 MSCL Distribution Pipework	-			$ -	
3.3.21	DN1575 MSCL Distribution Pipework	-			$ -	
3.4	**Distribution - Darling Downs**					
3.4.1	DN150 PVC-M PN16 Distribution Pipework	-			$ -	
3.4.2	DN200 PVC-M PN16 Distribution Pipework	-			$ -	
3.4.3	DN250 PVC-M PN16 Distribution Pipework	-			$ -	
3.4.4	DN300 PVC-M PN16 Distribution Pipework	-			$ -	
3.4.5	DN375 PVC-M PN16 Distribution Pipework	58,351	m	$ 524	$ 30,551,699	
3.4.6	DN502 MSCL Distribution Pipework	8,393	m	$ 932	$ 7,822,499	
3.4.7	DN559 MSCL Distribution Pipework	2,972	m	$ 1,077	$ 3,202,242	
3.4.8	DN648 MSCL Distribution Pipework	9,273	m	$ 1,167	$ 10,819,842	
3.4.9	DN711 MSCL Distribution Pipework	10,698	m	$ 1,207	$ 12,916,041	
3.4.10	DN762 MSCL Distribution Pipework	5,693	m	$ 1,275	$ 7,261,336	
3.4.11	DN800 MSCL Distribution Pipework	8,602	m	$ 1,351	$ 11,624,251	
3.4.12	DN813 MSCL Distribution Pipework	-			$ -	
3.4.13	DN914 MSCL Distribution Pipework	14,419	m	$ 1,711	$ 24,674,140	
3.4.14	DN960 MSCL Distribution Pipework	-			$ -	
3.4.15	DN1125 MSCL Distribution Pipework	2,848	m	$ 2,059	$ 5,865,017	
3.4.16	DN1290 MSCL Distribution Pipework	-			$ -	
3.4.17	DN1404 MSCL Distribution Pipework	60,770	m	$ 2,870	$ 174,384,616	
3.4.18	DN1422 MSCL Distribution Pipework	-			$ -	
3.4.19	DN1440 MSCL Distribution Pipework	-			$ -	
3.4.20	DN1500 MSCL Distribution Pipework	-			$ -	
3.4.21	DN1575 MSCL Distribution Pipework	-			$ -	
	Subtotal				**$ 615,606,000**	
4	**PUMP STATIONS**					
4.1	**Transfer**					
4.1.1	Redcliffe STP - 157kW	120	m^2	$ 35,696	$ 4,283,475	240 L/s @ 40m
4.1.2	Sandgate STP - 476kW	120	m^2	$ 40,191	$ 4,822,902	467 L/s @ 60m
4.1.3	Luggage Point to Gibson Island (additional) - 214kW	150	m^2	$ 9,009	$ 1,351,297	543 L/s @ 24.1m
4.1.4	Heathwood PS - 1787kW	730	m^2	$ 10,414	$ 7,602,569	2102 L/s @ 52m
4.2	**Delivery**					
4.2.1	Lowood Booster PS - 800kW	615	m^2	$ 9,967	$ 6,129,544	2929 L/s @ 16.7m
4.2.2	Gatton (interim booster PS) - 15087kW	666	m^2	$ 29,864	$ 19,889,406	2929 L/s @ 315m
4.2.3	Toowoomba Range (bottom) - 12659kW	666	m^2	$ 27,016	$ 17,992,565	2670 L/s @ 290m
	Subtotal				**$ 62,071,758**	
5	**STORAGE**					Assume delivery straight to farm / on-farm storage
	Subtotal				**$ -**	
6	**CROSSINGS**					Crossings, access tracks, land ownership, traffic management, fibre optic cable, environmental offset costs
6.1	**Railway**					100 m crossing length microtunnelling
	DN200 PVC-M PN16 Pipework	1	item	$ 170,000	$ 170,000	
	DN375 PVC-M PN16 Pipework	1	item	$ 200,000	$ 200,000	
	DN1422 MSCL Pipework	1	item	$ 350,000	$ 350,000	
	DN1500 MSCL Pipework	2	item	$ 350,000	$ 700,000	
	DN1575 MSCL Pipework	1	item	$ 350,000	$ 350,000	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project Capital Estimate
Option A

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: A

Quality/product: PRW
Treatment: Fully recommission WCRWS AWTPs
Delivery: Pipelines from Redcliffe STP to Sandgate STP and from Sandgate STP to Luggage Point STP
Quantity (ML/d): 232
Quantity (ML/a): 84680

Item	Description	Qty	Unit	Rate	Amount	Comments
6.2	**Road - minor (Lockyer Valley +)**					50 m crossing cut and cover
	DN150 PVC-M PN16 Distribution Pipework	1	item	$ 80,000	$ 80,000	
	DN200 PVC-M PN16 Distribution Pipework	1	item	$ 90,000	$ 90,000	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -		
	DN375 PVC-M PN16 Distribution Pipework	2	item	$ 100,000	$ 200,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	10	item	$ 150,000	$ 1,500,000	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.3	**Road - major (Lockyer Valley +)**					100 m crossing thrust bore
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	2	item	$ 210,000	$ 420,000	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	2	item	$ 240,000	$ 480,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	4	item	$ 290,000	$ 1,160,000	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	4	item	$ 310,000	$ 1,240,000	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.4	**Road - minor (Darling Downs)**					50 m crossing cut and cover
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	5	item	$ 100,000	$ 500,000	
	DN502 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN914 MSCL Distribution Pipework	2	item	$ 150,000	$ 300,000	
	DN1404 MSCL Distribution Pipework	4	item	$ 175,000	$ 700,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.5	**Road - major (Darling Downs)**					100 m crossing thrust bore
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	2	item	$ 390,000	$ 780,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.6	**Water - minor (Lockyer Valley +)**					50 m crossing Open cut (coffer dams)
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	2	item	$ 168,000	$ 336,000	Exception - cut and sink
	DN610 MSCL Distribution Pipework	1	item	$ 168,000	$ 168,000	Exception - cut and sink
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.7	**Water - major (Lockyer Valley +)**					150 m crossing microtunnelling
	DN150 PVC-M PN16 Distribution Pipework	3	item	$ 470,000	$ 1,410,000	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	3	item	$ 600,000	$ 1,800,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	1	item	$ 603,000	$ 603,000	Exception - HDD
	DN610 MSCL Distribution Pipework	1	item	$ 639,000	$ 639,000	Exception - HDD
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: A

Project Capital Estimate
Option A

Quality/product: PRW
Treatment: Fully recommission WCRWS AWTPs
Delivery: Pipelines from Redcliffe STP to Sandgate STP and from Sandgate STP to Luggage Point STP
Quantity (ML/d): 232
Quantity (ML/a): 84680

Item	Description	Qty	Unit	Rate	Amount	Comments
				$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.8	**Water - minor (Darling Downs)**				$ -	50 m crossing Open cut (coffer dams)
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	3	item	$ 160,000	$ 480,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	2	item	$ 220,000	$ 440,000	
	DN762 MSCL Distribution Pipework	3	item	$ 220,000	$ 660,000	
	DN800 MSCL Distribution Pipework	1	item	$ 220,000	$ 220,000	
	DN914 MSCL Distribution Pipework	1	item	$ 230,000	$ 230,000	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	17	item	$ 250,000	$ 4,250,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.9	**Water - major (Darling Downs)**					150 m crossing microtunnelling
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	1	item	$ 720,000	$ 720,000	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN762 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	1	item	$ 880,000	$ 880,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.10	**Super Crossing**					
	DN508 MSCL Transfer Pipework - Redcliffe STP to Sandgate STP	9	item	$ 7,600,000	$ 68,400,000	1000m crossing HDD
	DN610 MSCL Transfer Pipework - Sandgate STP to Luggage Point STP	3	item	$ 8,000,000	$ 24,000,000	1000m crossing HDD
	DN900 HDPE PN8 Transfer Pipework - Luggage Point STP to Gibson Island STP	1	item	$ 6,160,000	$ 6,160,000	700m crossing HDD
	Subtotal				**$ 121,216,000**	
7	**Power**					
7.1	Land Purchase	331.5	ha	$ 20,000	$ 6,630,000	**Outside Scope of WTP**
7.2	**Transfer pumps**	Solar PV				
7.2.1	Redcliffe STP	1.0	MW	$ 1,000,000	$ 1,000,000	
7.2.2	Sandgate STP	1.6	MW	$ 625,000	$ 1,000,000	only includes grid connection, PV not included due not available land
7.2.3	Luggage Point to Gibson Island (additional)	1.6	MW	$ 625,000	$ 1,000,000	
7.2.4	Heathwood PS	9.4	MW	$ 180,851	$ 1,700,000	
7.3	**Delivery pumps**					
7.3.1	Lowood Booster PS	3.6	MW	$ 2,572,222	$ 9,260,000	
7.3.2	Gatton(interim booster PS)	69.0	MW	$ 2,132,609	$ 147,150,000	
7.3.3	Toowoomba Range (bottom)	60.0	MW	$ 2,137,500	$ 128,250,000	
	Subtotal				**$ 295,990,000**	
	DIRECT COSTS				**$ 1,329,057,037**	
8	**INDIRECTS**					
8.1	Design			10%	$ 132,905,704	
8.2	Project Management (owner's cost)			15%	$ 199,358,556	
8.3	Contingency			42%	$ 558,203,955.59	
	INDIRECT COSTS				**$ 890,468,215**	
	TOTAL COSTS				**$ 2,219,525,252**	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: **A**

Project Capital Estimate
Option B

Quality/product: Class A+
Treatment: Partially recommission WCRWS AWTPs
Delivery: WCRWS pipeline + construction of Heathwood PS and upgrade of Gibson Island AWTP
Quantity (ML/d): 232
Quantity (ML/a): 84680

Item	Description	Qty	Unit	Rate	Amount	Comments
1	**PROJECT ESTABLISHMENT**					
1.1	Planning Period (10 People)	3	months	$ 259,800	$ 779,400	
1.2	Site office establishment	4	item	$ 250,000	$ 1,000,000	
	Subtotal				**$ 1,779,400.00**	
2	**TREATMENT/WCRWS**					
2.1	Water	1	item	$ 134,538,234	$ 134,538,234	
2.2	Concentrate	1	item	$ 4,691,362	$ 4,691,362	
	Subtotal				**$ 139,229,595**	
3	**PIPELINES**					
3.1	**Delivery**					
3.1.1	Lowood Booster PS to Gatton (interim booster PS) - DN1575 MSCL	25,161	m	$ 3,444	$ 86,656,509	DN1575 MSCL pipe
3.1.2	Gatton (interim booster PS) to Toowoomba Range (bottom) - DN1575 MSCL	22,733	m	$ 3,444	$ 78,294,281	DN1575 MSCL pipe
3.1.3	Gatton (interim booster PS) to Toowoomba Range (bottom) - DN1500 MSCL	15,509	m	$ 3,225	$ 50,013,891	DN1500 MSCL pipe
3.1.4	Toowoomba Range (bottom) to Toowoomba Range (top) - DN1500 MSCL	4,858	m	$ 3,225	$ 15,666,225	DN1500 MSCL pipe
3.2	**Distribution - Lockyer Valley**				$ -	
3.2.1	DN150 PVC-M PN16 Distribution Pipework	14,250	m	$ 234	$ 3,337,885	
3.2.2	DN200 PVC-M PN16 Distribution Pipework	3,403	m	$ 275	$ 934,342	
3.2.3	DN250 PVC-M PN16 Distribution Pipework	3,484	m	$ 332	$ 1,155,545	
3.2.4	DN300 PVC-M PN16 Distribution Pipework	2,295	m	$ 394	$ 903,305	
3.2.5	DN375 PVC-M PN16 Distribution Pipework	9,806	m	$ 524	$ 5,134,273	
3.2.6	DN502 MSCL Distribution Pipework	-			$ -	
3.2.7	DN559 MSCL Distribution Pipework	-			$ -	
3.2.8	DN648 MSCL Distribution Pipework	-			$ -	
3.2.9	DN711 MSCL Distribution Pipework	-			$ -	
3.2.10	DN762 MSCL Distribution Pipework	-			$ -	
3.2.11	DN800 MSCL Distribution Pipework	-			$ -	
3.2.12	DN813 MSCL Distribution Pipework	-			$ -	
3.2.13	DN914 MSCL Distribution Pipework	-			$ -	
3.2.14	DN960 MSCL Distribution Pipework	-			$ -	
3.2.15	DN1125 MSCL Distribution Pipework	-			$ -	
3.2.16	DN1290 MSCL Distribution Pipework	-			$ -	
3.2.17	DN1404 MSCL Distribution Pipework	-			$ -	
3.2.18	DN1422 MSCL Distribution Pipework	-			$ -	
3.2.19	DN1440 MSCL Distribution Pipework	-			$ -	
3.2.20	DN1500 MSCL Distribution Pipework	-			$ -	
3.2.21	DN1575 MSCL Distribution Pipework	-			$ -	
3.3	**Distribution - Darling Downs**				$ -	
3.3.1	DN150 PVC-M PN16 Distribution Pipework	-			$ -	
3.3.2	DN200 PVC-M PN16 Distribution Pipework	-			$ -	
3.3.3	DN250 PVC-M PN16 Distribution Pipework	-			$ -	
3.3.4	DN300 PVC-M PN16 Distribution Pipework	-			$ -	
3.3.5	DN375 PVC-M PN16 Distribution Pipework	58,351	m	$ 524	$ 30,551,699	
3.3.6	DN502 MSCL Distribution Pipework	8,393	m	$ 932	$ 7,822,499	
3.3.7	DN559 MSCL Distribution Pipework	2,972	m	$ 1,077	$ 3,202,242	
3.3.8	DN648 MSCL Distribution Pipework	9,273	m	$ 1,167	$ 10,819,842	
3.3.9	DN711 MSCL Distribution Pipework	10,698	m	$ 1,207	$ 12,916,041	
3.3.10	DN762 MSCL Distribution Pipework	5,693	m	$ 1,275	$ 7,261,336	
3.3.11	DN800 MSCL Distribution Pipework	8,602	m	$ 1,351	$ 11,624,251	
3.3.12	DN813 MSCL Distribution Pipework	-			$ -	
3.3.13	DN914 MSCL Distribution Pipework	14,419	m	$ 1,711	$ 24,674,140	
3.3.14	DN960 MSCL Distribution Pipework	-			$ -	
3.3.15	DN1125 MSCL Distribution Pipework	2,848	m	$ 2,059	$ 5,865,017	
3.3.16	DN1290 MSCL Distribution Pipework	-			$ -	
3.3.17	DN1404 MSCL Distribution Pipework	60,770	m	$ 2,870	$ 174,384,616	
3.3.18	DN1422 MSCL Distribution Pipework	-			$ -	
3.3.19	DN1440 MSCL Distribution Pipework	-			$ -	
3.3.20	DN1500 MSCL Distribution Pipework	-			$ -	
3.3.21	DN1575 MSCL Distribution Pipework	-			$ -	
	Subtotal				**$ 531,217,942**	
4	**PUMP STATIONS**					
4.1	**Transfer**					
4.1.1	Heathwood PS - 1664kW	730	m^2	$ 10,105	$ 7,376,643	2102 L/s @ 52m
4.2	**Delivery**					
4.1	Lowood Booster PS - 800kW	615	m^2	$ 9,967	$ 6,129,544	2929 L/s @ 16.7m
4.2	Gatton (interim booster PS) - 15087kW	666	m^2	$ 29,864	$ 19,889,406	2929 L/s @ 315m
4.3	Toowoomba Range (bottom) - 12659kW	666	m^2	$ 27,016	$ 17,992,565	2670 L/s @ 290m
	Subtotal				**$ 51,388,159**	
5	**STORAGE**					
5.1	Farm storages	4	item	$ 630,000	$ 2,520,000	Lockyer Valley storage
	- earthworks	42000	m^3	$ 15	$ 630,000	1 GL storage
	Subtotal				**$ 2,520,000**	
6	**CROSSINGS**					Crossings, access tracks, land ownership, traffic management, fibre optic cable, environmental offset costs
6.1	**Railway**					100 m crossing length microtunnelling
	DN200 PVC-M PN16 Pipework	1	item	$ 170,000	$ 170,000	
	DN375 PVC-M PN16 Pipework	1	item	$ 200,000	$ 200,000	
	DN1422 MSCL Pipework	1	item	$ 350,000	$ 350,000	
	DN1500 MSCL Pipework	2	item	$ 350,000	$ 700,000	
	DN1575 MSCL Pipework	1	item	$ 350,000	$ 350,000	
6.2	**Road - minor (Lockyer Valley)**					50 m crossing cut and cover
	DN150 PVC-M PN16 Distribution Pipework	1	item	$ 80,000	$ 80,000	
	DN200 PVC-M PN16 Distribution Pipework	1	item	$ 90,000	$ 90,000	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	2	item	$ 100,000	$ 200,000	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: A

Project Capital Estimate
Option B

Quality/product: Class A+
Treatment: Partially recommission WCRWS AWTPs
Delivery: WCRWS pipeline + construction of Heathwood PS and upgrade of Gibson Island AWTP
Quantity (ML/d): 232
Quantity (ML/a): 84680

Item	Description	Qty	Unit	Rate	Amount	Comments
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.3	**Road - major (Lockyer Valley)**					100 m crossing thrust bore
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	2	item	$ 210,000	$ 420,000	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	2	item	$ 240,000	$ 480,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.4	**Road - minor (Darling Downs)**				$ -	50 m crossing cut and cover
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	5	item	$ 100,000	$ 500,000	
	DN502 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN914 MSCL Distribution Pipework	2	item	$ 150,000	$ 300,000	
	DN1404 MSCL Distribution Pipework	4	item	$ 175,000	$ 700,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.5	**Road - major (Darling Downs)**					100 m crossing thrust bore
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	2	item	$ 390,000	$ 780,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.6	**Water - minor (Lockyer Valley)**					50 m crossing Open cut (coffer dams)
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	Exception - cut and sink
	DN610 MSCL Distribution Pipework	-		$ -	$ -	Exception - cut and sink
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.7	**Water - major (Lockyer Valley)**					150 m crossing microtunnelling
	DN150 PVC-M PN16 Distribution Pipework	3	item	$ 470,000	$ 1,410,000	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	3	item	$ 600,000	$ 1,800,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	Exception - HDD
	DN610 MSCL Distribution Pipework	-		$ -	$ -	Exception - HDD
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.8	**Water - minor (Darling Downs)**					50 m crossing Open cut (coffer dams)
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	3	item	$ 160,000	$ 480,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	2	item	$ 220,000	$ 440,000	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: **A**

Project Capital Estimate
Option B

Quality/product: Class A+
Treatment: Partially recommission WCRWS AWTPs
Delivery: WCRWS pipeline + construction of Heathwood PS and upgrade of Gibson Island AWTP
Quantity (ML/d): 232
Quantity (ML/a): 84680

Item	Description	Qty	Unit	Rate	Amount	Comments
	DN762 MSCL Distribution Pipework	3	item	$ 220,000	$ 660,000	
	DN800 MSCL Distribution Pipework	1	item	$ 220,000	$ 220,000	
	DN914 MSCL Distribution Pipework	1	item	$ 230,000	$ 230,000	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	17	item	$ 250,000	$ 4,250,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.9	**Water - major (Darling Downs)**					150 m crossing microtunnelling
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	1	item	$ 720,000	$ 720,000	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN762 MSCL Distribution Pipework	-		$ -		
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	1	item	$ 880,000	$ 880,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
					$ -	
	Subtotal				**$ 16,860,000**	
7	**Power**					
7.1	Land Purchase	331.5	ha	$ 20,000	$ 6,630,000	**Outside Scope of WTP**
7.2	**Transfer**	Solar PV				
7.2.1	Heathwood PS	9.4	MW	$ 180,851	$ 1,700,000	only includes grid connection, PV not included due not available land
7.3	**Delivery**					
7.3.1	Lowood Booster PS	3.6	MW	$ 2,572,222	$ 9,260,000	
7.3.2	Gatton(interim booster PS)	69.0	MW	$ 2,132,609	$ 147,150,000	
7.3.3	Toowoomba Range (bottom)	60.0	MW	$ 2,137,500	$ 128,250,000	
	Subtotal				**$ 292,990,000**	
	DIRECT COSTS				**$ 1,035,985,096**	
8	**INDIRECTS**					
8.1	Design			10%	$ 103,598,510	
8.2	Project Management (owner's cost)			15%	$ 155,397,764	
8.3	Contingency			42%	$ 435,113,740.35	
	INDIRECT COSTS				**$ 694,110,014**	
	TOTAL COSTS				$ 1,730,095,110	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: **A**

Project Capital Estimate
Option C

Quality/product: Class B/C (as produced)
Treatment: Nil (STP effluent) for Darling DownsEnd of pipe treatment (to Class A+) for Lockyer Valley
Delivery: WCRWS pipeline + construction of Heathwood PS
Quantity (ML/d): 232
Quantity (ML/a): 84680

Item	Description	Qty	Unit	Rate	Amount	Comments
1	**PROJECT ESTABLISHMENT**					
1.1	Planning Period (10 People)	3	months	$ 259,800	$ 779,400	
1.2	Site office establishment	4	item	$ 250,000	$ 1,000,000	
	Subtotal				**$ 1,779,400**	
2	**TREATMENT/WCRWS**					
2.1	Water	1	item	$ 56,040,059	$ 56,040,059	
2.2	Concentrate	1	item	$ 1,030,510	$ 1,030,510	
	Subtotal				**$ 57,070,569**	
3	**PIPELINES**					
3.1	**Delivery**					
3.1.1	Lowood Booster PS to Gatton (interim booster PS) - DN1575 MSCL	25,161	m	$ 3,444	$ 86,656,509	DN1575 MSCL pipe
3.1.2	Gatton (interim booster PS) to Toowoomba Range (bottom) - DN1575 MSCL	22,733	m	$ 3,444	$ 78,294,281	DN1575 MSCL pipe
3.1.3	Gatton (interim booster PS) to Toowoomba Range (bottom) - DN1500 MSCL	15,509	m	$ 3,225	$ 50,013,891	DN1500 MSCL pipe
3.1.4	Toowoomba Range (bottom) to Toowoomba Range (top) - DN1500 MSCL	4,858	m	$ 3,225	$ 15,666,225	DN1500 MSCL pipe
3.2	**Distribution - Lockyer Valley**				$ -	
3.2.1	DN150 PVC-M PN16 Distribution Pipework	14,250	m	$ 234	$ 3,337,885	
3.2.2	DN200 PVC-M PN16 Distribution Pipework	3,403	m	$ 275	$ 934,342	
3.2.3	DN250 PVC-M PN16 Distribution Pipework	3,484	m	$ 332	$ 1,155,545	
3.2.4	DN300 PVC-M PN16 Distribution Pipework	2,295	m	$ 394	$ 903,305	
3.2.5	DN375 PVC-M PN16 Distribution Pipework	9,806	m	$ 524	$ 5,134,273	
3.2.6	DN502 MSCL Distribution Pipework	-			$ -	
3.2.7	DN559 MSCL Distribution Pipework	-			$ -	
3.2.8	DN648 MSCL Distribution Pipework	-			$ -	
3.2.9	DN711 MSCL Distribution Pipework	-			$ -	
3.2.10	DN762 MSCL Distribution Pipework	-			$ -	
3.2.11	DN800 MSCL Distribution Pipework	-			$ -	
3.2.12	DN813 MSCL Distribution Pipework	-			$ -	
3.2.13	DN914 MSCL Distribution Pipework	-			$ -	
3.2.14	DN960 MSCL Distribution Pipework	-			$ -	
3.2.15	DN1125 MSCL Distribution Pipework	-			$ -	
3.2.16	DN1290 MSCL Distribution Pipework	-			$ -	
3.2.17	DN1404 MSCL Distribution Pipework	-			$ -	
3.2.18	DN1422 MSCL Distribution Pipework	-			$ -	
3.2.19	DN1440 MSCL Distribution Pipework	-			$ -	
3.2.20	DN1500 MSCL Distribution Pipework	-			$ -	
3.2.21	DN1575 MSCL Distribution Pipework	-			$ -	
3.3	**Distribution - Darling Downs**				$ -	
3.3.1	DN150 PVC-M PN16 Distribution Pipework	-			$ -	
3.3.2	DN200 PVC-M PN16 Distribution Pipework	-			$ -	
3.3.3	DN250 PVC-M PN16 Distribution Pipework	-			$ -	
3.3.4	DN300 PVC-M PN16 Distribution Pipework	-			$ -	
3.3.5	DN375 PVC-M PN16 Distribution Pipework	58,351	m	$ 524	$ 30,551,699	
3.3.6	DN502 MSCL Distribution Pipework	8,393	m	$ 932	$ 7,822,499	
3.3.7	DN559 MSCL Distribution Pipework	2,972	m	$ 1,077	$ 3,202,242	
3.3.8	DN648 MSCL Distribution Pipework	9,273	m	$ 1,167	$ 10,819,842	
3.3.9	DN711 MSCL Distribution Pipework	10,698	m	$ 1,207	$ 12,916,041	
3.3.10	DN762 MSCL Distribution Pipework	5,693	m	$ 1,275	$ 7,261,336	
3.3.11	DN800 MSCL Distribution Pipework	8,602	m	$ 1,351	$ 11,624,251	
3.3.12	DN813 MSCL Distribution Pipework	-			$ -	
3.3.13	DN914 MSCL Distribution Pipework	14,419	m	$ 1,711	$ 24,674,140	
3.3.14	DN960 MSCL Distribution Pipework	-			$ -	
3.3.15	DN1125 MSCL Distribution Pipework	2,848	m	$ 2,059	$ 5,865,017	
3.3.16	DN1290 MSCL Distribution Pipework	-			$ -	
3.3.17	DN1404 MSCL Distribution Pipework	60,770	m	$ 2,870	$ 174,384,616	
3.3.18	DN1422 MSCL Distribution Pipework	-			$ -	
3.3.19	DN1440 MSCL Distribution Pipework	-			$ -	
3.3.20	DN1500 MSCL Distribution Pipework	-			$ -	
3.3.21	DN1575 MSCL Distribution Pipework	-			$ -	
	Subtotal				**$ 531,217,942**	
4	**PUMP STATIONS**					
4.1	**Transfer**					
4.1.1	Heathwood PS - 1589kW	730	m^2	$ 9,916	$ 7,238,884	2102 L/s @ 52m
4.2	**Delivery**					
4.1	Lowood Booster PS - 800kW	615	m^2	$ 9,967	$ 6,129,544	2929 L/s @ 16.7m
4.2	Gatton (interim booster PS) - 15087kW	666	m^2	$ 29,864	$ 19,889,406	2929 L/s @ 315m
4.3	Toowoomba Range (bottom) - 12659kW	666	m^2	$ 27,016	$ 17,992,565	2670 L/s @ 290m
	Subtotal				**$ 51,250,400**	
5	**STORAGE**					
5.1	Farm storages	4	item	$ 630,000	$ 2,520,000	Lockyer Valley storage
	- earthworks	42000	m^3	$ 15	$ 630,000	1 GL storage
	Subtotal				**$ 2,520,000**	
6	**CROSSINGS**					Crossings, access tracks, land ownership, traffic management, fibre optic cable, environmental offset costs
6.1	**Railway**					100 m crossing length microtunnelling
	DN200 PVC-M PN16 Pipework	1	item	$ 170,000	$ 170,000	
	DN375 PVC-M PN16 Pipework	1	item	$ 200,000	$ 200,000	
	DN1422 MSCL Pipework	1	item	$ 350,000	$ 350,000	
	DN1500 MSCL Pipework	2	item	$ 350,000	$ 700,000	
	DN1575 MSCL Pipework	1	item	$ 350,000	$ 350,000	
6.2	**Road - minor (Lockyer Valley)**					50 m crossing cut and cover
	DN150 PVC-M PN16 Distribution Pipework	1	item	$ 80,000	$ 80,000	
	DN200 PVC-M PN16 Distribution Pipework	1	item	$ 90,000	$ 90,000	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	2	item	$ 100,000	$ 200,000	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: **A**

Project Capital Estimate
Option C

Quality/product: Class B/C (as produced)
Treatment: Nil (STP effluent) for Darling DownsEnd of pipe treatment (to Class A+) for Lockyer Valley
Delivery: WCRWS pipeline + construction of Heathwood PS
Quantity (ML/d): 232
Quantity (ML/a): 84680

Item	Description	Qty	Unit	Rate	Amount	Comments
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.3	**Road - major (Lockyer Valley)**					100 m crossing thrust bore
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	2	item	$ 210,000	$ 420,000	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	2	item	$ 240,000	$ 480,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.4	**Road - minor (Darling Downs)**					50 m crossing cut and cover
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	5	item	$ 100,000	$ 500,000	
	DN502 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN559 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN914 MSCL Distribution Pipework	2	item	$ 150,000	$ 300,000	
	DN1404 MSCL Distribution Pipework	4	item	$ 175,000	$ 700,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.5	**Road - major (Darling Downs)**					100 m crossing thrust bore
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	2	item	$ 390,000	$ 780,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.6	**Water - minor (Lockyer Valley)**					50 m crossing Open cut (coffer dams)
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	Exception - cut and sink
	DN610 MSCL Distribution Pipework	-		$ -	$ -	Exception - cut and sink
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.7	**Water - major (Lockyer Valley)**					150 m crossing microtunnelling
	DN150 PVC-M PN16 Distribution Pipework	3	item	$ 470,000	$ 1,410,000	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	3	item	$ 600,000	$ 1,800,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	Exception - HDD
	DN610 MSCL Distribution Pipework	-		$ -	$ -	Exception - HDD
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.8	**Water - minor (Darling Downs)**					50 m crossing Open cut (coffer dams)
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	3	item	$ 160,000	$ 480,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	2	item	$ 220,000	$ 440,000	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: **A**

Project Capital Estimate
Option C

Quality/product: Class B/C (as produced)
Treatment: Nil (STP effluent) for Darling DownsEnd of pipe treatment (to Class A+) for Lockyer Valley
Delivery: WCRWS pipeline + construction of Heathwood PS
Quantity (ML/d): 232
Quantity (ML/a): 84680

Item	Description	Qty	Unit	Rate	Amount	Comments
	DN762 MSCL Distribution Pipework	3	item	$ 220,000	$ 660,000	
	DN800 MSCL Distribution Pipework	1	item	$ 220,000	$ 220,000	
	DN914 MSCL Distribution Pipework	1	item	$ 230,000	$ 230,000	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	17	item	$ 250,000	$ 4,250,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.9	**Water - major (Darling Downs)**					150 m crossing microtunnelling
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	1	item	$ 720,000	$ 720,000	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN762 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	1	item	$ 880,000	$ 880,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
	Subtotal				**$ 16,860,000**	
7	**Power**					
7.1	Land Purchase	331.5	ha	$ 20,000	$ 6,630,000	**Outside Scope of WTP**
7.2	**Transfer**	Solar PV				
7.2.1	Heathwood PS	9.4	MW	$ 180,851	$ 1,700,000	only includes grid connection, PV not included due not available land
7.3	**Delivery**					
7.3.1	Lowood Booster PS	3.6	MW	$ 2,572,222	$ 9,260,000	
7.3.2	Gatton(interim booster PS)	69.0	MW	$ 2,132,609	$ 147,150,000	
7.3.3	Toowoomba Range (bottom)	60.0	MW	$ 2,137,500	$ 128,250,000	
	Subtotal				**$ 292,990,000**	
	DIRECT COSTS				**$ 953,688,311**	
8	**INDIRECTS**					
8.1	Design			10%	$ 95,368,831	
8.2	Project Management (owner's cost)			15%	$ 143,053,247	
8.3	Contingency			42%	$ 400,549,090.62	
	INDIRECT COSTS				**$ 638,971,168**	
	TOTAL COSTS				**$ 1,592,659,479**	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: **A**

Project Capital Estimate
Option D

Quality/product: PRW (LV)
Treatment: Fully recommission LP & GI AWTPs
WCRWS pipeline (current capacity) and Pipeline from Bundamba AWTP to Lowood
Delivery: Booster PS
Quantity (ML/d): 200
Quantity (ML/a): 73000

Item	Description	Qty	Unit	Rate	Amount	Comments
1	**PROJECT ESTABLISHMENT**					
1.1	Planning Period (10 People)	3	months	$ 259,800	$ 779,400	
1.2	Site office establishment	7	item	$ 250,000	$ 1,750,000	
	Subtotal				**$ 2,529,400**	
2	**TREATMENT/WCRWS**					Lockyer Valley only
2.1	Water				$ 113,760,000	
2.2	Concentrate				$ 11,026,001	
	Subtotal				**$ 124,786,001**	
3	**PIPELINES**					
3.1	**Transfer**					
3.1.1	Bundamba AWTP to Lowood Booster PS	32,000	m	$ 1,711	$ 54,759,171	DN914 MSCL
3.2	**Delivery - Lockyer Valley**					
3.2.1	Lowood Booster PS to Gatton (interim booster PS)				$ -	
3.2.1.1	DN502 MSCL Delivery Pipework	23,514	m	$ 932	$ 21,915,673	DN502 MSCL pipe
3.2.2	Gatton (interim booster PS) to end of Lockyer Valley				$ -	
3.2.2.1	DN502 MSCL Delivery Pipework	17,547	m	$ 932	$ 16,354,271	DN502 MSCL pipe
3.2.2.2	DN200 PVC-M PN16 Delivery Pipework	5,758	m	$ 275	$ 1,580,942	DN200 PVC-M PN16
3.3	**Delivery - Darling Downs**					
3.3.1	Lowood Booster PS to Gatton (interim booster PS)	25,213	m	$ 2,919	$ 73,598,651	DN1422 MSCL pipe
3.3.2	Gatton (interim booster PS) to Toowoomba Range (bottom)	37,716	m	$ 2,919	$ 110,095,853	DN1422 MSCL pipe
3.3.3	Toowoomba Range (bottom) to Toowoomba Range (top)	5,446	m	$ 2,919	$ 15,897,285	DN1422 MSCL pipe
3.4	**Distribution - Lockyer Valley**					
3.4.1	DN150 PVC-M PN16 Distribution Pipework	14,250	m	$ 234	$ 3,337,885	
3.4.2	DN200 PVC-M PN16 Distribution Pipework	3,403	m	$ 275	$ 934,342	
3.4.3	DN250 PVC-M PN16 Distribution Pipework	3,484	m	$ 332	$ 1,155,545	
3.4.4	DN300 PVC-M PN16 Distribution Pipework	2,295	m	$ 394	$ 903,305	
3.4.5	DN375 PVC-M PN16 Distribution Pipework	9,806	m	$ 524	$ 5,134,273	
3.4.6	DN502 MSCL Distribution Pipework	-			$ -	
3.4.7	DN559 MSCL Distribution Pipework	-			$ -	
3.4.8	DN648 MSCL Distribution Pipework	-			$ -	
3.4.9	DN711 MSCL Distribution Pipework	-			$ -	
3.4.10	DN762 MSCL Distribution Pipework	-			$ -	
3.4.11	DN800 MSCL Distribution Pipework	-			$ -	
3.4.12	DN813 MSCL Distribution Pipework	-			$ -	
3.4.13	DN914 MSCL Distribution Pipework	-			$ -	
3.4.14	DN960 MSCL Distribution Pipework	-			$ -	
3.4.15	DN1125 MSCL Distribution Pipework	-			$ -	
3.4.16	DN1290 MSCL Distribution Pipework	-			$ -	
3.4.17	DN1404 MSCL Distribution Pipework	-			$ -	
3.4.18	DN1422 MSCL Distribution Pipework	-			$ -	
3.4.19	DN1440 MSCL Distribution Pipework	-			$ -	
3.4.20	DN1500 MSCL Distribution Pipework	-			$ -	
3.4.21	DN1575 MSCL Distribution Pipework	-			$ -	
3.5	**Distribution - Darling Downs**					
3.5.1	DN150 PVC-M PN16 Distribution Pipework	-			$ -	
3.5.2	DN200 PVC-M PN16 Distribution Pipework	-			$ -	
3.5.3	DN250 PVC-M PN16 Distribution Pipework	-			$ -	
3.5.4	DN300 PVC-M PN16 Distribution Pipework	-			$ -	
3.5.5	DN375 PVC-M PN16 Distribution Pipework	58,351	m	$ 524	$ 30,551,699	
3.5.6	DN502 MSCL Distribution Pipework	8,393	m	$ 932	$ 7,822,499	
3.5.7	DN559 MSCL Distribution Pipework	12,245	m	$ 1,077	$ 13,193,627	
3.5.8	DN648 MSCL Distribution Pipework	10,698	m	$ 1,167	$ 12,482,548	
3.5.9	DN711 MSCL Distribution Pipework	8,602	m	$ 1,207	$ 10,385,473	
3.5.10	DN762 MSCL Distribution Pipework	5,693	m	$ 1,275	$ 7,261,336	
3.5.11	DN800 MSCL Distribution Pipework	-			$ -	
3.5.12	DN813 MSCL Distribution Pipework	-			$ -	
3.5.13	DN914 MSCL Distribution Pipework	14,419	m	$ 1,711	$ 24,674,140	
3.5.14	DN960 MSCL Distribution Pipework	2,848	m	$ 1,689	$ 4,811,577	
3.5.15	DN1125 MSCL Distribution Pipework	-			$ -	
3.5.16	DN1290 MSCL Distribution Pipework	60,770	m	$ 2,563	$ 155,782,615	
3.5.17	DN1404 MSCL Distribution Pipework	-			$ -	
3.5.18	DN1422 MSCL Distribution Pipework	-			$ -	
3.5.19	DN1440 MSCL Distribution Pipework	-			$ -	
3.5.20	DN1500 MSCL Distribution Pipework	-			$ -	
3.5.21	DN1575 MSCL Distribution Pipework	-			$ -	
					$ -	
	Subtotal				**$ 572,632,712**	
4	**PUMP STATIONS**					
4.1	**Transfer**					
4.1.1	Bundamba to Lowood Booster PS - 2251kW	315	m^2	$ 25,237	$ 7,949,622	
4.2	**Delivery - Lockyer Valley**					
4.2.1	Lowood Booster PS - 382kW	349	m^2	$ 14,546	$ 5,076,381	259 L/s @ 90m
4.2.2	Gatton Booster PS - 1048kW	495	m^2	$ 13,353	$ 6,609,819	259 L/s @ 247m
4.3	**Delivery - Darling Downs**					
4.3.1	Lowood Booster PS - 796kW	349	m^2	$ 16,773	$ 5,853,886	2266 L/s @ 22m
4.3.2	Gatton (interim booster PS) - 11299kW	666	m^2	$ 25,761	$ 17,156,529	2266 L/s @ 305m
4.3.3	Toowoomba Range (bottom) - 11299kW	666	m^2	$ 25,936	$ 17,273,529	2266 L/s @ 305m
4.4	**Distribution - Lockyer Valley**					
4.2.3	Upper Tenthill Booster PS - 74kW	255	m^2	$ 18,080	$ 4,610,444	57 L/s @ 80m
	Subtotal				**$ 64,530,211**	
5	**STORAGE**					Assume delivery straight to farm / on-farm storage
	Subtotal				**$ -**	
6	**CROSSINGS**					Crossings, access tracks, land ownership, traffic management, fibre optic cable, environmental offset costs
6.1	**Railway**					100 m crossing length microtunnelling

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

Project No: 41-30968
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Revision: **A**

Project Capital Estimate
Option D

Quality/product: PRW (LV)
Treatment: Fully recommission LP & GI AWTPs
WCRWS pipeline (current capacity) and Pipeline from Bundamba AWTP to Lowood
Delivery: Booster PS
Quantity (ML/d): 200
Quantity (ML/a): 73000

Item	Description	Qty	Unit	Rate	Amount	Comments
	DN200 PVC-M PN16 Pipework	1	item	$ 170,000	$ 170,000	
	DN375 PVC-M PN16 Pipework	1	item	$ 200,000	$ 200,000	
	DN1290 MSCL Pipework	1	item	$ 340,000	$ 340,000	
	DN1422 MSCL Pipework	3	item	$ 350,000	$ 1,050,000	
6.2	**Road - minor (Lockyer Valley +)**					50 m crossing cut and cover
	DN150 PVC-M PN16 Distribution Pipework	1	item	$ 80,000	$ 80,000	
	DN200 PVC-M PN16 Distribution Pipework	1	item	$ 90,000	$ 90,000	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	2	item	$ 100,000	$ 200,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	4	item	$ 150,000	$ 600,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.3	**Road - major (Lockyer Valley +)**					100 m crossing thrust bore
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	2	item	$ 210,000	$ 420,000	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	2	item	$ 240,000	$ 480,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN610 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	3	item	$ 340,000	$ 1,020,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.4	**Road - minor (Darling Downs)**					50 m crossing cut and cover
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	5	item	$ 100,000	$ 500,000	
	DN502 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN559 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	1	item	$ 150,000	$ 150,000	
	DN914 MSCL Distribution Pipework	2	item	$ 150,000	$ 300,000	
	DN1404 MSCL Distribution Pipework	4	item	$ 175,000	$ 700,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.5	**Road - major (Darling Downs)**					100 m crossing thrust bore
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	2	item	$ 390,000	$ 780,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.6	**Water - minor (Lockyer Valley +)**					50 m crossing Open cut (coffer dams)
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	Exception - cut and sink
	DN610 MSCL Distribution Pipework	-		$ -	$ -	Exception - cut and sink
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	11	item	$ 230,000	$ 2,530,000	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.7	**Water - major (Lockyer Valley +)**					150 m crossing microtunnelling
	DN150 PVC-M PN16 Distribution Pipework	3	item	$ 470,000	$ 1,410,000	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	3	item	$ 600,000	$ 1,800,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN508 MSCL Distribution Pipework	-		$ -	$ -	Exception - HDD
	DN610 MSCL Distribution Pipework	-		$ -	$ -	Exception - HDD
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	2	item	$ 790,000	$ 1,580,000	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	

Queensland Farmers' Federation Ltd
NuWater Project Feasibility Study

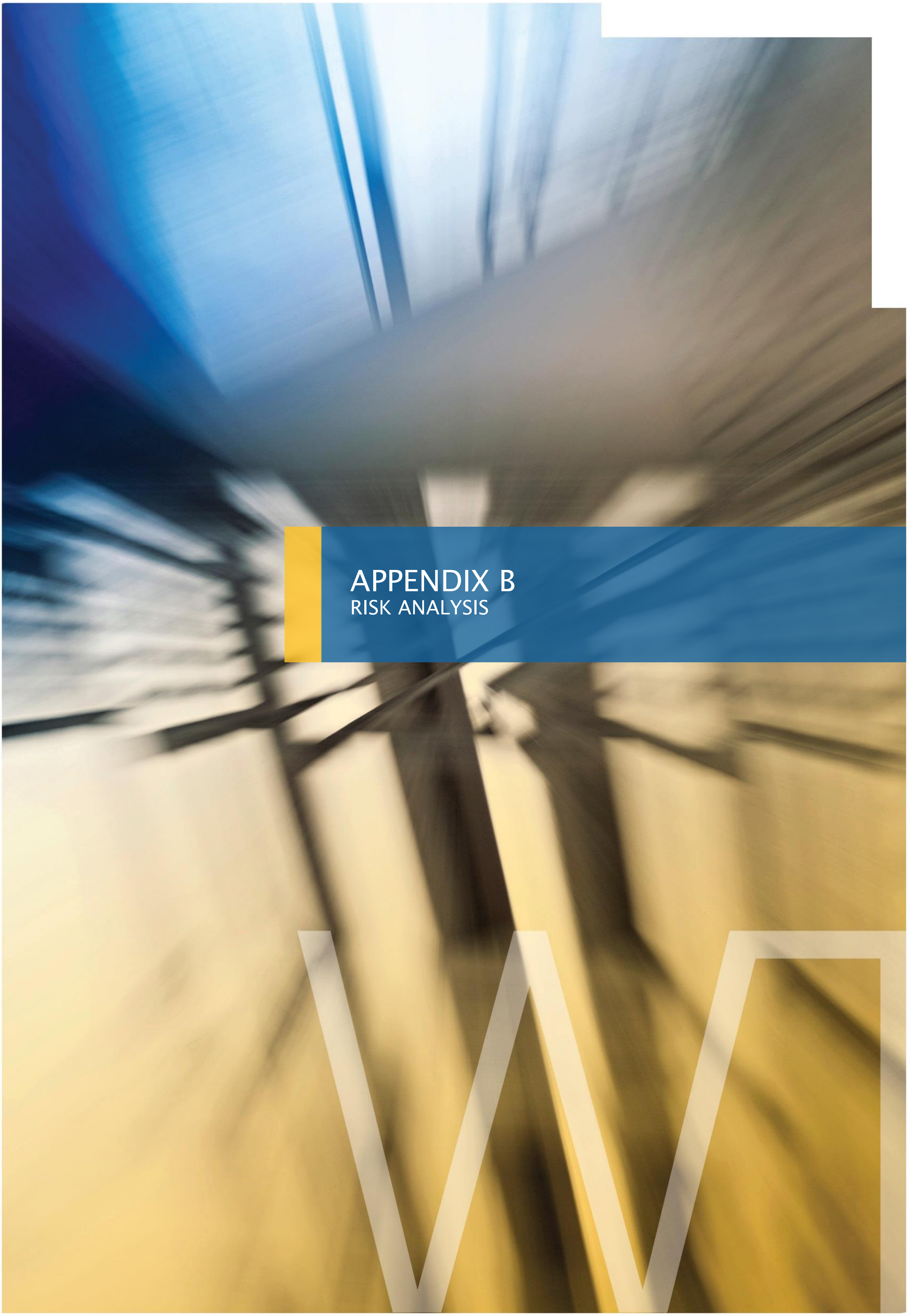
Project Capital Estimate
Option D

Project No: 41-30968
Prepared By:
Reviewed By:
Revision: **A**

Quality/product: PRW (LV)
Treatment: Fully recommission LP & GI AWTPs
WCRWS pipeline (current capacity) and Pipeline from Bundamba AWTP to Lowood
Delivery: Booster PS
Quantity (ML/d): 200
Quantity (ML/a): 73000

Item	Description	Qty	Unit	Rate	Amount	Comments
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.8	**Water - minor (Darling Downs)**					50 m crossing Open cut (coffer dams)
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	3	item	$ 160,000	$ 480,000	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	-		$ -	$ -	
	DN711 MSCL Distribution Pipework	2	item	$ 220,000	$ 440,000	
	DN762 MSCL Distribution Pipework	3	item	$ 220,000	$ 660,000	
	DN800 MSCL Distribution Pipework	1	item	$ 220,000	$ 220,000	
	DN914 MSCL Distribution Pipework	1	item	$ 230,000	$ 230,000	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	17	item	$ 250,000	$ 4,250,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
6.9	**Water - major (Darling Downs)**					150 m crossing microtunnelling
	DN150 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN200 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN250 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN375 PVC-M PN16 Distribution Pipework	-		$ -	$ -	
	DN502 MSCL Distribution Pipework	-		$ -	$ -	
	DN559 MSCL Distribution Pipework	-		$ -	$ -	
	DN648 MSCL Distribution Pipework	1	item	$ 720,000	$ 720,000	
	DN711 MSCL Distribution Pipework	-		$ -	$ -	
	DN762 MSCL Distribution Pipework	-		$ -	$ -	
	DN800 MSCL Distribution Pipework	-		$ -	$ -	
	DN914 MSCL Distribution Pipework	-		$ -	$ -	
	DN1125 MSCL Distribution Pipework	-		$ -	$ -	
	DN1404 MSCL Distribution Pipework	1	item	$ 880,000	$ 880,000	
	DN1500 MSCL Distribution Pipework	-		$ -	$ -	
	DN1575 MSCL Distribution Pipework	-		$ -	$ -	
	Subtotal				**$ 22,580,000**	
7	**Power**					
7.1	Land Purchase	366.35	ha	$ 20,000	$ 7,327,000.0	**Outside Scope of WTP**
7.2	**Transfer**	Solar PV				
7.2.1	Bundamba to Lowood Booster PS	7.3	MW	$ 2,332,877	$ 17,030,000.0	Includes PV and grid connection
7.3	**Delivery - Lockyer Valley**					
7.3.1	Lowood Booster PS	1.6	MW	$ 3,162,500	$ 5,060,000.0	Includes PV and grid connection
7.3.2	Gatton Booster PS	4.7	MW	$ 2,578,723	$ 12,120,000.0	Includes PV and grid connection
7.4	**Delivery - Darling Downs**					
7.4.1	Lowood Booster PS	3.6	MW	$ 2,572,222	$ 9,260,000.0	Includes PV and grid connection
7.4.2	Gatton(interim booster PS)	69.0	MW	$ 2,132,609	$ 147,150,000.0	Includes PV and grid connection
7.4.3	Toowoomba Range (bottom)	60.0	MW	$ 2,137,500	$ 128,250,000.0	Includes PV and grid connection
7.5	**Distribution - Lockyer Valley**					
7.5.1	Upper Tenthill Booster PS	0.3	MW	$ 7,100,000	$ 2,414,000.0	
						$ 19,926,000.00
	Subtotal				**$ 328,611,000**	$ 308,685,000.0
	DIRECT COSTS				**$ 1,115,669,324**	
	Lockyer Valley Component				$ 109,643,156	
	Darling Downs Component				$ 980,916,769	
8	**INDIRECTS**					
8.1	Design			10%	$ 111,566,932	
8.2	Project Management (owner's cost)			15%	$ 167,350,399	
8.3	Contingency			42%	$ 468,581,116.08	
	INDIRECT COSTS				**$ 747,498,447**	
	Lockyer Valley Component				**$ 73,460,914**	
	Darling Downs Component				**$ 657,214,234.93**	
	TOTAL COSTS				**$ 1,863,167,771**	
	TOTAL Lockyer Valley				$ 183,104,070	
	TOTAL Darling Downs				$ 1,638,131,003	

APPENDIX B
RISK ANALYSIS

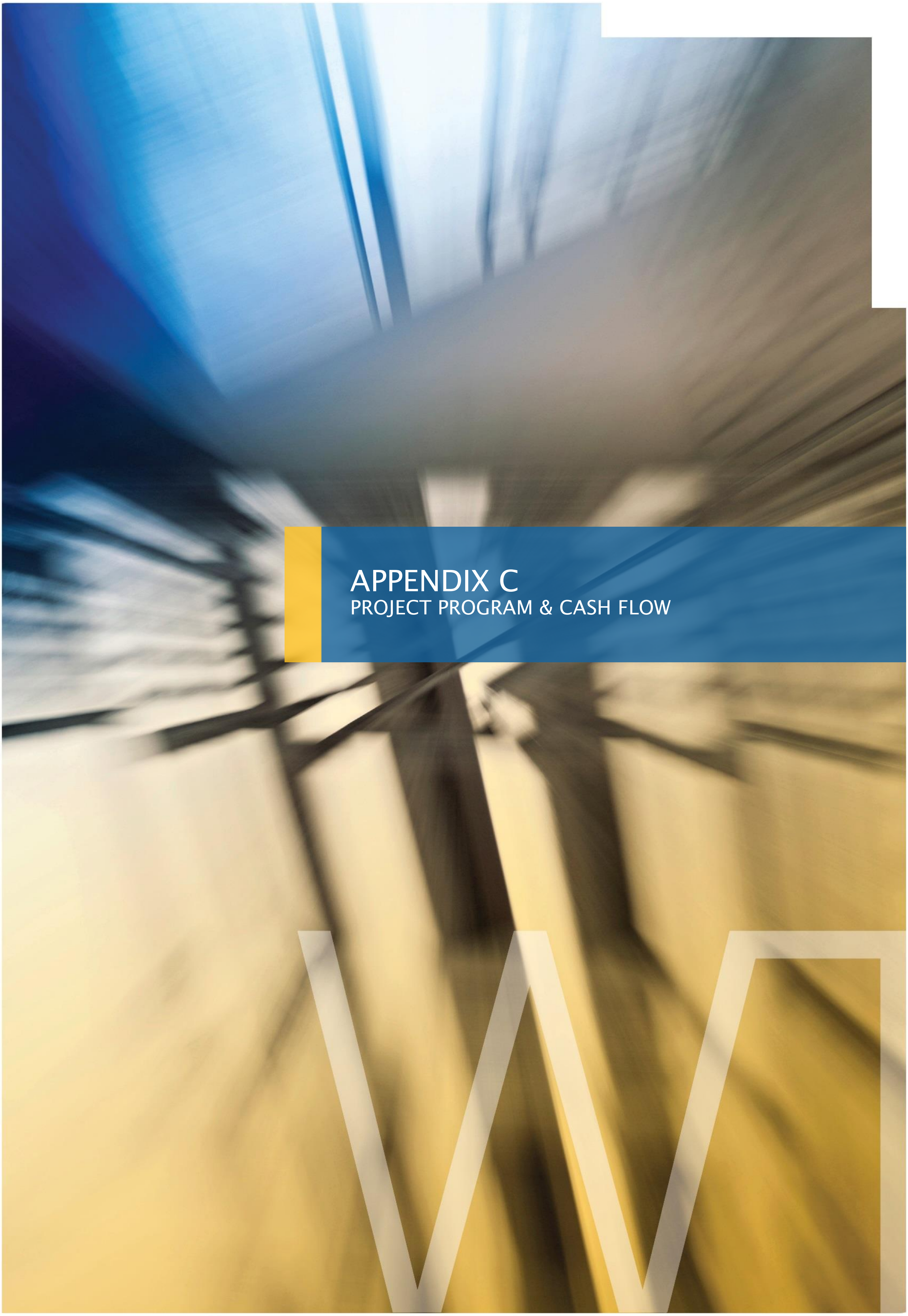


STRATEGIC CONTINGENCY/ RISK TABLE

Estimate Stage: Strategic / Planning

Project Location:	Queensland
Project Description:	171517-NuWater Feasability

Task/activity	Comments	Highly Confident & Reliable	Reasonably Confident & Reliable	Not Confident & Not Reliable	Adopted Contingency
Project Scope	Is it well defined? Yes V No Λ	3%	4%	5%	5%
	Is there room to vary the works? Yes Λ No V	3%	4%	5%	5%
	Are there many options? Yes Λ No V	3%	4%	5%	5%
Risks	Are there Significant Risks? Yes Λ No V Political, Community, Technical, Financial.	5%	6%	8%	6%
	Has a detailed Risk analysis been done? Yes V No Λ	4%	6%	7%	6%
Constructability	Has a constructability review been undertaken? Yes V No Λ	3%	4%	5%	5%
	Is constructability a problem? Yes Λ No V	3%	4%	5%	5%
Key Dates	Are the Project dates known? Yes V No Λ	1%	2%	3%	1%
	Is the project planned for the distant future? Yes Λ No V	1%	2%	3%	1%
Information	Has investigation been Undertaken? Yes V No Λ Geotechnical, Heritage, Environmental, Technical, Hydraulic	9%	12%	15%	9%
Length of the Project	Is the Project Short? Yes Λ No V	4%	7%	10%	4%
Scalability	What is the size of the project? Large Λ Small V small, medium, large	0%	-5%	-10%	-10%
				Total Contingency percentage to be adopted:	**42%**

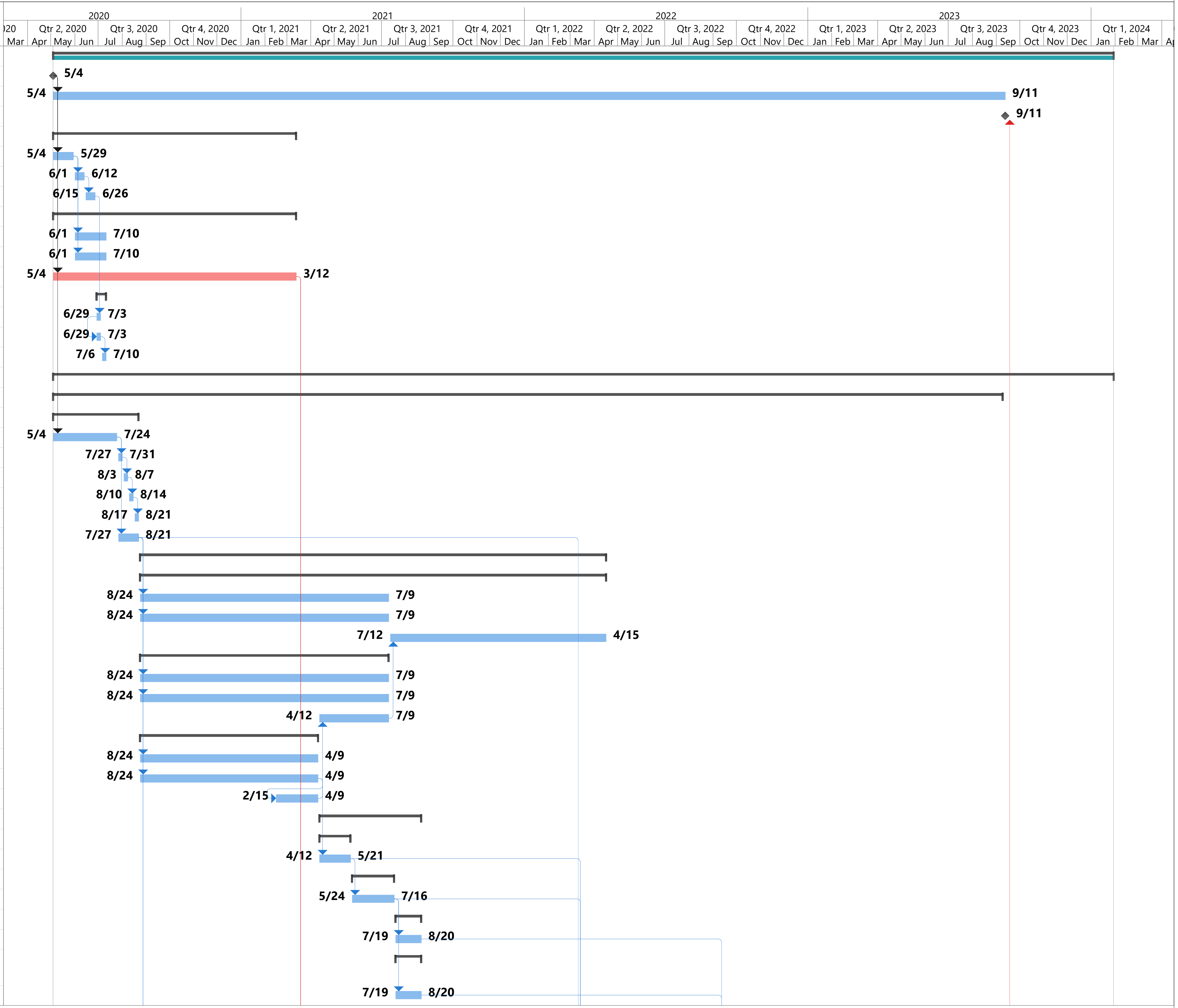


APPENDIX C

PROJECT PROGRAM & CASH FLOW

NuWater - Preliminary Design - Draft Construction Program_B

ID	Task Name
1	**Project**
2	Award of Contract
3	Project Duration
4	Project Completion
5	**Preliminaries**
6	Submission of insurance and contractors documents
7	Client review & approval documents
8	Estimated Possession of Site & Induction
9	**Procurement**
10	HDPE pipes
11	Steel pipes
12	Pumps
13	**Mobilisation**
14	Site Establishment
15	Office Setup
16	Survey & Setout
17	**Construction**
18	**NuWater Project**
19	**Preconstruction works**
20	Planning period
21	Installation of traffic management signage
22	Installation of ersosion and sediment control devices
23	Installation of noise & vibration monitoring devices
24	Peform water quality baseline testing
25	Condition surveys
26	**Transfer Lines**
27	**Stage 1 - Redcliffe STP to Sandgate STP**
28	DN508 Mild steel cement lined pipeline
29	DN508 Mild steel cement lined pipeline
30	Super Crossings
31	**Stage 2 - Sandgate STP to Luggage Point STP**
32	DN610 Mild steel cement lined pipeline
33	DN610 Mild steel cement lined pipeline
34	Super Crossings
35	**Stage 3 - Luggage Point STP to Gibson Island STP**
36	DN900 HDPE Pipeline
37	DN900 HDPE Pipeline
38	Super Crossings
39	**Delivery Lines**
40	**Stage 4 - Lowood Booster PS to Gatton Booster PS**
41	DN1575 Mild steel cement lined pipeline
42	**Stage 5a - Gatton Booster PS to bottom Toowoomba Range**
43	DN1575 Mild steel cement lined pipeline
44	**Stage 5b - Gatton Booster PS to bottom Toowoomba Range**
45	DN1500 Mild steel cement lined pipeline
46	**Stage 6 - Toowoomba Range bottom to Toowoomba Range top**
47	DN1500 Mild steel cement lined pipeline



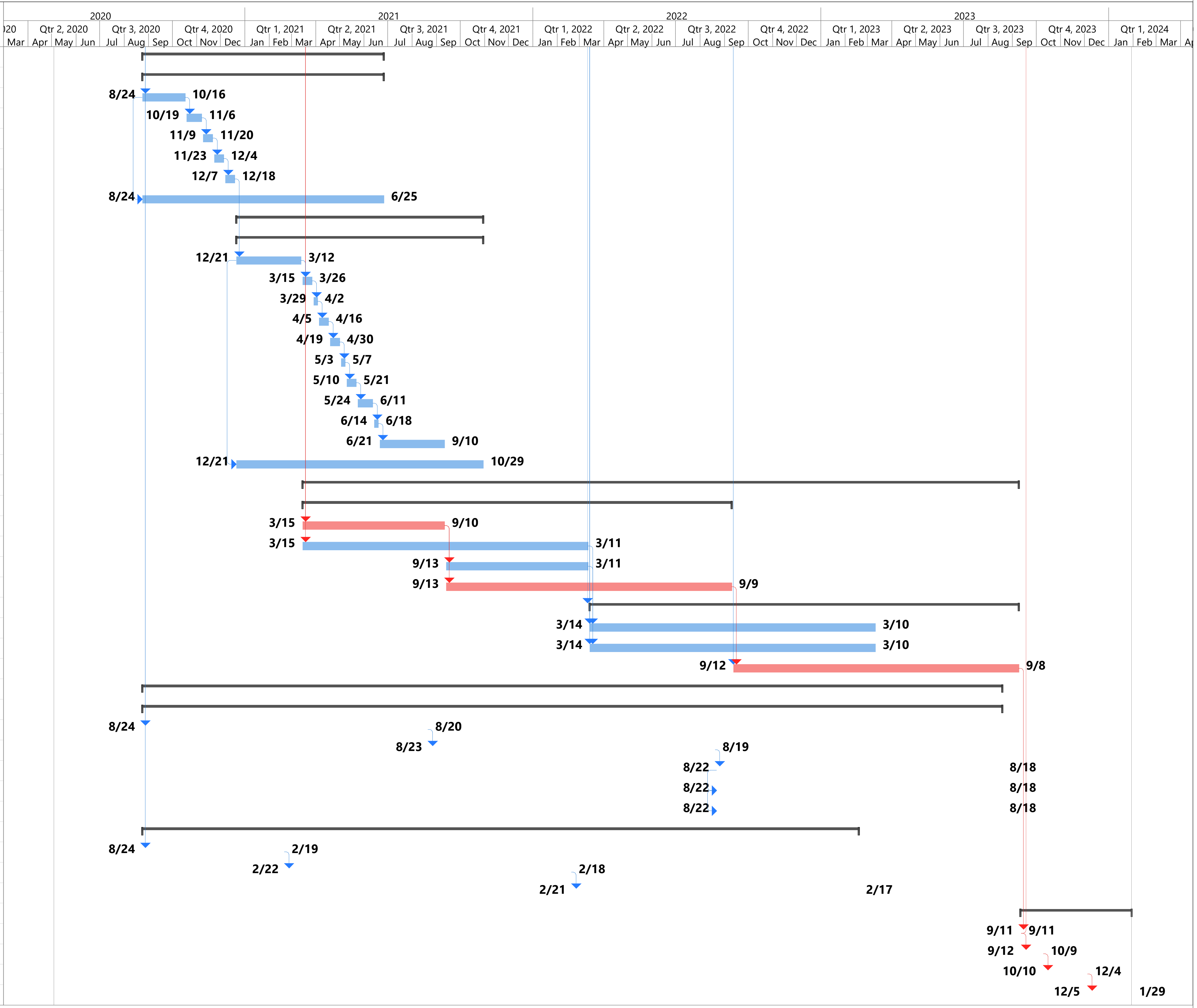
WT PARTNERS

Date: Thu 11/23/17

Task
Split
Milestone ◆
Summary
Project Summary
Inactive Task
Inactive Milestone ◇
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only [
Finish-only]
External Tasks
External Milestone ◆
Deadline ⬇
Critical
Critical Split
Progress
Manual Progress

NuWater - Preliminary Design - Draft Construction Program_B

ID	Task Name
48	**Distribution - Lockyer Valley**
49	**Stage 7**
50	DN150 PVC-M PN16 Distribution Pipework
51	DN200 PVC-M PN16 Distribution Pipework
52	DN250 PVC-M PN16 Distribution Pipework
53	DN300 PVC-M PN16 Distribution Pipework
54	DN375 PVC-M PN16 Distribution Pipework
55	Crossings, incl 6 x Rail
56	**Distribution - Darling Downs**
57	**Stage 8**
58	DN375 PVC-M PN16 Distribution Pipework
59	DN502 MSCL Distribution Pipework
60	DN559 MSCL Distribution Pipework
61	DN648 MSCL Distribution Pipework
62	DN711 MSCL Distribution Pipework
63	DN762 MSCL Distribution Pipework
64	DN800 MSCL Distribution Pipework
65	DN914 MSCL Distribution Pipework
66	DN1125 MSCL Distribution Pipework
67	DN1404 MSCL Distribution Pipework
68	Crossings
69	**Pump Stations**
70	**Transfer**
71	Redcliffe STP - 157kW
72	Sandgate STP - 476kW
73	Luggage Point to Gibson Island (additional) - 214kW
74	Heathwood PS - 1787kW
75	**Delivery**
76	Lowood Booster PS - 800kW
77	Gatton (interim booster PS) - 15087kW
78	Toowoomba Range (bottom) - 12659kW
79	**Power**
80	**Transfer**
81	Land
82	Redcliffe STP
83	Sandgate STP
84	Luggage Point to Gibson Island (additional)
85	Heathwood PS
86	**Delivery**
87	Lowood Booster PS
88	Gatton (interim booster PS)
89	Toowoomba Range (bottom)
90	**Project Completion**
91	Contractor date for practical completion
92	Site disestablishment
93	Contractors float
94	Inclement weather allowance



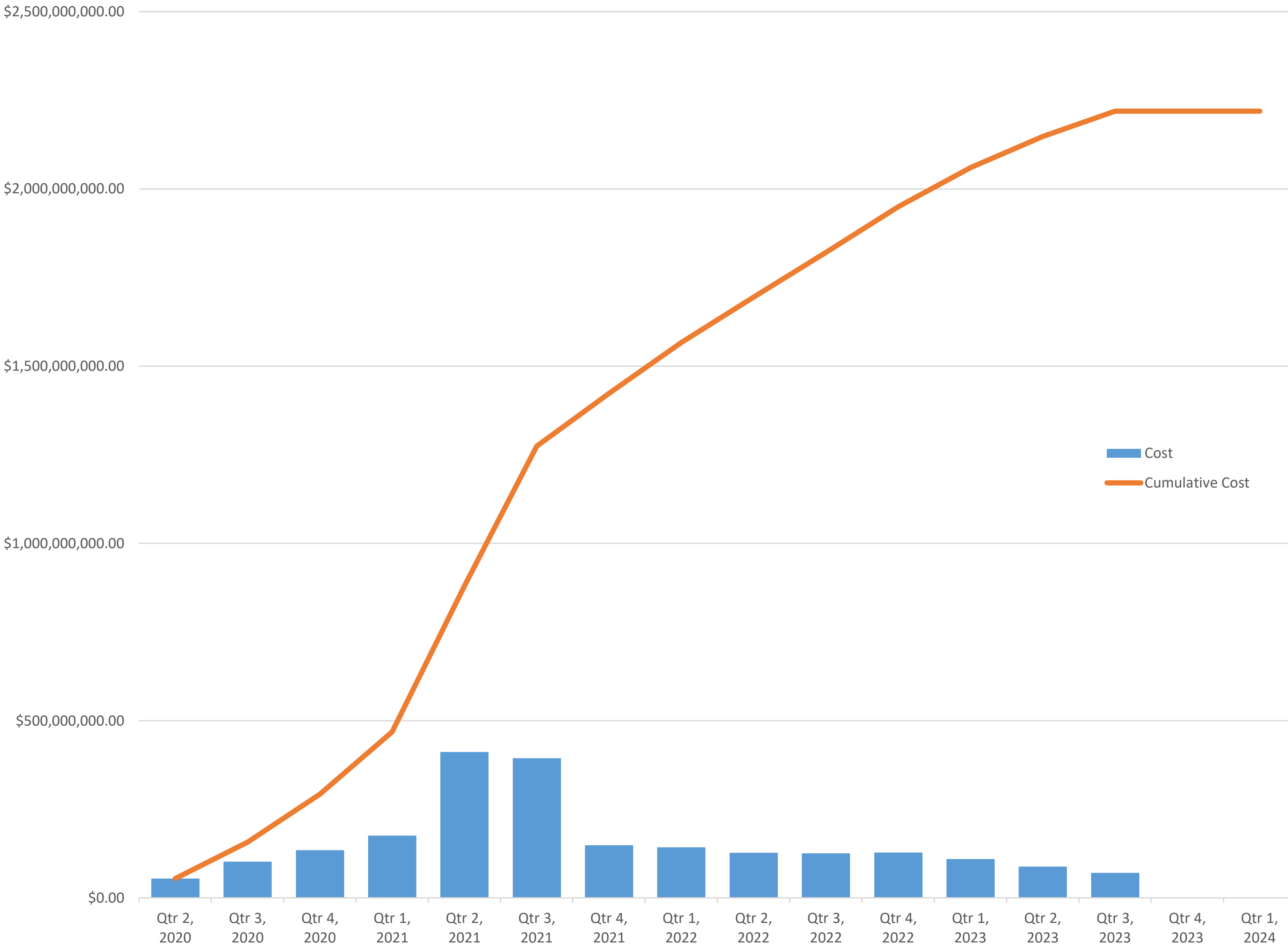
Task	Project Summary	Manual Task	Start-only	Deadline	Manual Progress
Split	Inactive Task	Duration-only	Finish-only	Critical	
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Critical Split	
Summary	Inactive Summary	Manual Summary	External Milestone	Progress	

WT PARTNERS

Date: Thu 11/23/17

Actual Cost	Baseline Cost	Remaining Cost	Cost Variance
$0.00	$0.00	$2,219,525,248.00	$2,219,525,248.00

CASH FLOW

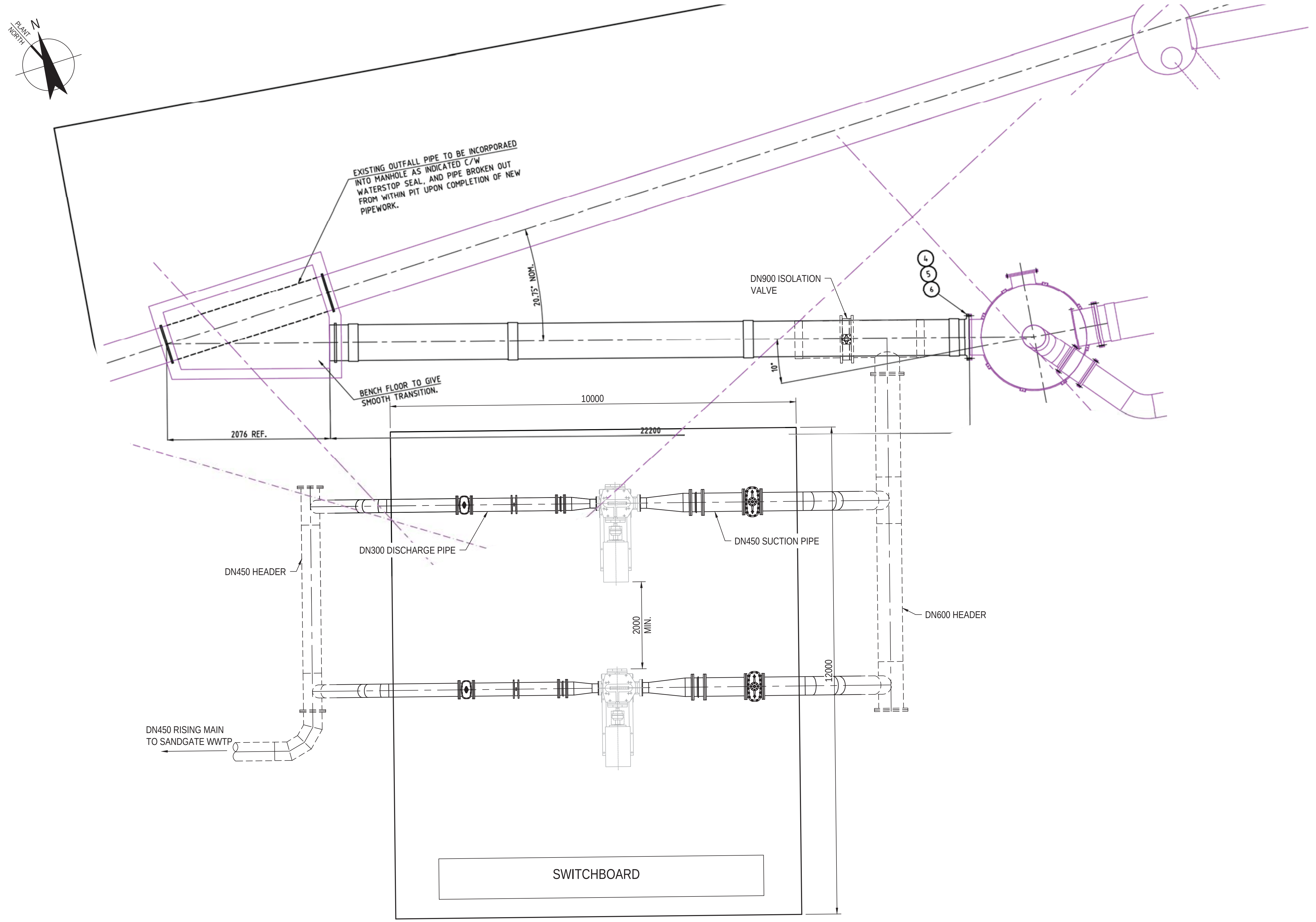


The chart shows the project's cumulative cost and the cost per quater.
To see the costs for a different time period, select the Edit option from the Field List.

The table below shows cost information for all top-level tasks.
To see cost stats for all tasks, set the Outline Level in the Field List.

Name	Actual Cost	Cost
Project	$0.00	$2,219,525,248.00

Appendix G – Short Listed Options - Technical Details



EXISTING OUTFALL PIPE TO BE INCORPORAED INTO MANHOLE AS INDICATED C/W WATERSTOP SEAL, AND PIPE BROKEN OUT FROM WITHIN PIT UPON COMPLETION OF NEW PIPEWORK.

PUMP STATION PLAN

SCALE 1:50

PRELIMINARY

UR	UNDER REVISION				
No	Revision Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Job Manager	Project Director	Date

0 500 1000 1500 2000 2500mm

SCALE 1:50 AT ORIGINAL SIZE

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Designer K.WALDUCK
Drafting Check
Design Check
Approved (Project Director)
Date
Scale AS SHOWN
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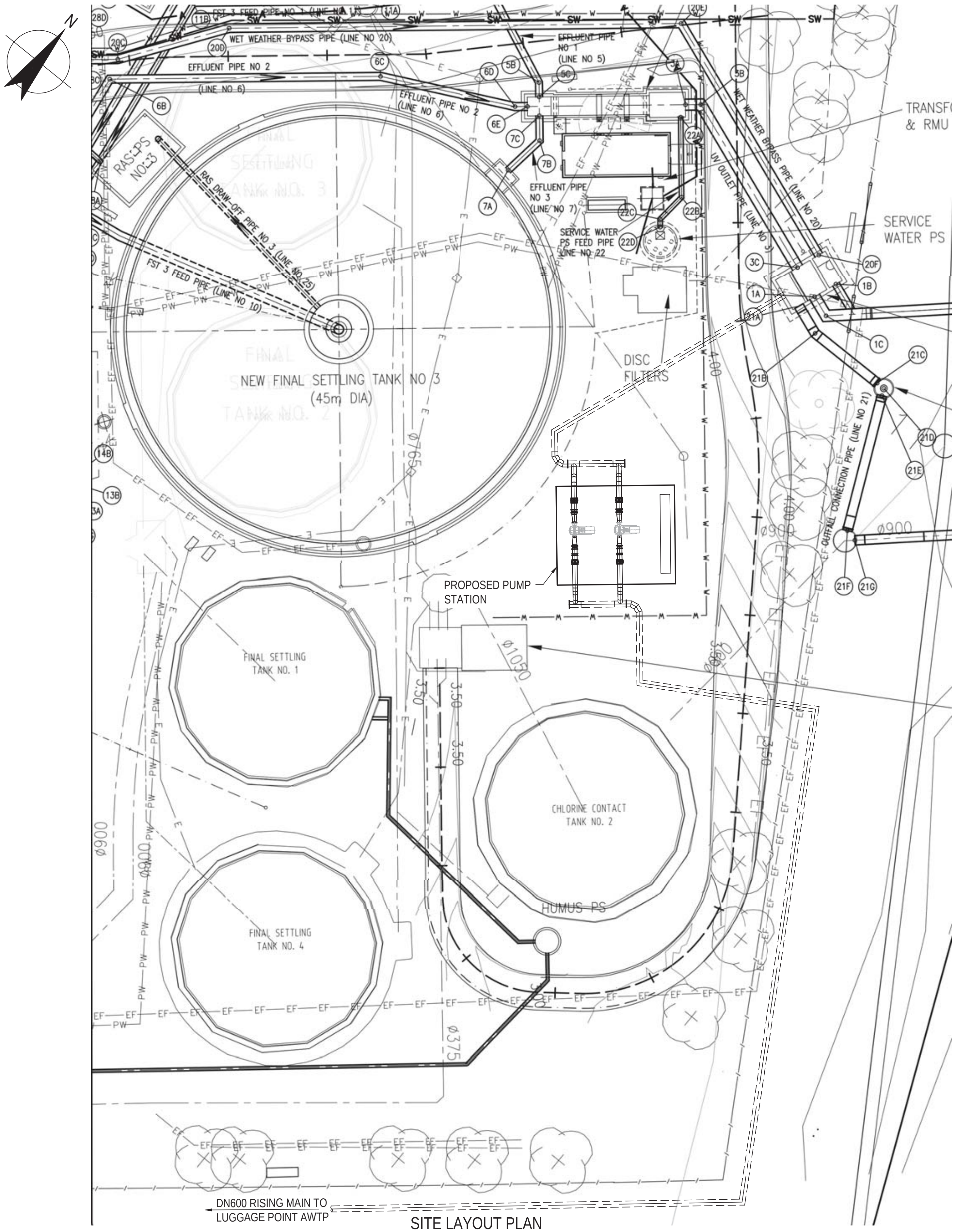
Client **QUEENSLAND FARMERS FEDERATION**
Project **NUWATER PROJECT FEASABILITY STUDY**
Title **REDCLIFFE PUMP STATION - OPTION A LAYOUT PLAN**

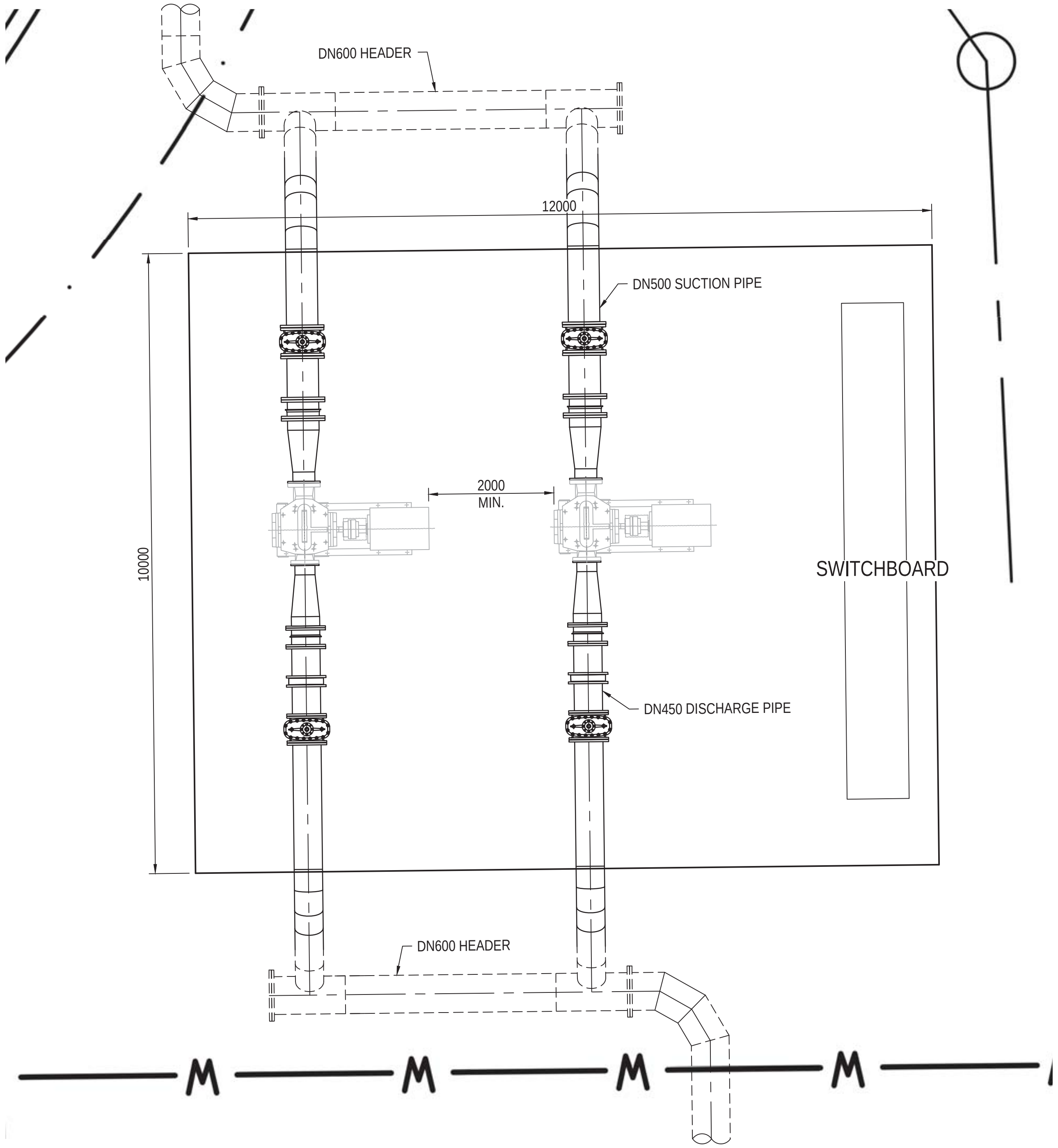
Original Size **A1** **Drawing No: 41-30968-W010** **Rev: UR**

Plot Date: 21 November 2017 - 1:14 PM Plotted by: Kirsty Eldridge Cad File No: G:\41\30968\CADD\Drawings\41-30968-W010.dwg



SITE LAYOUT PLAN

SCALE 1:250



PUMP STATION PLAN

SCALE 1:50

PRELIMINARY

No	Revision	Drawn	Job Manager	Project Director	Date
UR	UNDER REVISION				

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0 500 1000 1500 2000 2500mm SCALE 1:50 AT ORIGINAL SIZE

0 2500 5000 7500 10000 12500mm SCALE 1:250 AT ORIGINAL SIZE

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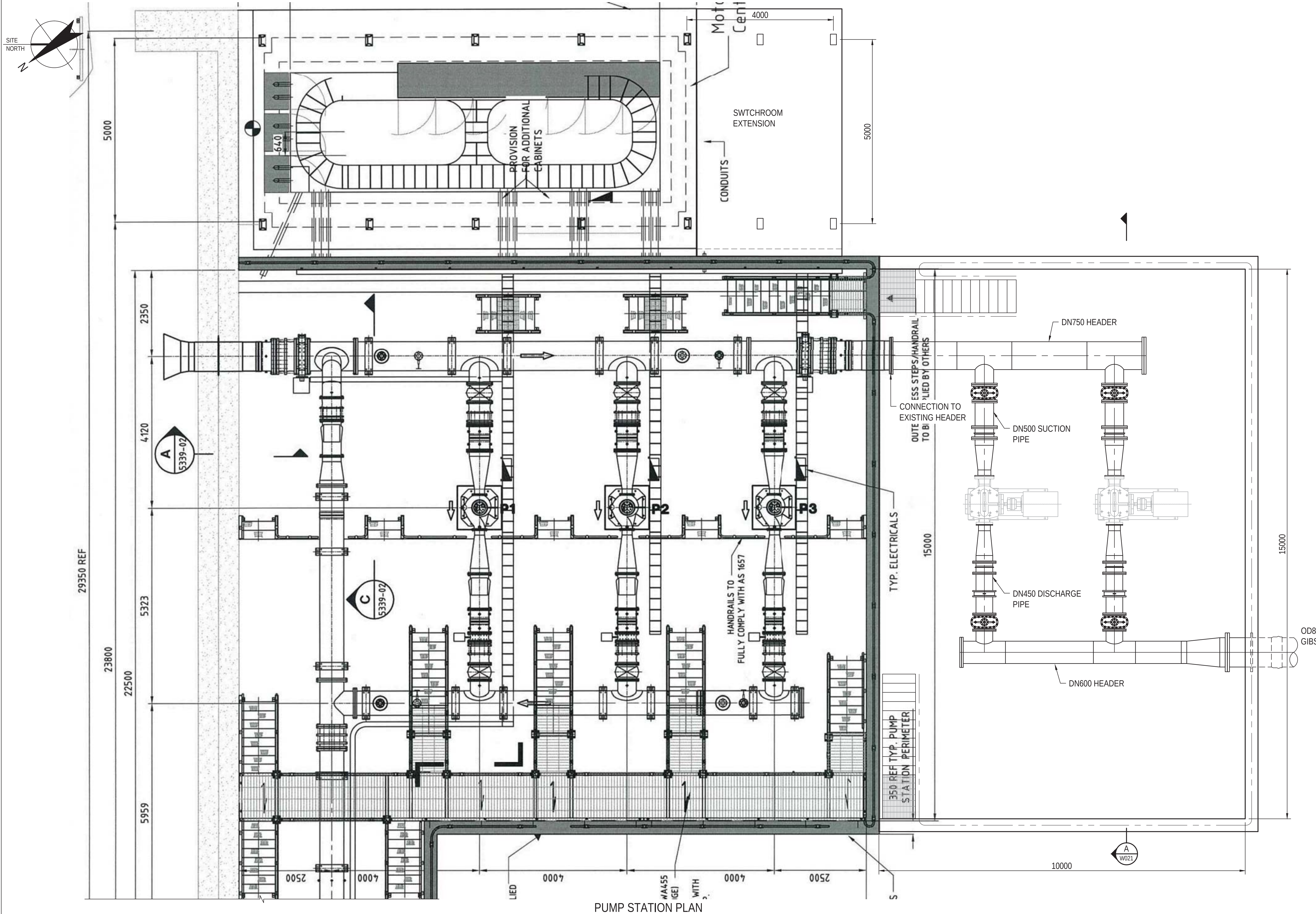
Client **QUEENSLAND FARMERS FEDERATION**
Project **NUWATER PROJECT FEASABILITY STUDY**
Title **SANDGATE PUMP STATION - OPTION A LAYOUT PLAN**

Original Size **A1**
Drawing No: **41-30968-W015**
Rev: **UR**

Plot Date: 21 November 2017 - 1:30 PM Plotted by: Kirsty Eldridge Cad File No: G:\41\30968\CADD\Drawings\41-30968-W015.dwg



PUMP STATION PLAN

SCALE 1:50

PRELIMINARY

UR	UNDER REVISION				
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0 500 1000 1500 2000 2500mm

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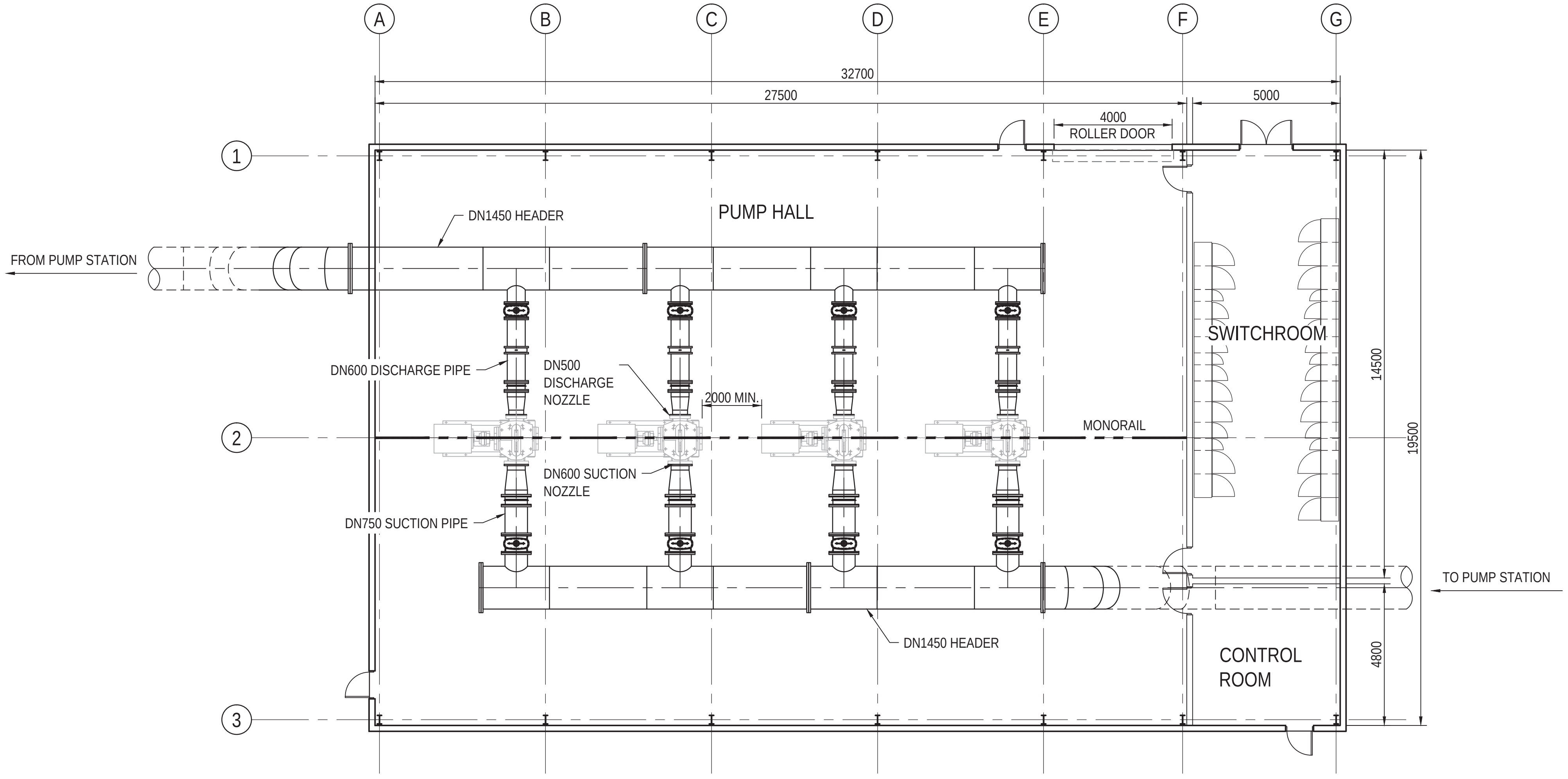
Client **QUEENSLAND FARMERS FEDERATION**
Project **NUWATER PROJECT FEASABILITY STUDY**
Title **LUGGAGE POINT PUMP STATION - OPTION A LAYOUT PLAN**

Original Size **A1**
Drawing No: **41-30968-W020**
Rev: **UR**

Plot Date: 21 November 2017 - 1:47 PM Plotted by: Kirsty Eldridge Cad File No: G:\41\30968\CADD\Drawings\41-30968-W020.dwg

NOTE:

1. PUMP HALL AND SWITCHROOM/CONTROL ROOM TO BE FULLY AIR-CONDITIONED.



PUMP STATION PLAN

SCALE 1:100

PRELIMINARY

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Client **QUEENSLAND FARMERS FEDERATION**
Project **NUWATER PROJECT FEASABILITY STUDY**
Title **LOWOOD BOOSTER PUMP STATION - OPTIONS A, B, C & D LAYOUT PLAN**

Original Size A1
Drawing No: 41-30968-W030
Rev: UR

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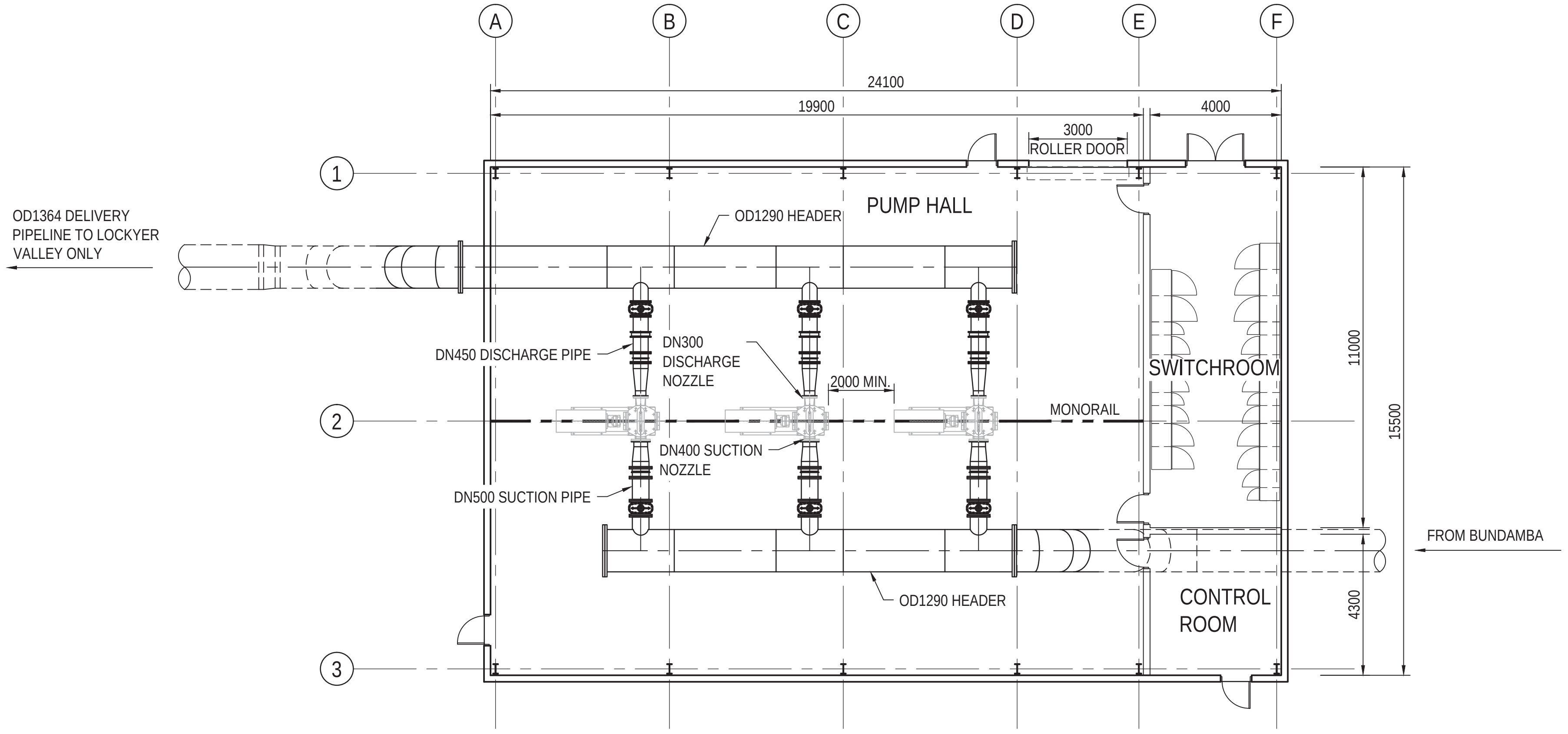

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Project **NUWATER PROJECT FEASABILITY STUDY**

Title **BUNDAMBA TO LOWOOD PS (LOCKYER VALLEY ONLY)**
LOWOOD BOOSTER PUMP STATION - OPTION D - LAYOUT PLAN

Original Size **A1**

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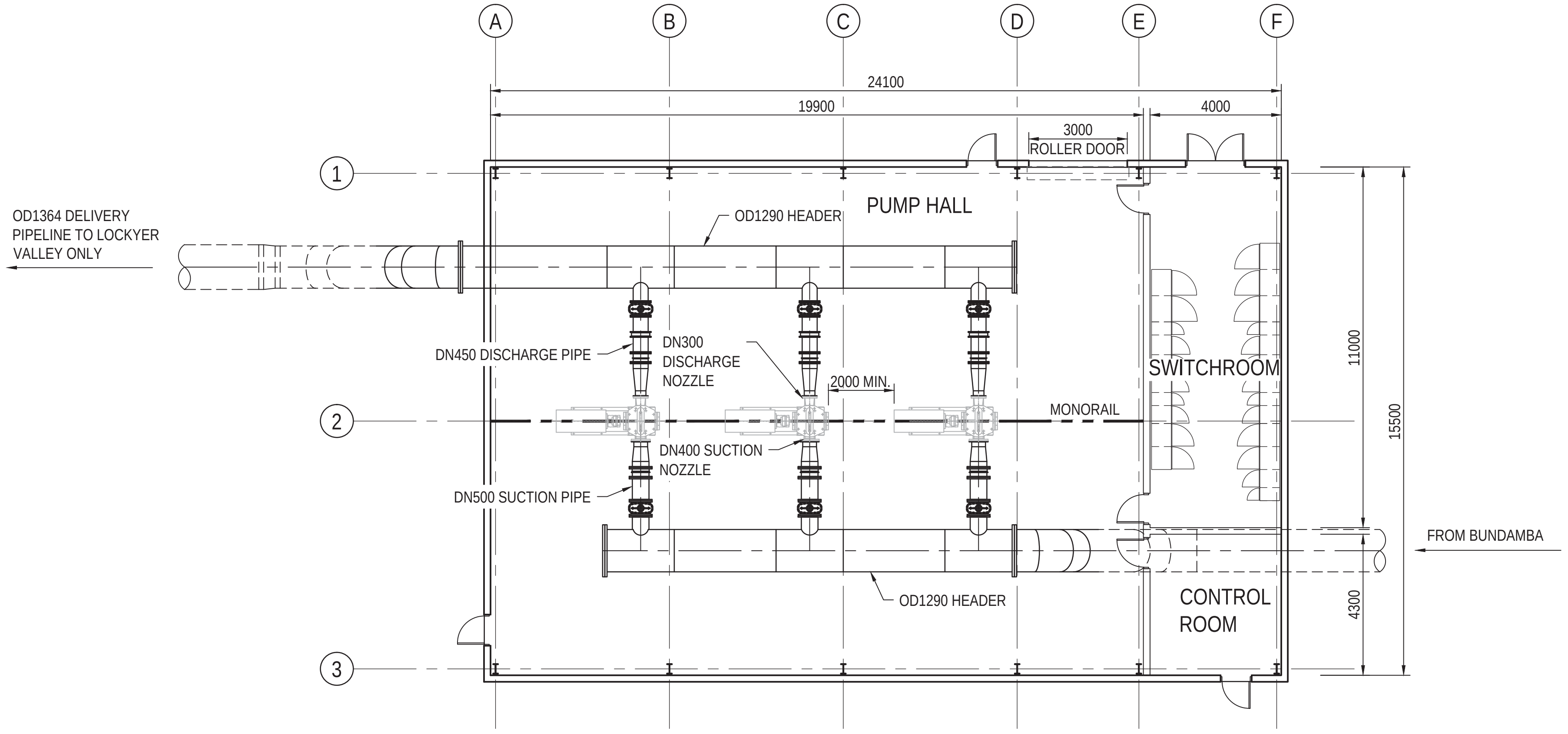

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Project **NUWATER PROJECT FEASABILITY STUDY**
Title **LOWOOD BOOSTER PUMP STATION (LOCKYER VALLEY ONLY) - OPTION D - LAYOUT PLAN**

Original Size **A1** **Drawing No: 41-30968-W034** **Rev: UR**

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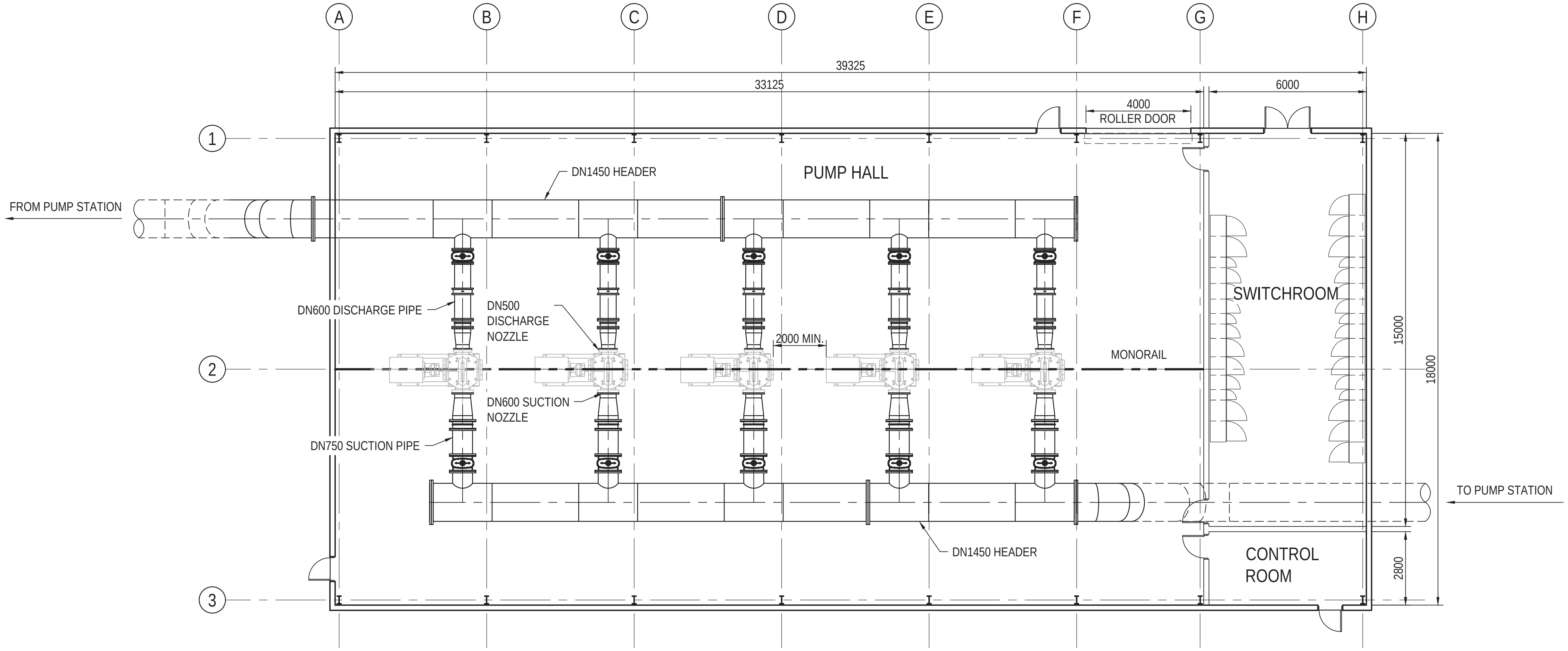

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Project **NUWATER PROJECT FEASABILITY STUDY**
Title **GATTON PUMP STATION - OPTIONS A, B, C & D LAYOUT PLAN**
Original Size **A1**
Drawing No: 41-30968-W040
Rev: UR

Plot Date: 21 November 2017 - 1:19 PM Plotted by: Kirsty Eldridge Cad File No: G:\41\30968\CADD\Drawings\41-30968-W040.dwg

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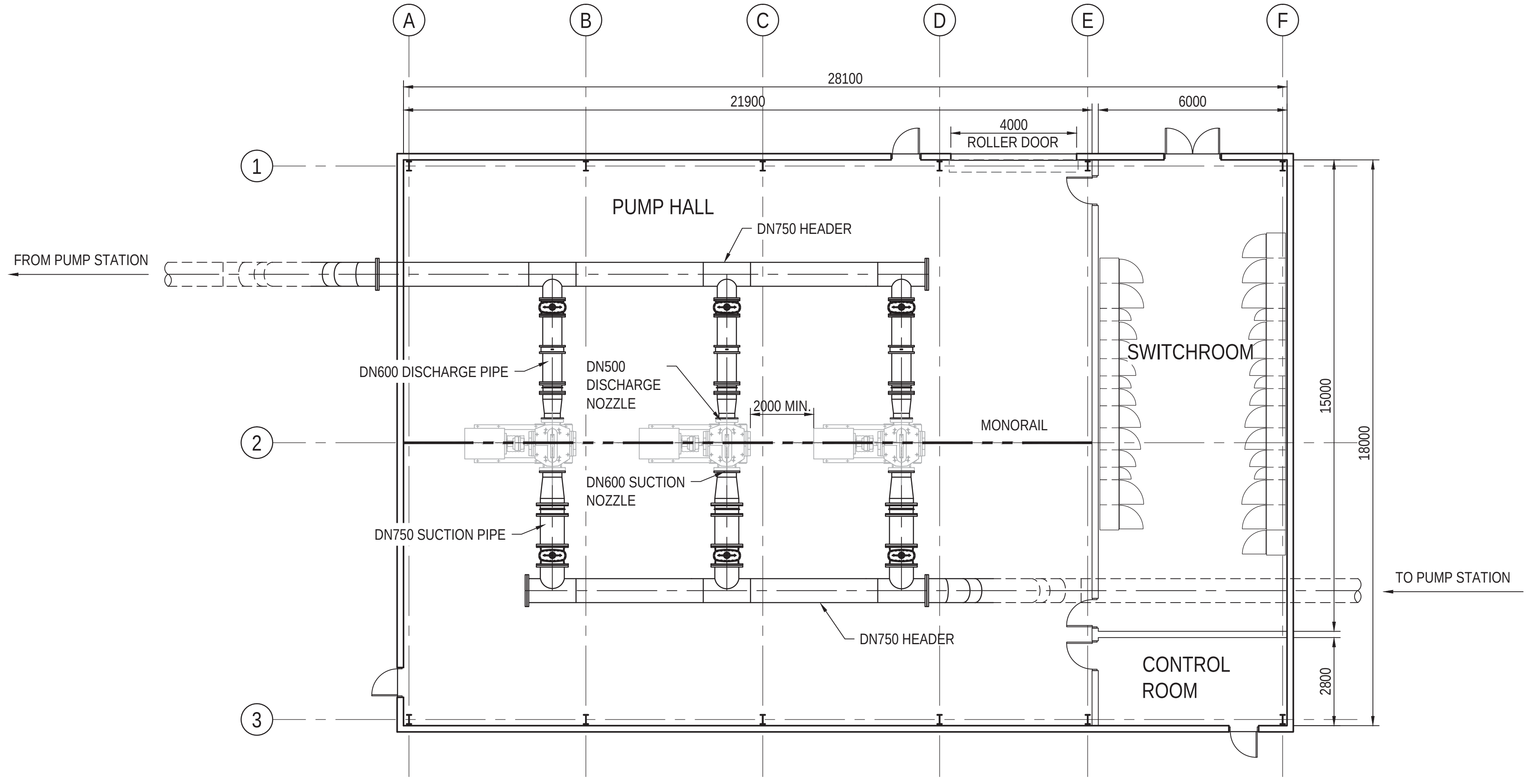

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Project **NUWATER PROJECT FEASABILITY STUDY**
Title **GATTON BOOSTER PUMP STATION - OPTION D LOCKYER VALLEY ONLY - LAYOUT PLAN**
Original Size **A1**
Drawing No: 41-30968-W045
Rev: UR

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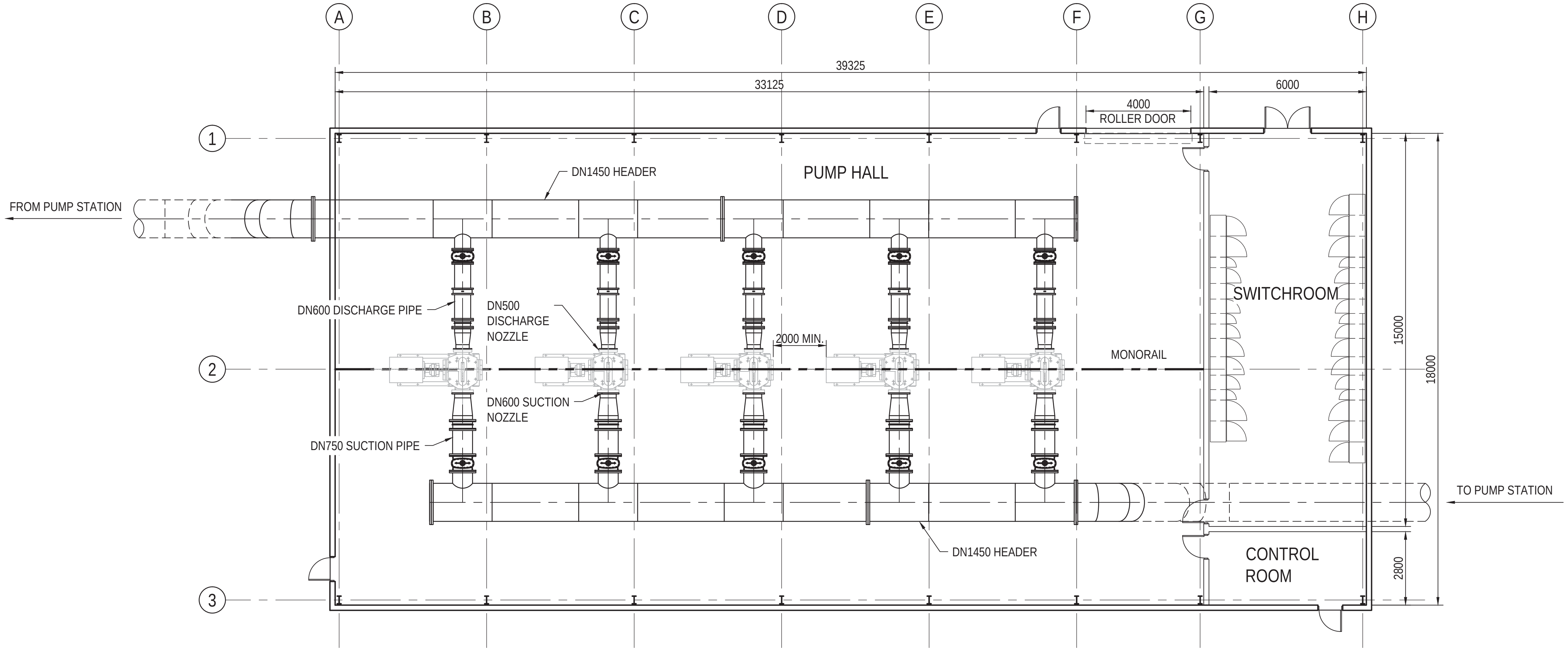

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Client **QUEENSLAND FARMERS FEDERATION**

Project **NUWATER PROJECT FEASABILITY STUDY**

Title **TOOWOOMBA PUMP STATION - OPTIONS A, B, C & D LAYOUT PLAN**

Original Size **A1**

Drawing No: 41-30968-W050

Rev: UR

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Appendix H – Economic and financial assessment of the NuWater project

Final report to the Queensland Farmers' Federation

Economic and financial assessment of the NuWater project

March 2018

Synergies Economic Consulting Pty Ltd
www.synergies.com.au

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Executive Summary

Background

This report presents the results of the economic and financial and commercial analyses of the shortlisted options for the NuWater project, which involves the supply of recycled wastewater from Sewage Treatment Plants (STPs) located in South East Queensland (SEQ) for beneficial reuse in the Lockyer Valley and on the Darling Downs. The economic and financial and commercial assessment of the shortlisted options was undertaken following the completion of a demand assessment for the project.

Defining the base case

The first step in assessing the economic and financial and commercial impacts of a project is to define the base case against which the impacts are to be assessed. The key features of the base case for this project are as follows:

- for the Lockyer Valley, water use to continue to be dominated by horticultural producers, with demand for additional water largely dependent on the future management and regulation of groundwater resources;
- for the Darling Downs, the continuation of the use of water for the production of broadacre crops, predominantly for supply into export markets; and
- the continued deterioration of water quality levels and environmental conditions of SEQ waterways and Moreton Bay due to increased nutrient loads, partly due to ongoing increases in the volumes of wastewater effluent discharged from STPs.

Project options

Four options were shortlisted for the economic and financial and commercial assessments. The options are summarised in the table below.

Summary of shortlisted options

Option	ML supplied per annum	Water quality level	Use of WCRWS	Other infrastructure required
Option A	84,680	PRW	Full use of WCRWS	Pipeline from Redcliffe STP to Luggage Point STP via Sandgate STP Gibson Island AWTP upgrade Construction of Heathwood Pumping Station (PS)
Option B	84,680	Class A+	Partial use of WCRWS, including pipeline	Gibson Island AWTP upgrade Construction of Heathwood PS Construction of new storage dams in the Lockyer Valley
Option C	84,680	Class B/C	Full use of WCRWS pipeline, with bypass of AWTPs	Construction of Heathwood PS Construction of new storage dams in the Lockyer Valley
Option D	Total of 73,000 Up to 25,000 to LV Up to 65,500 to DD	PRW to LV Class B/C to DD	Partial use of WCRWS	Construction of pipeline to deliver PRW from Lowood Booster PS to the Lockyer Valley Construction of pipeline to deliver Class B/C water from Lowood Booster PS to Darling Downs

Economic analysis

The economic analysis of the NuWater project adopts standard cost-benefit analysis techniques. This approach estimates the net economic impact of a project by comparing all economic benefits that are measurable, material and attributable to the project with the identified economic costs.

Benefits

The key economic benefits identified and assessed for the shortlisted options were:

- the additional economic value from the use of recycled wastewater for irrigated agricultural production, both in the Lockyer Valley and on the Darling Downs;
- the avoidance of costs associated with the maintenance of WCRWS infrastructure in 'care and maintenance' and 'hot standby' modes; and
- the avoidance of the cost associated with increased nutrient loads in Moreton Bay as a result of the continued discharge of wastewater effluent from STPs in SEQ.

The additional value of agricultural production in the Lockyer Valley and on the Darling Downs was quantified based on the results of the crop modelling undertaken as part of the demand assessment. The table below sets out the annual volumes of water use and the Present Value (PV) of the total economic benefit derived from crop production under each shortlisted option.

Total economic benefits of increased agricultural production (PV terms)

Crop type and region	Economic benefits (PV terms)		
	Existing crops	New crops	Total benefit
Options A, B and C			
Vegetable crops – Lockyer Valley		$157.8m	$157.8m
Broadacre crops – Darling Downs	$228.0m	$99.0m	$327.0m
Total benefits	**$228.0m**	**$256.8m**	**$484.8m**
Option D			
Vegetable crops – Lockyer Valley		$157.8m	$157.8m
Broadacre crops – Darling Downs	$193.5m	$84.0m	$277.5m
Total benefits	**$193.5m**	**$241.8m**	**$435.3m**

Notes: PV totals are calculated based on a real discount rate of 7 per cent and include terminal values in year 30. Benefits were estimated assuming demand of 7,500 ML per annum in the Lockyer Valley, with remaining volumes to be supplied to the Darling Downs. The benefits were also adjusted for the supply disruptions attributable to the recommissioning of the WCRWS for Indirect Potable Reuse (IPR) based on annual probabilities provided by Seqwater.

Source: Synergies modelling.

The following table presents the estimated benefits from the avoidance of 'care and maintenance' costs to be incurred by Seqwater under the base case. These costs would be avoided under the shortlisted options.

Avoidance of 'care and maintenance' costs under shortlisted options

Option	Proportion of costs to be avoided	Annual avoided cost (2018 dollars)	Total avoided costs (PV terms)[a]
Option A	100.0%	$10.3 million	$16.5 million
Option B	62.0%	$6.4 million	$10.2 million
Option C	10.0%	$1.0 million	$1.6 million
Option D	74.4%	$7.7 million	$12.3 million

a The total PV estimate is calculated over the evaluation period taking into account the probabilities of supply disruptions provided by Seqwater and applying the multiplicative probabilistic approach.

Note: PV estimates are calculated based on a real discount rate of 7 per cent.

Source: Proportions provided by GHD.

The reduction in nutrients (nitrogen and phosphorus) discharged into SEQ waterways and Moreton Bay from STPs, and subsequently the avoidance of adverse water quality and environmental impacts, is a key benefit of the shortlisted options.

The marginal nutrient abatement costs were applied as a 'proxy' value for the economic benefit of avoided nutrient discharges. It is important to note that the benefits have been assessed from a societal perspective (i.e. the value the community places on reduced nutrient discharges) as opposed to the financial impact on QUU. Based on industry sources, the cost of abating nitrogen loads (the 'limiting' nutrient in the Lower Brisbane catchment) via an alternative project was assumed to be approximately $23,000 per tonne.[1] Applying a proportion from a study of nutrient abatement costs previously conducted in SEQ results in an estimate of $18,400 per tonne for phosphorus. The following table sets out the benefit estimates (in PV terms) associated with the reduction in nutrients discharged into SEQ waterways and Moreton Bay under the shortlisted options.

Economic benefits from reduced nutrient loads in Moreton Bay under shortlisted options

Option	Avoided nutrient loads (tonnes p.a.)		Annual economic benefit		Total benefit (PV terms)[a]
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	
Option A	454	323	$10.4m	$5.9m	**$176.0m**
Option B	413	292	$9.5m	$5.4m	**$159.8m**
Option C	391	275	$9.0m	$5.1m	**$150.8m**
Option D	376	263	$8.6m	$4.8m	**$144.5m**

a PV estimates have been calculated based on a real discount rate of 7 per cent and include a terminal value in year 30.

Note: It is important to note that benefits have been assessed over the entire evaluation period regardless of interruptions to supply. This means that the assumption has been adopted that under the base case, current discharge rates for nitrogen and phosphorus will remain unchanged, regardless of whether the WCRWS is re-commissioned for IPR. Were the infrastructure upgrades to be undertaken as part of the recommissioning process to include works to avoid the discharge of nutrients into SEQ waterways and Moreton Bay from these STPs, the economic benefits attributable to the shortlisted options would be reduced.

Source: Synergies modelling.

It is noted that increased intensity of agricultural production, in particular vegetable production in the Lockyer Valley,[2] can result in additional nutrient discharges into waterways. To the extent that this were to occur under the shortlisted options, this would negate a proportion of the above benefit estimates. Noting this, it was not considered appropriate to reduce the above benefit estimates based on the following:

- the assumption that best practice nutrient management processes will be implemented where vegetable production is to be expanded in the Lockyer Valley;[3] and
- it is unlikely that the economic cost associated with an increase in nutrient loads resulting from an increase in vegetable production in the Lockyer Valley would be material relative to the overall reduction in nutrient discharges attributable to the shortlisted options (particularly as the demand assessment indicates the majority of water would be supplied to the Darling Downs).

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[1] Noting that nutrient abatement costs vary for different projects and activities.

[2] Noting that the Darling Downs is a closed system.

[3] Such best practice management arrangements count be incorporated into the water supply agreements to apply to the project.

Other benefits identified (although not quantified) were:

- the environmental benefits associated with increased flows in the Murray Darling Basin; and
- increased water security for other water users in the region (including intensive animal producers and industrial producers).

Costs

The costs identified and assessed in the economic analysis of the shortlisted options were capital costs; ongoing treatment, operating and maintenance (O&M) and energy costs; and the cost of on-farm infrastructure improvements.

The capital cost estimates derived for the shortlisted options are set out below.

Capital cost profiles for shortlisted options

Option	2018	2019	2020	2021	Totals	Totals (PV terms)
Option A						
LV	$33.0m	$74.1m	$34.8m	$11.6m	$153.5m	**$132.8m**
DD	$443.5m	$997.4m	$468.8m	$156.3m	$2,066.0m	**$1,787.6m**
Total	$476.5m	$1,071.5m	$503.7m	$167.9m	$2,219.5m	**$1,920.4m**
Option B						
LV	$22.2m	$49.9m	$23.5m	$7.8m	$103.4m	**$89.5m**
DD	$349.2m	$785.3m	$369.1m	$123.0m	$1,626.7m	**$1,407.4m**
Total	$371.4m	$835.2m	$392.6m	$130.9m	$1,730.1m	**$1,496.9m**
Option C						
LV	$19.6m	$44.1m	$20.7m	$6.9m	$91.3m	**$79.0m**
DD	$322.3m	$724.8m	$340.7m	$113.6m	$1,501.4m	**$1,299.1m**
Total	$341.9m	$768.9m	$361.4m	$120.5m	$1,592.7m	**$1,378.0m**
Option D						
LV	$38.4m	$86.4m	$40.6m	$13.5m	$179.0m	**$154.9m**
DD	$361.6m	$813.1m	$382.2m	$127.4m	$1,684.2m	**$1,457.2m**
Total	$400.0m	$899.5m	$422.8m	$140.9m	$1,863.2m	**$1,612.1m**

Note: Annual cost estimates are in 2018 dollars. The Present Value estimates have been calculated based on a real discount rate of 7 per cent. Capital costs are assumed to be incurred over a construction period of three and a half years.

Source: Capital cost estimates have been developed by GHD.

There is also a significant ongoing cost associated with supplying recycled wastewater from STPs in SEQ to agricultural producers in the Lockyer Valley and on the Darling Downs. In particular, the cost of treating water to the necessary water quality standard (particularly for users in the Lockyer Valley) and the energy costs incurred in supplying users on the Darling Downs are significant. The total operating and maintenance costs are summarised (in PV terms) in the table below.

Total operating and maintenance costs (PV terms) by shortlisted option

Cost	Option A	Option B	Option C	Option D
Lockyer Valley				
Energy	$51.3m	$40.2m	$40.2m	$58.1m
Treatment and O&M	$28.5m	$17.6m	$17.6m	$23.2m
Total	**$79.8m**	**$57.8m**	**$57.8m**	**$81.3m**
Darling Downs				
Energy	$584.1m	$470.3m	$414.3m	$393.7m
Treatment and O&M	$298.7m	$188.5m	$43.8m	$114.4m
Total	**$882.8m**	**$658.8m**	**$458.1m**	**$508.1m**
Totals	**$962.6m**	**$716.6m**	**$515.9m**	**$589.4m**

Note: PV estimates are based on a real discount rate of 7 per cent and contain terminal values in year 30.

Source: Unit cost estimates provided by GHD. Total PV estimates derived based on Synergies modelling.

For some growers, increasing irrigation water use will require capital investment in on-farm infrastructure improvements, including additional on-farm storage capacity and additional irrigation application equipment and water reticulation infrastructure. The table below sets out the estimates derived for these costs under the shortlisted options.

Cost of additional on-farm storage capacity and irrigation infrastructure and equipment (PV)

Option	Cost of on-farm storage (PV terms)[a]	Cost of irrigation infrastructure (PV terms)[a]	Total additional costs (PV terms)[a]
Options A, B and C	$6.9m	$11.4m	**$18.3m**
Option D	$5.9m	$9.8m	**$15.7m**

a Calculated based on a real discount rate of 7 per cent.

Note: It has been assumed that 25 per cent of growers in both regions will need to invest in additional on-farm storage capacity and additional irrigation equipment and infrastructure.

Source: Synergies modelling.

In addition to these quantified costs, there is also the potential for the shortlisted options to result in an increased cost associated with the recommissioning of the WCRWS for IPR. This cost has not been quantified given the uncertainty associated with the magnitude of the additional recommissioning costs and also the potential for some of the recommissioning costs to be avoided under the shortlisted options. The impact of the project on the cost of recommissioning the WCRWS for IPR is to be assessed in the development of the Detailed Business Case.

Results

The table below presents the results of the economic analysis of the shortlisted options. The results are based on demand of 7,500 ML per annum for the Lockyer Valley, with remaining volumes supplied to users on the Darling Downs.

Summary of results of economic analysis (PV terms)

Impact	Option A	Option B	Option C	Option D
Economic benefits				
Increased value of agricultural production (Lockyer Valley)	$157.8m	$157.8m	$157.8m	$157.8m
Increased value of agricultural production (Darling Downs)	$327.0m	$327.0m	$327.0m	$277.5m
Avoided environmental costs	$176.0m	$159.8m	$150.8m	$144.5m
Avoided 'care and maintenance' and 'hot standby' costs	$16.5m	$10.2m	$1.6m	$12.3m
Increased environmental flows	Qualitative	Qualitative	Qualitative	Qualitative
Increased water security	Qualitative	Qualitative	Qualitative	Qualitative
Total economic benefits	**$677.3m**	**$654.8m**	**$637.2m**	**$592.1m**
Economic costs				
Capital costs	$1,920.4m	$1,496.9m	$1,378.0m	$1,612.1m
Treatment and O&M costs	$327.2m	$206.1m	$61.4m	$137.6m
Energy costs	$635.4m	$510.5m	$454.5m	$451.8m
WCRWS recommissioning costs		Unquantified	Unquantified	Unquantified
On-farm infrastructure costs	$18.3m	$18.3m	$18.3m	$15.7m
Total economic costs	**$2,901.3m**	**$2,231.8m**	**$1,912.2m**	**$2,217.2m**
NET ECONOMIC IMPACT	**($2,224.0m)**	**($1,577.0m)**	**($1,275.0m)**	**($1,625.1m)**
Benefit Cost Ratio[a]	**0.23**	**0.29**	**0.33**	**0.27**

a The Benefit Cost Ratio is calculated by dividing the PV estimates for total benefits by total costs.

Note: PV estimates have been derived based on a discount rate of 7 per cent.

Source: Synergies modelling.

The significant negative NPVs of the shortlisted options are driven by the significant capital costs incurred in developing the infrastructure required to supply recycled wastewater to agricultural users and the significant ongoing treatment and energy costs incurred in maintaining supply. Option C results in the most favourable NPV and Benefit Cost Ratio (BCR) due to the lower up-front capital and ongoing treatment costs, however the BCR under this option is still significantly below 1.

Sensitivity and scenario analysis was undertaken to assess the impacts of changes in key parameters and different scenarios on the results of the analysis. Whilst some parameters and scenarios had a material impact on the results of the analysis (e.g. discount rate, capital cost, level of demand in the Lockyer Valley), the NPV was still significantly negative for all shortlisted options under all sensitivities and scenarios.

Financial and commercial analysis

The objective of financial and commercial analysis is to assess the financial implications and budgetary impacts of the shortlisted options by assessing the cashflows for each option.

Financial costs

The financial costs to be incurred under the shortlisted options, being capital costs and ongoing treatment, O&M and energy costs, are described above. The estimated total financial costs are summarised in the table below.

Total financial costs for shortlisted options (PV terms)

Cost category	Option A	Option B	Option C	Option D
Capital costs				
Lockyer Valley	$132.8m	$89.5m	$79.0m	$154.9m
Darling Downs	$1,787.6m	$1,407.4m	$1,299.1m	$1,457.2m
Operating and maintenance costs				
Lockyer Valley	$69.1m	$50.1m	$50.1m	$70.5m
Darling Downs	$764.4m	$570.4m	$396.6m	$439.9m
Totals costs	**$2,753.9m**	**$2,117.4m**	**$1,824.8m**	**$2,122.5m**

Note: PV estimates have been calculated based on a nominal discount rate of 9.7 per cent (consistent with the real discount rate of 7 per cent applied in the economic analysis). Based on demand of 7,500 ML per annum for the Lockyer Valley.

Source: Synergies modelling based on cost estimates provided by GHD.

The total ongoing costs of water supply are impacted by the level of demand in the Lockyer Valley. At this stage of the assessment, complexities in relation to the costing of different infrastructure elements and processes have prevented the allocation of treatment, O&M and energy costs to users in the two regions. The allocation of these costs and the implications of different levels of demand in the Lockyer Valley for the total financial cost of water supply is to be assessed in the Detailed Business Case.

Revenues

The sole source of revenue that has been identified for the project is water charges levied on water users.[4] Based on the outcomes of the demand assessment, it was concluded that the price at which it would be viable for end users to purchase water from the project was likely to range from $300 to $500 per ML per annum (financial modelling was undertaken using a base price of $400 per ML per annum). These price points were selected based on the results of the crop modelling undertaken as part of the water demand assessment, with the economic return derived from all crops included in the demand profile exceeding $400 per ML per annum.[5]

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[4] Noting the potential for a capital contribution to be made by an external party.

[5] Crops for which the economic return was estimated at below $400 per ML per annum were excluded from the demand profile.

The financial modelling was undertaken based on a uniform price applying to all water users, noting that the cost of supply will differ across the customer base. The following table summarises the revenues to be derived from water charges.

Revenue to be derived from water charges (PV terms)

Option	Annual water price		
	$300 per ML	**$400 per ML**	**$500 per ML**
Options A, B and C	$166.3m	$221.7m	$277.2m
Option D	$143.4m	$191.1m	$238.9m

Note: PV estimates calculated based on a nominal discount rate of 9.7 per cent (consistent with the real discount rate of 7 per cent applied in the economic analysis).

Source: Synergies modelling.

Results

The table below sets out the results of the financial and commercial analysis.

Results of the financial analysis of shortlisted options (PV terms)

Costs and revenues	Option A	Option B	Option C	Option D
Costs				
Capital costs	$1,920.4m	$1,496.9m	$1,378.0m	$1,612.1m
Treatment and O&M costs	$283.4m	$178.5m	$53.2m	$119.2m
Energy costs	$550.1m	$442.0m	$393.5m	$391.2m
TOTAL COSTS	**$2,753.9m**	**$2,117.4m**	**$1,824.7m**	**$2,122.5m**
Revenues				
Revenue from water users	$221.7m	$221.7m	$221.7m	$191.1m
TOTAL REVENUES	**$221.7m**	**$221.7m**	**$221.7m**	**$191.1m**
NET FINANCIAL IMPACT	**($2,532.2m)**	**($1,895.7m)**	**($1,603.0m)**	**($1,931.4m)**

Note: PV totals have been calculated based on a nominal discount rate of 9.7 per cent (consistent with the real discount rate of 7 per cent applied in the economic analysis). Results calculated based on demand of 7,500 ML per annum in the Lockyer Valley (remaining volumes supplied to the Darling Downs).

Source: Synergies modelling.

As with the results of the economic analysis, the significant negative Financial Net Present Values (FNPVs) are driven by the significant costs associated with developing the necessary infrastructure and supplying recycled wastewater to growers. A quantitative assessment of the financial risks demonstrates the need to ensure that the project is delivered, and the commercial frameworks are structured, in a manner that ensures that the risk of capital cost overrun is minimised.

Funding sources and budgetary impacts

The results from the financial and commercial analysis demonstrate that, for all shortlisted options, revenues will be insufficient to recover the financial costs incurred. The project will therefore require significant government funding to be financially viable. The magnitude of the government funding required will be subject to the option that is adopted and demand in the Lockyer Valley. The FNPV results from the financial and commercial analysis provide an indication as to the magnitude of government funding that is required.

Contents

Figures and Tables

1 Introduction

The NuWater project involves the supply of recycled wastewater from Sewage Treatment Plants (STPs) located in South East Queensland (SEQ) for beneficial reuse in the Lockyer Valley and on the Darling Downs, potentially facilitated by the use of the Western Corridor Recycled Water Scheme (WCRWS) infrastructure. In addition to the benefits to be derived from the re-use of the water, the project would also reduce the volumes of treated effluent, and associated nutrient content, that is discharged into Moreton Bay.

In January 2016, the NuWater Project Committee received funding under the 'Feasibility' component of the National Water Infrastructure Development Fund (NWIDF) to undertake a feasibility study on the project. Synergies Economic Consulting (Synergies) has been engaged, as a subconsultant to GHD, to undertake the following components of this feasibility study:

- *Demand Assessment* - Synergies completed a demand assessment in September 2017, which established the expected demand for recycled wastewater to be supplied by the NuWater project based on consultations with agricultural and industrial water users in the region. The findings of the demand assessment were key inputs into the economic and financial assessment of the shortlisted options; and
- *Economic and Financial Assessment* – in accordance with Building Queensland's Business Case Development Framework, the shortlisted options were subject to detailed economic and financial analyses. The economic analysis was completed by applying the cost-benefit analysis technique to assess the net economic impact of each shortlisted option based on identified economic benefits and costs, whilst the financial analysis involved a discounted cashflow analysis of the financial costs and revenues attributable to the shortlisted options to assess financial viability.

This report presents the economic and financial assessment of the shortlisted options. This report is set out as follows:

- section 2 sets out the relevant background information, including an overview of the outcomes of the demand assessment;
- section 3 sets out the base case for the economic and financial and commercial assessments;
- section 4 summarises the shortlisted options to be assessed;
- section 5 sets out the economic analysis of the project;
- section 6 includes the financial and commercial analysis; and

- section 7 summarises the key conclusions from the economic and financial analyses.

The report also includes one attachment – being a review of information applied to derive an estimate for the economic value of avoiding nutrient discharges into SEQ waterways and Moreton Bay.

2 Background

2.1 Project overview

The transportation of recycled wastewater from treatment plants in SEQ to agricultural producers in the Lockyer Valley and on the Darling Downs has been under consideration for over 20 years. In the late 1990s, over $2 million of funding was used to assess the feasibility of such a scheme through the Darling Downs Vision 2000.

This process resulted in the completion of a business case recommending the project proceed to financial close. However, the project was discontinued in 2004, primarily as a result of the development of the WCRWS in response to the worsening urban water supply outlook in SEQ due to the Millennium Drought. The incorporation of the use of recycled wastewater in the long-term water security planning for SEQ prevented further consideration of the use of recycled wastewater for agricultural and industrial use.

Consideration of the project recommenced in 2016, with the NuWater Project Committee securing funding from the Commonwealth Government under the NWIDF to assess the feasibility of the NuWater project. The funding is to be used to assess the feasibility of the NuWater project, which includes the potential for existing WCRWS infrastructure (including the $2.7 billion pipeline constructed as part of the scheme) to be used to facilitate the delivery of recycled wastewater from plants in SEQ to users in the Lockyer Valley and on the Darling Downs.

Key features of the NuWater project are:

- up to 84,680 ML of treated wastewater to be made available to agricultural and industrial users in the Lockyer Valley and on the Darling Downs;
- the wastewater effluent currently produced at Sewage Treatment Plants (STPs) in SEQ contains nitrogen and phosphorus. The discharge of these nutrients into SEQ waterways and Moreton Bay adversely impacts on water quality, particularly in Moreton Bay. The NuWater project provides an opportunity to avoid these adverse impacts by diverting wastewater effluent for beneficial reuse rather than continuing to discharge the effluent and nutrient content into Moreton Bay; and
- since the original consideration of the project, there has been significant investment in water treatment and transportation infrastructure that could improve the feasibility of the NuWater project, in particular the WCRWS pipeline infrastructure, which is not currently being utilised.

2.2 Outcome of Demand Assessment

Based on responses to the irrigator survey and consultation with growers both in the Lockyer Valley and on the Darling Downs, the following demand has been identified for crop production for the NuWater project:

- for the Darling Downs, 46,050 ML;[6] and
- for the Lockyer Valley, 7,500 ML under current groundwater management arrangements and 25,000 ML under the scenario in which groundwater resources become regulated and subject to volumetric allocations.[7]

The shortlisted options that have been identified for the NuWater project involve total water supply of up to 84,680 ML per annum (see section 4). Based on the outcomes of the demand assessment, the expected breakdown of water demand under these shortlisted options is set out in Table 1.

Table 1 Overview of demand for crop production from the NuWater project

Scenario	Lockyer Valley water demand	Darling Downs water demand
Maintenance of existing groundwater management arrangements in the Lockyer Valley	7,500 ML per annum for the expansion of crop production, with the crop mix to be determined by changing market factors.	77,180 ML per annum for broadacre crop production (primarily cotton) on the Darling Downs, including increasing yields on existing crops and new crop production. It is expected that the proportions in Table 5 would be broadly reflective of the breakdown of demand.
Groundwater resources in the Lockyer Valley to be subject to regulation and volumetric entitlements	25,000 ML per annum for crop production in the Lockyer Valley, including the expansion of production and potentially maintaining pre-existing levels of production. It is expected that water would be applied to a range of crops, with the mix to be determined by changing market factors.	59,680 ML per annum for broadacre crop production (primarily cotton) on the Darling Downs, including increasing yields on existing crops and new crop production. It is expected that the proportions in Table 5 would be broadly reflective of the breakdown of demand.

Note: Where a shortlisted option involves less than 84,680 ML of water being made available, Darling Downs demand will be lowered in accordance with the level of total water supply.

Source: Synergies modelling.

It was not possible to attribute demand to intensive animal producers[8] due to issues with reliability of supply and uncertainty over water quality. As a result, the economic analysis has been undertaken excluding these potential sources of demand. It is recommended that the potential for water to be supplied to intensive animal producers,

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[6] Noting that only a proportion of growers on the central and northern Darling Downs were consulted with as part of the demand assessment and that total demand is likely to be significantly greater than the volumes identified in survey responses.

[7] Noting that due to the low response rate from growers in the Lockyer Valley, these demand estimates are approximations based on informal discussions with growers and other stakeholders.

[8] Includes feedlot operators, pig producers, chicken meat producers and processors, dairy producers, and egg producers.

in particular feedlot operators and chicken meat producers and processors, be further investigated as part of the Detailed Business Case.

In terms of industrial demand, the only industrial water user identified as a potential customer for the NuWater project were Coal Seam Gas (CSG) producers on the Darling Downs. Specifically, the NuWater project represents an opportunity for these producers to access water from the project to satisfy their 'make good' requirements under the *Water Act 2000*. Whilst CSG producers have not been included in the demand profile based on the outcomes of the demand assessment, there is the potential for these producers to access water from the project to satisfy these requirements in the future.

3 Base case

This section sets out the base case against which the shortlisted options are to be assessed.

3.1.1 Lockyer Valley agricultural producers

Non-urban water use in the Lockyer Valley is dominated by horticultural production. The vegetable crops produced in the region include lettuces, cabbages, onions, potatoes, carrots, broccoli and cauliflowers. In 2010/11, the total value of agricultural production in the Lockyer Valley was estimated at around $263 million, of which almost 80 per cent was attributable to vegetable production.[9] The demand assessment report contains additional information on agricultural production in the Lockyer Valley.

Total annual water use for agricultural production in the Lockyer Valley is estimated at around 60,000 ML, with around 75 per cent being sourced from unregulated groundwater resources.[10] There is considerable uncertainty associated with the future management of groundwater resources in the Lockyer Valley, with the viability of current groundwater extraction rates to be assessed as part of the ongoing review of the Moreton Water Plan. If it is deemed that current extraction rates are unsustainable, there is the potential for the Queensland Government to implement volumetric allocations for groundwater use in the region, which would restrict the volume of water that horticultural producers are permitted to extract.

This uncertainty over the future management of groundwater resources makes it difficult to draw conclusions regarding future demand for water for agricultural production in the Lockyer Valley, both from the NuWater project and alternative supply sources. Based on a review of current production levels and water use volumes in the region and informal consultation with growers in the Lockyer Valley conducted as part of the demand assessment, the following are considered the two most likely outcomes:

- if the management arrangements for groundwater resources in the Lockyer Valley remain unchanged, demand for additional water from agricultural producers is likely to be limited to growers seeking additional volumes to expand production on a marginal basis. This additional demand has been estimated at between 5,000 ML and 10,000 ML per annum; or

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[9] Australian Bureau of Statistics (2012). Value of Agricultural Commodities Produced, Australia, 2010-11. Cat No 7503.0.

[10] It is difficult to estimate total water use for agricultural production in the Lockyer Valley as the majority of water use is attributable to unregulated and unmetered groundwater resources.

- if the Moreton Water Plan review results in material reductions to groundwater use, demand will be considerably greater (estimated at 20,000 ML to 30,000 ML per annum based on consultation with growers), as growers will require access to significant volumes of water from alternative sources in order to maintain their current levels of production.

Water use for other agricultural production in the region, such as dairy producers, is relatively limited. No major changes are foreseen in terms of the magnitude of water use of production in these sectors.

3.1.2 Lockyer Valley industrial users

Industrial activity in the Lockyer Valley is dominated by activities related to agricultural production, including logistics operators and food production and processing operations and other agribusinesses.[11] Industrial water users are serviced by urban reticulated networks. Industrial water use in the region is small in comparison to agricultural water use. This is expected to remain the case over the study period.

3.1.3 Darling Downs agricultural producers

The Darling Downs region accounts for around 20 per cent of the value of total agricultural production in Queensland. Broadacre crops production is the dominant agricultural activity in the region, with the key crops being cotton, wheat, sorghum, maize, barley and chickpeas. Broadacre crops are produced in the region using both dryland and irrigated farming systems.[12]

Crop producers on the Darling Downs are heavily reliant on groundwater resources, water harvesting and overland flows for their irrigation water supply. The majority of groundwater used for irrigation in the region is sourced from shallow alluvial aquifers in the Condamine catchment. Groundwater levels have declined in the Central Condamine Alluvium and tributaries. As a consequence of this, in recent years, groundwater use in the Condamine has been reduced by up to 50 per cent.[13]

Agricultural producers on the Darling Downs have access to significant on-farm water storages. It is estimated that within the Condamine Catchment, upstream of Chinchilla, there is approximately 300,000 ML of on-farm storage capacity. This provides producers

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[11] Lockyer Valley Regional Council (2013). Lockyer Valley Regional Development Framework 2013-2023.

[12] ABS (2008). *Agricultural commodities: small area data, Australia, 2000-01*. Cat. no. 7125.0, Canberra, Australia; ABS (2012). *Agricultural commodities, Australia, 2010-11.* Cat. no. 7121.0, Canberra, Australia.

[13] Central Downs Irrigators Limited (2014). Submission on the Agricultural Competitiveness Green Paper, 11 December 2014, p. 1.

with a significant amount of flexibility in managing their water supply and future irrigation requirements.

The region also includes a range of intensive animal producers, including feedlot operators, chicken meat producers and processors, pig producers, and egg producers. Toowoomba and the surrounding regions host Australia's largest concentration of feedlots that supply several meat processors, the majority of which export significant quantities of product.[14]

Consultation with producers indicates that broadacre crop production on the Darling Downs is constrained by water availability. Whilst the production of several key crops, including cotton and chickpeas, has increased in recent years to meet growing demand in global markets, growers reported that opportunities for further expansion were being lost due to a lack of sufficient water supply. As such, growers reported significant unmet demand for water to expand crop production in the region.

In relation to intensive animal producers, the production of cattle and calves represents the most significant source of water use. Whilst there is anecdotal evidence available that the expansion of the feedlot sector on the Darling Downs is currently constrained by a lack of sufficiently reliable water supplies, it is important to note that water use for this purpose is still small relative to the volumes of water that are applied to broadacre crops in the region.

3.1.4 Darling Downs industrial users

As noted in section 2.2, CSG producers have been identified as potential customers for the NuWater project. Specifically, there is the potential for water from the project to be supplied to CSG producers to assist them to satisfy their 'make good' requirements. In accordance with the 'Make Good' obligations under the *Water Act 2000*, if a groundwater bore supply is impaired by CSG water extraction at any time, the CSG producer is required to undertake actions that aim to restore water supply to water bores with impaired capacity or provide the bore owner with alternative water supply options. The demand assessment report contains additional information regarding the 'make good' requirements of CSG producers.

It has been estimated that over the lifetime of the CSG industry in the Surat Basin, up to 459 groundwater bores are expected to experience water-level decline beyond the trigger threshold (i.e. the point at which the capacity of a bore is considered to be impaired) in

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[14] TIQ Darling Downs regional profile.

the Surat Cumulative Management Area (CMA).[15] Of those 459 bores, 91 are predicted to be adversely impacted within the next three years.[16] This indicates that CSG producers may be exposed to significant 'make good' requirements in the future.

3.1.5 Adverse impact of nutrient releases on Moreton Bay

As noted in the preceding section, wastewater effluent is currently discharged from STPs into SEQ waterways and Moreton Bay. Table 2 sets out the volumes of wastewater effluent and key nutrients that are discharged from QUU's STPs into SEQ waterways and Moreton Bay each year.

Table 2 Wastewater and nutrient loads by STP

STPs	**ML per day**				**Kilograms per ML**	
	Option A	**Option B**	**Option C**	**Option D**	**Nitrogen**	**Phosphorus**
Luggage Point	126	120	108	101	6.2	4.7
Gibson Island	40	40	40	40	2.5	2.8
Oxley	47	47	51	51	3.8	1.9
Wacol	5	5	5	5	3.0	3.0
Goodna	13	13	13	13	2.5	0.9
Bundamba	15	15	15	15	4.1	0.6
Redcliffe	19	-	-	-	2.0	1.5
Sandgate	18	-	-	-	2.0	1.5
TOTALS	**283**	**240**	**232**	**225**		

Source: Based on data provided by GHD and QUU.

The discharge of nitrogen and phosphorus results in a reduction in water quality levels in Moreton Bay, which adversely impacts on the health and resilience of plant and animal species, the benefit derived from commercial fishers and recreational users of the Bay, and human health. In particular, high nutrient levels can result in harmful algal blooms in Moreton Bay. Further information on the adverse consequences of increasing nutrient levels in Moreton Bay is provided in section 5.3.3.

Water quality levels in Moreton Bay have deteriorated significantly in recent years, largely due to increased nutrient levels.[17] The pressure on water quality levels in Moreton Bay will continue to increase with further growth in the population of SEQ

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[15] Although Surat CMA covers the area of current and planned CSG development in the Surat Basin and the Bowen Basin, CSG production in the Surat Basin was found to being more than four times higher compared to production in the Bowen Basin.

[16] Department of Natural Resources and Mines (2016). Surat Underground Water Impact Report 2016 – Summary.

[17] EHMP (2009). Report Card 2009 for the waterways and catchments of SEQ. Ecosystem Health Monitoring Program, South East Queensland Healthy Waterways Partnership.

meaning increased wastewater treatment requirements. Furthermore, intensive land uses and increased urban development within water catchments is also expected to result in increases to nutrient loads in Moreton Bay. As such, without intervention, the economic cost imposed by nutrient discharges into Moreton Bay are expected to continue to increase.

3.1.6 Summary of base case

In summary, the base case against which the shortlisted options are to be assessed is defined as follows:

- for the Lockyer Valley, non-urban water use in the region will continue to be dominated by horticultural producers, however the base case with regards to water use will be largely determined by the outcomes of the current water planning process. Either:
  - current groundwater management arrangements will be maintained and water use practices and volumes for vegetable crop production will remain relatively stable; or
  - groundwater use will be significantly reduced as a result of the outcomes of the review of the Moreton Water Plan, resulting in a significant decrease in agricultural production in the region (unless an alternative source of water supply can be secured);
- for the Darling Downs, the continuation of the use of water for the production of broadacre crops, predominantly cotton, wheat and sorghum, predominantly for supply into export markets; and
- the continued deterioration in water quality levels and environmental conditions of SEQ waterways and Moreton Bay due to increased nutrient loads, partly due to ongoing increases in the volumes of wastewater effluent discharged from STPs.

4 Shortlisted options

This section describes the shortlisted options for which the economic and financial impacts are to be assessed relative to the base case.

4.1 Option A

The key elements of Option A are as follows:

- up to 84,680 ML of Purified Recycled Water (PRW) being delivered to the Lockyer Valley and Darling Downs per annum;
- full use of the WCRWS infrastructure, including the Advanced Water Treatment Plants (AWTPs) and pipeline;
- the construction of pipelines from the Redcliffe Sewage Treatment Plant (STP) to Luggage Point STP via the Sandgate STP to provide additional source water (i.e. treatment plant effluent);
- the transfer of additional volumes of source water from Luggage Point STP to Gibson Island STP;
- Gibson Island AWTP upgrade; and
- construction of Heathwood Pumping Station (part of the WCRWS).

4.2 Option B

The key elements of Option B are as follows:

- up to 84,680 ML of Class A+ water being delivered to the Lockyer Valley and Darling Downs per annum;
- partial use of the WCRWS infrastructure, including the pipeline;
- the transfer of additional volumes of source water from Luggage Point STP to Gibson Island STP;
- Gibson Island AWTP upgrade;
- construction of Heathwood Pumping Station (part of the WCRWS); and
- the construction of new storage dams (totalling 12 GL) in the Lockyer Valley.

4.3 Option C

The key elements of Option C are as follows:

- up to 84,680 ML of Class B/C water being delivered to the Lockyer Valley and Darling Downs (includes end of pipe treatment to Class A+ for the Lockyer Valley);
- full use of the WCRWS pipeline, with AWTPs being bypassed;
- the transfer of additional volumes of source water from Luggage Point STP to Gibson Island STP;
- construction of Heathwood Pumping Station (part of the WCRWS); and
- the construction of new storage dams (totalling 12 GL) in the Lockyer Valley.

4.4 Option D

The key elements of Option D are as follows:

- up to 25,000 ML of PRW being delivered to the Lockyer Valley and up to 65,500 ML of Class B/C water being delivered to the Darling Downs, with a total potential annual supply of 73,000 ML;
- partial use of the WCRWS, including a component of the pipeline and AWTPs at Luggage Point STP and Gibson Island STP;
- the construction of a separate pipeline to deliver PRW from the Lowood Booster Pumping Station to the Lockyer Valley;
- bypass of the Bundamba AWTP, with water being sourced from Bundamba, Goodna, Wacol and Oxley Creek STPs; and
- the construction of a separate pipeline to deliver Class B/C water from the Lowood Booster Pumping Station to the Darling Downs.

4.5 Summary of shortlisted options

Table 3 summarises the key characteristics of the shortlisted options.

Table 3 Summary of shortlisted options

Option	ML supplied per annum	Water quality level	Use of WCRWS	Other infrastructure required
Option A	84,680	PRW	Full use of WCRWS	Pipeline from Redcliffe STP to Luggage Point STP via Sandgate STP Gibson Island AWTP upgrade Construction of Heathwood Pumping Station
Option B	84,680	Class A+	Partial use of WCRWS, including pipeline	Gibson Island AWTP upgrade Construction of Heathwood Pumping Station Construction of new storage dams in the Lockyer Valley
Option C	84,680	Class B/C	Full use of WCRWS pipeline, with bypass of AWTPs	Construction of Heathwood Pumping Station Construction of new storage dams in the Lockyer Valley
Option D	Total of 73,000 Up to 25,000 to LV Up to 65,500 to DD	PRW to LV Class B/C to DD	Partial use of WCRWS, including a component of the pipeline	Construction of pipeline to deliver PRW from Lowood Booster Pumping Station to the Lockyer Valley Construction of pipeline to deliver Class B/C water from Lowood Booster Pumping Station to the Darling Downs

Source: Based on information provided by GHD.

5 Economic analysis

This section sets out the economic analysis undertaken for the shortlisted options.

5.1 Purpose and approach

The economic analysis of the NuWater project adopts standard cost-benefit analysis techniques. This approach estimates the net economic impact of a project by comparing all economic benefits that are measurable, material and attributable to the project with the identified economic costs. The results of an economic cost-benefit analysis demonstrate whether the reference project will result in a net economic benefit for the community.

The approach adopted to undertaking the economic cost-benefit analysis was as follows:

- define the base case (i.e. the scenario in which the NuWater project does not proceed) for each entity/asset/resource that will be impacted by the shortlisted options, being:
  - agricultural and industrial water users in the Lockyer Valley;
  - agricultural and industrial water users on the Darling Downs;
  - water infrastructure owners (i.e. wastewater treatment plants and pipeline infrastructure); and
  - Moreton Bay;
- identify the shortlisted options for which the economic impacts of the project are to be assessed;
- identify all impacts to be considered under each shortlisted option, having regard to the base case that has been defined;
- where economic impacts are material and quantifiable, quantify the economic benefits and costs under each of the shortlisted options relative to the base case; and
- estimate the net economic impact, in terms of both the Benefit-Cost Ratio (BCR) and the Net Present Value (NPV) of the shortlisted options relative to the base case.

The benefits associated with the use of water for agricultural production in the Lockyer Valley and Darling Downs have been estimated by developing detailed models of the value of production to be derived from the identified agricultural applications and the costs associated with production. This enables robust estimates to be derived for the net economic value (i.e. gross value of production less all costs incurred, including opportunity cost of land) that is to be derived from the use of water for agricultural production.

The modelling of economic benefits from the expansion of agricultural production is consistent with the water demand assessment undertaken for the project.

5.2 Assumptions

The following key assumptions have been applied in undertaking the economic analysis:

- discount rate of 7 per cent real (as per Building Queensland's guidelines, with sensitivity analysis to be undertaken at 4 and 10 per cent);
- starting date of 31 December 2017; and
- a study period of 30 years, as per Building Queensland guidelines.

5.3 Benefits

This section identifies and discusses the economic benefits to be assessed; sets out the approach to quantifying the benefits (where possible); and the assumptions and parameter estimates applied to derive the benefit estimates.

In assessing the benefits associated with the shortlisted options, it is important to note that the magnitude of the benefits is primarily determined by the volume of recycled wastewater that is to be supplied to users.[18] Hence, given there is no difference in terms of the volume of recycled wastewater to be supplied under Options A, B and C, the economic benefits will be the same under these three options. Under Option D, the benefit estimates have been adjusted taking into account the volumes of recycled wastewater to be supplied.

The economic benefits to be assessed for the shortlisted options are as follows:

- the additional economic value from the use of recycled wastewater for irrigated agricultural production, both in the Lockyer Valley and on the Darling Downs;
- the avoidance of the cost associated with increased nutrient loads in SEQ waterways and Moreton Bay as a result of the continued discharge of wastewater effluent from STPs in SEQ;
- the avoidance of costs associated with the maintenance of WCRWS infrastructure in 'care and maintenance' and 'hot standby' modes;

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[18] Noting that the volume of recycled wastewater that is supplied to users is the same as the volume that will be diverted from Moreton Bay (which is the determinant of the benefit from reduced nutrient loads in the Moreton Bay).

- the environmental benefits associated with increased flows in the Murray Darling Basin; and
- increased water security for other water users in the region (including intensive animal producers and industrial producers).

5.3.1 Increased agricultural production

The use of recycled wastewater to be supplied by the project to increase agricultural production is a key benefit across all the shortlisted options. This benefit is measured based on the net economic value that is derived from the use of water for crop production, including the application of water to increase yields on existing crops and for the expansion of crop production.

This net economic value is estimated by developing models for each crop on which the recycled wastewater would be applied that estimates the value of additional production derived from crop production in addition to measuring the additional costs. This approach enables robust estimates to be derived for the net economic value (i.e. gross value of production less all costs incurred, including the opportunity cost of land) that is to be derived from the use of recycled wastewater for agricultural production.

The approach to estimating the economic benefit from increased agricultural production is as follows:

- consult with growers[19] to identify:
  - the crops on which recycled wastewater would be applied;
  - the purpose for which water would be used, being either increasing yields on existing crops or expanding the area of crop production;
- estimate the revenue per hectare derived from the production of each crop, based on estimates for the crop yield (i.e. units of production per hectare) and farm gate crop prices;[20]
- estimate the gross margin per hectare by subtracting all variable growing costs incurred in crop production, including pre-harvest costs, irrigation costs, harvest and post-harvest costs; and

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[19] This includes initial consultation with grower and irrigator representative bodies; open consultation days with growers in the Lockyer Valley and on the Darling Downs; and responses to an irrigator survey distributed through grower and irrigator representative bodies.

[20] Estimates for these parameters were derived based on a review of publicly available gross margin data; information provided by growers over the duration of the consultation process; and market price data.

- this estimate is then divided by the irrigation application rate to estimate the net on-farm return per ML from crop production.

To estimate the net economic value derived from the expansion of crop production,[21] this estimate for the net return per ML was amended to take into account the opportunity cost of land onto which production is to be expanded (being the economic value that would have been derived from the next best alternative use of the land).[22]

Where water is to be used to increase yields on existing crops, the net economic value from this use of the water is estimated by, for each crop:

- determining the additional volume of water that would be applied to existing crops, based on the outcomes of consultation with growers;
- estimating the yield response (and subsequent increase in farm gate revenue) as a result of the increased application of irrigation water. This is also estimated based on the outcomes of consultation with growers;
- estimating the costs incurred in applying additional irrigation water, including the increases to harvest and post-harvest costs as a result of increased crop yields; and
- based on the above, estimate the net increase in economic value generated by the increased application of irrigation water to existing crops.

This section sets out the economic benefit from the increase in agricultural production for both the Lockyer Valley and Darling Downs.

It is acknowledged that the volumes underpinning the economic benefit estimates set out in the following sections exceed the total volumes for which growers registered interest during the water demand assessment. However, given the preliminary nature of the assessment, the significant unknowns at the time the demand assessment was undertaken, and the small proportion of growers consulted with (compared to the total number of growers in the region), it is considered that the outcomes from the water demand assessment are sufficient to support the full take-up of volumes from the project. This is particularly the case for the Darling Downs, where the total area under crop production and results from the crop modelling conducted as part of the demand

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[21] The expansion of the area of crop production could include the production of crops on new areas of land or an increase in the intensity of crop production on land currently used for production of the crop (e.g. the use of additional water to move from skip row cotton plantings to full cotton plantings).

[22] It is noted that expanding production onto new areas of land will require some growers to incur additional costs in order to obtain the necessary irrigation infrastructure and equipment, in addition to potentially significant investments in order for land to be made suitable for irrigated crop production.

assessment indicate there would be sufficient demand from growers to take up the full volume of water to be supplied under the shortlisted options.[23]

It is recommended that as part of the Detailed Business Case, a formal expression of interest process be undertaken to obtain additional certainty with regards to the level of demand for water from growers in the Lockyer Valley and on the Darling Downs.

Lockyer Valley

As discussed in section 3.1.1, consultation with growers in the Lockyer Valley indicated that future demand for water for irrigated crop production in the region will be sensitive to the future management of groundwater resources. Based on the outcomes of this consultation, the following scenarios have been developed in terms of the volume of demand for water in the Lockyer Valley:

- under the scenario in which groundwater management arrangements remain unchanged, demand of around 7,500 ML per annum; and
- under the scenario in which the review of the Moreton Water Plan results in volumetric entitlements being implemented and significant reductions in groundwater use in the Lockyer Valley, demand of around 25,000 ML per annum.

The low survey response rate from growers in the Lockyer Valley makes it difficult to draw conclusions in relation to the crops on which water would be applied. It is noted that due to the quality requirements with which vegetable growers are required to comply, there is little scope for growers to vary irrigation application rates on vegetable crops. Hence, any additional water that is secured by growers in the Lockyer Valley would be used to increase the area under crop production, either by altering crop rotation practices or expanding crop production onto new land.

The limited survey responses make it is necessary to rely on the modelling results generated to estimate the on-farm returns to be derived from the increase in vegetable crop production in the Lockyer Valley.[24] As such, the net economic value to be derived from the use of additional water for irrigated crop production in the Lockyer Valley has been estimated based on the modelling results for the following crops:

- broccoli
- lettuces

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[23] Furthermore, there is also the potential for industrial water users to be included in the demand profile at a later stage of the project assessment.

[24] Growers advised that the crops to which additional water would be applied would be determined by ongoing market factors, and would likely include a wide range of vegetable crops.

- onions
- carrots
- cabbages
- cauliflowers.

Table 4 summarises the results of the modelling conducted of the on-farm returns from the production of each of these crops in the Lockyer Valley. The modelling was informed by a review of available data and information on the production of these crops in the region; publicly available gross margin data; pricing data; and information provided by growers over the duration of the consultation process.

Table 4 Results of modelling of on-farm returns from increased crop production in the Lockyer Valley

Crop	Gross margin per ha	Irrigation water requirement[a]	Gross margin per ML	On-farm return per ML
Lettuces	$14,583	4.4 ML	$3,314	$3,223
Broccoli	$3,947	3.3 ML	$1,196	$1,075
Onions	$12,390	5.5 ML	$2,253	$2,180
Carrots	$14,933	4.4 ML	$3,394	$3,303
Cabbages	$6,140	4.4 ML	$1,395	$1,305
Cauliflowers	$25,089	4.4 ML	$5,702	$5,611

a Includes a 10 per cent ‘security requirement’ to provide growers with necessary confidence to expand area of crop production.

Note: The on-farm return per ML includes an allowance for the opportunity cost of land used to expand crop production. This has been based on a value of $400 per hectare, commensurate with the gross margin derived from the production of dryland sorghum.

Source: Synergies modelling.

The average net return from the use of additional water for the production of these crops in the Lockyer Valley is $2,783 per ML per annum. This estimate has been applied to determine the economic benefit from the use of water for increased agricultural production in the Lockyer Valley under the shortlisted options.

As discussed in section 2.2, due to the uncertainty over future water demand in the Lockyer Valley, two scenarios have been modelled in relation to the level of demand. Under these scenarios, demand in the Lockyer Valley is estimated at 7,500 ML and 25,000 ML per annum. The estimated economic benefits associated with these demand scenarios is $20.9 million and $69.6 million respectively per annum (2018 dollars).

As per section 4, all of the shortlisted options result in at least 25,000 ML of water being made available to users in the Lockyer Valley. As a result, the economic benefits derived from the use of water for agricultural production in the region are the same under each of the shortlisted options.[25]

The total benefits to be derived from the use of water for agricultural production, both in the Lockyer Valley and on the Darling Downs, will be affected by interruptions to supply during periods in which the WCRWS is required for Indirect Potable Reuse (IPR). Seqwater has provided estimates of the likelihood of supply interruption to 2050. These probabilities have been applied to estimate the total economic benefit to be derived from the use of water for agricultural production under the shortlisted options (see below).

It is important to note that as part of the demand assessment, growers were consulted with in relation to the interruptibility of supply and the corresponding impact on the value of water use. Whilst growers noted that the interruptibility of supply would impact on the value of water allocations, most growers stated that it would not impact on their quantum of demand for water from the NuWater project or the net return that could be derived from the use of the water on an annual basis. The demand assessment report provides additional information on the impact of the interruptibility of supply on the value of water from the project.

Darling Downs

A total of 34 Darling Downs growers responded to the irrigator survey. These growers identified a total demand for additional water exceeding 46,000 ML. Given the preliminary stage of this assessment and the number of irrigators located on the central and northern Darling Downs, it is concluded that total demand for additional water in the region is well in excess of 46,000 ML. Additional information on the responses to the irrigator survey from Darling Downs growers is provided in the demand assessment report.

In addition to the survey responses, targeted consultation was undertaken with growers to identify the crops on which additional water would be applied and the breakdown between application to existing crops and expansion of crop production. Modelling was then undertaken to determine the net return per ML to be derived from the use of additional water, by crop and intended use.

Based on the outcomes of this consultation and modelling, it is anticipated that water would be applied to four key crops – cotton, maize (corn), chickpeas and wheat. Table 5 sets out the proportions of water that would be applied to each crop by use. These proportions are based on the breakdowns provided by growers in survey responses.

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[25] Noting that for Options B and C, additional costs will need to be incurred in order to ensure that water is treated to a quality level appropriate for application to vegetable crops.

Table 5 Breakdown of total water use by Darling Downs growers by crop and intended use

Crop	% total water use on existing crops	% total water use for expansion of crop area
Cotton	47.4%	22.3%
Maize	6.4%	4.3%
Chickpeas	3.6%	6.7%
Wheat	7.1%	2.4%

Note: Total may not add to 100 per cent due to rounding.

Source: Synergies modelling.

The above table shows that the majority of water to be supplied by the project would be applied to cotton crops, both to increase yields on existing crops and to expand the area of crop production. This is reflective of the strong on-farm returns to cotton growers on the Darling Downs and also the positive outlook in terms of demand and price levels in the global cotton market.

Table 6 sets out the on-farm returns to be derived from the use of water to expand crop production on the Darling Downs. As discussed above, the gross margin per hectare and subsequently return per ML have been derived taking into account the opportunity cost of expanding the area of crop production.

Table 6 On-farm returns from expansion of crop production on the Darling Downs

Crop	Gross margin per ha	Irrigation water requirement[a]	Gross margin per ML	On-farm return per ML
Cotton	$3,237	6.05 ML	$535	$502
Maize	$1,766	4.75 ML	$373	$331
Chickpeas	$1,566	2.75 ML	$569	$497
Wheat	$1,433	2.75 ML	$521	$448

a Includes a 10 per cent allowance to account for on-farm storage losses (i.e. evaporation and seepage).

Note: The on-farm return per ML includes an allowance for the opportunity cost of land used to expand crop production. This has been based on a value of $200 per hectare, commensurate with the gross margin derived from the production of dryland sorghum and the assumption that 50 per cent of the land onto which crop production would be expanded would be currently under productive use.

Source: Synergies modelling.

The above table shows that for new crops, cotton and chickpeas generate the highest economic value per ML of water used. The latter is largely attributable to the favourable global market conditions that currently exist.

As noted above, growers also indicated that water would be applied to increase yields on existing crops. Table 7 sets out the on-farm returns to be derived from the application of water to increase yields on existing crops.

Table 7 On-farm returns from increased application to existing crops on the Darling Downs

Crop	Current irrigation rate	Target irrigation rate	Increase in yield	Increase in gross margin per ha	On-farm return per ML
Cotton	3.5 ML	5.5 ML	3.5 bales per ha	$1,401	$637
Maize	3.1 ML	4.3 ML	3 tonnes per ha	$547	$416
Chickpeas	1.7 ML	2.5 ML	1.1 tonnes per ha	$600	$766
Wheat	1.4 ML	2.5 ML	2.25 tonnes per ha	$556	$496

Note: The on-farm return per ML from the increased yield derived as a result of increasing irrigation application rates has been calculated including an additional irrigation water requirement of 10 per cent to account for on-farm storage losses (i.e. evaporation and seepage).

Source: Synergies modelling.

The above table shows that for all crops, the return derived from increasing irrigation application rates on existing crops exceeds the value derived from the use of water to expand crop production. As such, it would be expected that growers would use additional water to ensure that they are at the target irrigation application rate on their existing areas of production before expanding production onto new areas of land. This is consistent with the breakdown of water use based on survey responses (see Table 5).

As noted in section 4, under Options A, B and C, the same volume of water is to be made available for agricultural production. However, the uncertainty in relation to demand in the Lockyer Valley means there is also uncertainty over the volume of water to be supplied to growers on the Darling Downs under each of these options. In addition, the volume of water to be made available to growers on the Darling Downs under Option D also differs relative to the other shortlisted options.

Table 8 sets out the volumes of water to be made available for agricultural production on the Darling Downs under each of the shortlisted options and under the two scenarios in relation to the level of demand in the Lockyer Valley.

Table 8 Volumes available for supply to the Darling Downs under shortlisted options and alternative Lockyer Valley demand scenarios

Option	Volume available with Lockyer Valley demand of 7,500 ML	Volume available with Lockyer Valley demand of 25,000 ML
Option A	77,180 ML	59,680 ML
Option B	77,180 ML	59,680 ML
Option C	77,180 ML	59,680 ML
Option D	65,500 ML	48,000 ML

Source: Volumes provided by GHD.

The above table shows that for Options A, B and C, the volume of water available for supply to the Darling Downs ranges from 59,680 ML to 77,180 ML per annum, subject to demand in the Lockyer Valley. Under Option D, the volume of water available for supply to the Darling Downs is capped at 65,500 ML due to the total volume of water available under this option.

Total economic value from agricultural production

Table 9 sets out the volumes to be applied and associated economic value to be derived, on an annual basis, from the use of water for agricultural production under each of the shortlisted options. The breakdown of water use is based on demand in the Lockyer Valley of 7,500 ML per annum (i.e. demand at current levels of groundwater use).

Table 9 Annual volumes and economic value by crop and intended use under shortlisted options

Crop	Application to existing crops		Expansion of crop area		Totals	
	ML	Net economic return (p.a.)[a]	ML	Net economic return (p.a.)[a]	ML	Net economic return (p.a.)[a]
Options A, B and C						
Lettuce			1,250	$4.03m	1,250	$4.03m
Broccoli			1,250	$1.34m	1,250	$1.34m
Onions			1,250	$2.73m	1,250	$2.73m
Cabbage			1,250	$1.63m	1,250	$1.63m
Carrots			1,250	$4.13m	1,250	$4.13m
Cauliflower			1,250	$7.01m	1,250	$7.01m
Cotton	36,559	$23.29m	17,204	$8.64m	53,763	$31.93m
Maize	4,920	$2.05m	3,280	$1.09m	8,200	$3.14m
Chickpeas	2,772	$2.12m	5,149	$2.56m	7,921	$4.68m
Wheat	5,469	$2.71m	1,823	$0.82m	7,292	$3.53m
Totals	**49,720**	**$30.17m**	**34,956**	**$33.98m**	**84,676**	**$64.15m**
Option D						
Lettuce			1,250	$4.03m	1,250	$4.03m
Broccoli			1,250	$1.34m	1,250	$1.34m
Onions			1,250	$2.73m	1,250	$2.73m
Cabbage			1,250	$1.63m	1,250	$1.63m
Carrots			1,250	$4.13m	1,250	$4.13m
Cauliflower			1,250	$7.01m	1,250	$7.01m
Cotton	31,027	$19.76m	14,601	$7.33m	45,628	$27.09m
Maize	4,176	$1.74m	2,784	$0.92m	6,960	$2.66m
Chickpeas	2,353	$1.80m	4,370	$2.17m	6,723	$3.97m
Wheat	4,642	$2.30m	1,547	$0.69m	6,189	$2.99m
Totals	**42,198**	**$25.60m**	**30,802**	**$31.98m**	**73,000**	**$57.58m**

a Calculated in 2018 dollars.

Note: Totals may not add due to rounding.

Source: Synergies modelling.

It is noted that based on the volumes of water allocated to the different crops and uses, the economic value attributable to vegetable crop production in the Lockyer Valley is disproportionately high compared to cotton and other broadacre crops on the Darling Downs. For example, under Options A, B and C, only 1,250 ML is allocated to the production of cauliflower in the Lockyer Valley compared to over 17,000 ML for the expansion of the area of cotton production on the Darling Downs, yet the economic value derived from the latter only just exceeds that derived from increased cauliflower production.

This is attributable to the high value (per unit of production) of vegetable production in the Lockyer Valley compared to broadacre crop production on the Darling Downs, noting that the scope to expand production in the Lockyer Valley, and subsequently unmet demand for water, is significantly lower than is the case on the Darling Downs.

Accounting for interruptibility of supply

The primary purpose of the WCRWS infrastructure is to supply PRW for IPR. As such, there will be periods during the study period in which water will not be available for agricultural production. It is therefore necessary to take the annual probability of supply interruptions into account in estimating the total economic benefit to be derived from the use of water for agricultural production under the shortlisted options.

Seqwater has provided information on the probability of supply interruptions due to the WCRWS being required for IPR out to 2050. These probabilities are set out in Table 10.

Table 10 Estimated probability of supply interruptions

Year	2020	2030	2050
Probability of interruption	19%	32%	44%

Note: Probabilities have been estimated taking into account the impacts of climate change.

Source: Probabilities provided by Seqwater.

Annual probabilities of supply interruption have been estimated assuming a linear rate of increase between the years for which probabilities have been estimated.[26]

Given the uncertainty associated with the probability of supply interruptions over the duration of the study period, and the significant impact of supply interruptions on the results of the economic analysis, two alternative scenarios have been modelled, one in which the annual probabilities of supply interruptions are reduced by 50 per cent and another in which it is assumed that supply is not interrupted over the duration of the study period.

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[26] This results in increases of 1.3 per cent per annum between 2020 and 2030 and 0.6 per cent per annum between 2030 and 2050.

Total benefits from increased agricultural production

Table 11 sets out annual volumes of water use and the Present Value (PV) of the total economic benefit derived from crop production in the Lockyer Valley and on the Darling Downs under each shortlisted option. The PV estimates have been calculated based on the annual probabilities of supply interruption provided by Seqwater.

Table 11 Total economic benefits of increased agricultural production (PV terms)

Crop	Economic benefits (PV terms)		
	Existing crops	New crops	Total benefit
Options A, B and C			
Lettuce		$30.5m	$30.5m
Broccoli		$10.2m	$10.2m
Onions		$20.6m	$20.6m
Cabbage		$12.3m	$12.3m
Carrots		$31.2m	$31.2m
Cauliflower		$53.0m	$53.0m
Cotton	$176.0m	$65.3m	$241.3m
Maize	$15.4m	$8.2m	$23.6m
Chickpeas	$16.1m	$19.3m	$35.4m
Wheat	$20.5m	$6.2m	$26.7m
Totals	**$228.0m**	**$256.8m**	**$484.8m**
Option D			
Lettuce		$30.5m	$30.5m
Broccoli		$10.2m	$10.2m
Onions		$20.6m	$20.6m
Cabbage		$12.3m	$12.3m
Carrots		$31.2m	$31.2m
Cauliflower		$53.0m	$53.0m
Cotton	$149.3m	$55.4m	$204.7m
Maize	$13.1m	$7.0m	$20.1m
Chickpeas	$13.6m	$16.4m	$30.0m
Wheat	$17.4m	$5.2m	$22.6m
Totals	**$193.5m**	**$241.8m**	**$435.3m**

Note: PV totals are calculated based on a real discount rate of 7 per cent and include terminal values in year 30.

Source: Synergies modelling.

The total benefits from increased agricultural production for Options A, B and C are greater than under Option D due to the increased volume of water made available under the first three options. Despite only accounting for 9 per cent of total water use under Options A, B and C and 10 per cent under Option D, vegetable crops in the Lockyer Valley account for over 30 per cent of economic benefits from increased agricultural production under all shortlisted options. This is attributable to the high per ML returns derived from the production of these higher value crops relative to the broadacre crops produced on the Darling Downs.

The estimates also demonstrate the impact of the supply interruptions on the total economic benefit derived from increased agricultural production under the shortlisted options. In the absence of supply interruptions, the PV for total benefits from increased agricultural production would be $715.4 million under Options A, B and C and $642.4 million under Option D. This means that the supply interruptions as a result of the re-commissioning of the WCRWS for IPR result in a reduction in total agricultural benefits of over 30 per cent over the evaluation period.

These benefit estimates do not take into account the costs associated with on-farm infrastructure improvements that will need to be made by some growers. These costs have been separately assessed in section 5.4.4.

5.3.2 Avoided 'care and maintenance' and 'hot standby' costs for the WCRWS

Seqwater currently incurs costs to maintain the WCRWS infrastructure in 'care and maintenance' mode. Seqwater has advised that the annual cost incurred in maintaining the infrastructure in 'care and maintenance' mode is approximately $10.3 million per annum. Under the shortlisted options, the WCRWS infrastructure would be re-purposed to supply treated wastewater to users in the Lockyer Valley and on the Darling Downs. Hence, a proportion of these costs will be avoided.

Seqwater has also advised that once the WCRWS is re-commissioned for IPR, it will be maintained in 'hot standby' mode, to enable it to be more rapidly re-commissioned for IPR in the future. Under the shortlisted options, the WCRWS and associated infrastructure will remain operational during these periods. Hence, the costs Seqwater would otherwise incur to maintain the infrastructure in 'hot standby' mode will also be avoided under the shortlisted options.

Based on the above, the costs to be avoided (i.e. benefits) under the shortlisted options are as follows:

- a proportion of the cost of maintaining WCRWS infrastructure in 'care and maintenance' mode up until the initial re-commissioning of the scheme for IPR; and
- the cost of maintaining WCRWS infrastructure in 'hot standby' mode over the remainder of the study period, excluding periods in which the WCRWS is in operation for IPR.

As the cost of maintaining the WCRWS in 'hot standby' mode is yet to be estimated, the quantification of this benefit has been limited to the avoidance of 'care and maintenance' costs to be incurred by Seqwater up until the initial re-commissioning of the WCRWS for IPR. The benefit of avoiding this cost has been estimated by applying the annual probabilities estimated by Seqwater to this cost estimate (see section 5.3.1)[27] and the proportion by which 'care and maintenance' costs would be avoided under the shortlisted options.[28]

Table 12 summarises the proportion of 'care and maintenance' costs to be avoided under each shortlisted option and, based on the approach described above, the total benefit estimates (in PV terms) for each option.

Table 12 Avoidance of 'care and maintenance' costs under shortlisted options

Option	Proportion of costs to be avoided	Annual avoided cost (2018 dollars)	Total avoided costs (PV terms)[a]
Option A	100.0%	$10.3 million	$16.5 million
Option B	62.0%	$6.4 million	$10.2 million
Option C	10.0%	$1.0 million	$1.6 million
Option D	74.4%	$7.7 million	$12.3 million

a The total PV estimate is calculated over the evaluation period taking into account the probabilities of supply disruptions provided by Seqwater and applying the multiplicative probabilistic approach.

Note: PV estimates are calculated based on a real discount rate of 7 per cent.

Source: Proportions provided by GHD.

5.3.3 Reduced nutrient loads in Moreton Bay

Reducing the nutrients discharged from STPs is a key driver of the NuWater project. As discussed in section 3.1.5, QUU (along with other water and wastewater service providers in SEQ) currently discharges nitrogen and phosphorus from its STPs into SEQ waterways and Moreton Bay.

By diverting recycled wastewater effluent produced at these STPs for beneficial reuse, the shortlisted options will result in a reduction in the quantity of nutrients that are discharged into SEQ waterways and Moreton Bay, hence avoiding the adverse water quality and environmental impacts associated with the build-up of nitrogen and phosphorus loads.

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[27] A multiplicative probabilistic approach has been adopted to estimate the total benefit in PV terms attributable to avoided 'care and maintenance' costs. This approach accounts for the probability that the WCRWS will not be required for IPR in any year of the study period.

[28] The proportion of 'care and maintenance' costs to be avoided were provided by GHD.

This section assesses the adverse impacts associated with the discharge of nutrients into Moreton Bay; the impact of the shortlisted options on nutrient loads in the Bay; and the economic value associated with this reduction in nutrient loads.

Economic value of Moreton Bay

The discharge of nutrients into Moreton Bay adversely affects water quality levels and the environmental condition of Moreton Bay. Moreton Bay is an environmental asset of significant value, as demonstrated by the following:[29]

- Moreton Bay is one of three declared Marine Parks in Queensland and is one of Australia's largest sites listed under the Convention on Wetlands of International Significance (Ramsar Convention);
- the wetlands within Moreton Bay include intertidal mudflats, marshes, sandflats and mangroves adjoining the Bay's island and the mainland. This variety of habitats contributes to the Bay's high level of biodiversity;
- there are eleven declared Fish Habitat Areas in Moreton Bay which support a large number of fish species;
- seagrass habitats in Moreton Bay support a wide range of species including turtles, fish, crustaceans and dugongs. Turtles (Green and Hawksbill) and dugong are listed as vulnerable under the *Nature Conservation Act 1992*;
- mangroves in Moreton Bay also stabilise the intertidal zone, which reduces sediment flows and reduces the risk of erosion; and
- it is estimated that 32 species of migratory shorebirds visit Moreton Bay on an annual basis, with the majority being listed under the Japan Australian Migratory Bird Agreement (JAMBA) or the China Australia Migratory Bird Agreement (CAMBA). In addition, there are approximately 3,500 resident shorebirds that breed in and around Moreton Bay each year.

In addition to its significant environmental value, Moreton Bay also supports Queensland's commercial fishing industry, with an estimated output of $24 million per annum.[30] The majority of this output is sold in domestic markets within SEQ. Commercial fishing operations also play an important role in the seafood chain within

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[29] Available at: https://www.npsr.qld.gov.au/parks/moreton-bay/culture.html [Accessed 19 September 2017]

[30] Available at: http://www.naturalassetsseqyoursay.com.au/seq-nrm-plan-beneficiaries/fisheries [Accessed 19 September 2017]

Moreton Bay and hence contribute to the environmental sustainability of the surrounding environment. Activities that impact on commercial fishing in the Bay will subsequently have flow on impacts for a range of business sectors that rely on the current environmental conditions in Moreton Bay.[31]

Moreton Bay also possesses significant value as a major source of recreation, both for tourists and SEQ residents. The primary recreational uses include fishing and boating activities. In 2015/16, total international and domestic visitor nights in the Moreton Bay region totalled almost 4.4 million. There were also around 2.6 million domestic day trips to the region.[32]

Impact of nutrient loads on Moreton Bay

Increasing nitrogen and phosphorus loads are having a significant impact on water quality levels and hence the environmental value of Moreton Bay. Whilst these nutrients are necessary for ecological functioning in coastal waters, excess loads can have severe negative environmental consequences. The most significant of these consequences that are relevant to Moreton Bay are:[33]

- eutrophication, which occurs when a body of water becomes enriched in dissolved nutrients that stimulate the growth of aquatic plant life, usually resulting in the depletion of dissolved oxygen;
- harmful algal blooms, which cause depleted oxygen levels in the water, reducing plant growth, triggering fish deaths and increasing public health risks due to contamination of fisheries and aquaculture;
- high turbidity, which limits light penetration, affecting plant growth;
- the creation of coastal low-oxygen dead zones (hypoxic events), which occurs when excess nutrients enter coastal areas and cause algae to flourish to unnatural levels. When these algae die and are decomposed by microorganisms, oxygen is depleted. This adversely affects animal species; and
- disruption of natural biogeochemical cycling. These processes and elemental cycles affect the availability of nutrients such as carbon and nitrogen. Disruption to these

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[31] Available at: http://www.naturalassetsseqyoursay.com.au/seq-nrm-plan-beneficiaries/fisheries [Accessed 19 September 2017]

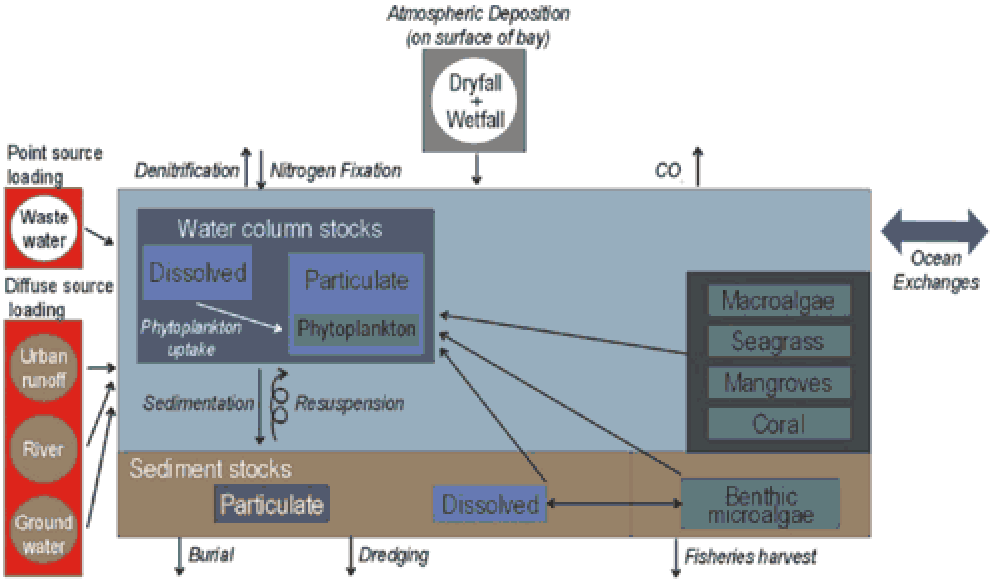
[32] 'Moreton Bay Region – Tourism visitor summary'; Moreton Bay Region Industry and Tourism; See: http://economy.id.com.au/moreton-bay/tourism-visitor-summary; DOA: 25 October 2017.

[33] Available at: https://soe.environment.gov.au/theme/coasts/topic/2016/coastal-waters [Accessed 19 September 2017]

cycles can strongly influence food-web structure, lead to toxic bloom events and adversely impact on commercial fishing yields.

Figure 1 shows a conceptual model of nutrient flows in Moreton Bay, showing nutrient sources, recycling pathways, storages and losses.

Figure 1 Conceptual model of nutrient flows in Moreton Bay



Source: Available at: http://www.ozcoasts.gov.au/indicators/water_column_nutrients.jsp [Accessed 19 September 2017].

It has been estimated that each year, around 465,000 tonnes of sediment, 5,850 tonnes of nitrogen, and 730 tonnes of phosphorus are released into SEQ waterways, a significant proportion of which flow into Moreton Bay.[34] This has resulted in a significant decline in the condition of SEQ waterways and Moreton Bay.[35] Investigations have found that without significant intervention, the health of SEQ waterways and Moreton Bay will continue to decline,[36] with pressures on water quality levels increasing due to continued population growth in SEQ and associated wastewater disposal requirements and more intensive land use within water catchments.

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[34] Marsden Jacob Associates (2011). *The future of our bay*. Prepared for the Department of Environment and Resource Management, Queensland Government.

[35] EHMP (2009). *Report Card 2009 for the waterways and catchments of SEQ*. Ecosystem Health Monitoring Program, South East Queensland Healthy Waterways Partnership, Brisbane.

[36] Mainstream Economics and Policy (2011). Sharing the load: A collaborative approach to investing in South East Queensland's waterways.

Impact of the shortlisted options on nutrient loads

The preceding sections describe the adverse impact of increasing nitrogen and phosphorus loads in Moreton Bay. Under the shortlisted options, recycled wastewater effluent will be diverted for beneficial re-use as opposed to being discharged into waterways, hence avoiding these adverse impacts. Table 2 set out the volumes of wastewater effluent to be diverted and nutrient loads at each of the STPs under each shortlisted option. Based on these estimates, Table 13 sets out the tonnes of nitrogen and phosphorus that will be diverted from SEQ waterways and Moreton Bay under each shortlisted option.

Table 13 Tonnes of nitrogen and phosphorus to be avoided under each shortlisted option

STP	Option A		Option B		Option C		Option D	
	N (tonnes p.a.)	P (tonnes p.a.)	N (tonnes p.a.)	P (tonnes p.a.)	N (tonnes p.a.)	P (tonnes p.a.)	N (tonnes p.a.)	P (tonnes p.a.)
Luggage Point	285	216	272	206	244	185	229	173
Gibson Island	37	41	37	41	37	41	37	41
Oxley	65	33	65	33	71	35	71	35
Wacol	5	5	5	5	5	5	5	5
Goodna	12	4	12	4	12	4	12	4
Bundamba	22	3	22	3	22	3	22	3
Redcliffe	14	10	-	-	-	-	-	-
Sandgate	13	10	-	-	-	-	-	-
TOTALS	**454**	**323**	**413**	**292**	**391**	**275**	**376**	**263**

Source: Synergies modelling based on data provided by GHD and QUU.

As per the estimates in the above table, the reduction in nitrogen and phosphorus discharges is greatest under Option A. This is due to the greater volume of wastewater effluent that is diverted under this option. Under all shortlisted options, a greater tonnage of nitrogen is avoided, largely attributable to the higher nitrogen content of wastewater effluent produced by the Luggage Point, Oxley and Bundamba STPs.

It is important to note that the economic benefits of reduced nutrient discharges have been quantified based on the assumption that, under the base case, nutrient discharges will continue to occur from the relevant STPs at their current rates. There is the potential that as part of the recommissioning of the WCRWS (and associated upgrades to STPs), nutrient capture technology could be implemented to achieve a similar reduction in nutrient discharge levels as will be achieved under the shortlisted options. However, in the absence of a defined trigger for the implementation of this technology, it is considered appropriate to quantify the economic benefit of reduced nutrient discharges under the shortlisted options in full over the evaluation period.

It is noted that an increase in water use for agricultural production can result in additional nutrient loads in waterways. If this were to occur this would offset a proportion of the reduction in nutrient loads attributable to the diversion of treated wastewater from SEQ waterways and Moreton Bay. However, regarding this potential impact, the following is noted:

- irrigation farming enterprises on the Darling Downs (the region in which the majority of the recycled wastewater is to be supplied) effectively operate as closed systems as a result of their tail-water return/recycling systems. This largely contains run-off and associated nutrients within the farm boundaries;
- it has been assumed that best practice nutrient management processes would be applied in any expansion of agricultural production in the Lockyer Valley. There is also the potential for requirements around nutrient management processes and practices to be incorporated into the water supply agreements to apply to the project; and
- it is unlikely that the economic cost associated with an increase in nutrient loads resulting from an increase in agricultural production in the Lockyer Valley would be material relative to the overall reduction in nutrient discharges attributable to the shortlisted options (particularly as the demand assessment indicates the majority of water would be supplied to the Darling Downs).

Based on the above, no adjustment has been made to the quantity of nutrients being diverted from SEQ waterways and Moreton Bay to account for the increased use of water for agricultural production for the purpose of assessing the economic impact of the project options.

Valuing the reduction in nutrient loads

To estimate the economic benefit from the reduction in nitrogen and phosphorus discharged from STPs, it is necessary to apply a value for the economic cost associated with the discharge of these nutrients into SEQ waterways and Moreton Bay.

Valuing the adverse impact of polluting activities can be challenging, as the impacts are non-monetary and marginal impacts can be difficult to identify. These challenges are present in this case, as whilst there is clearly an economic cost associated with the adverse impact of the discharge of nutrients into SEQ waterways and Moreton Bay, there is no clear value that can be applied as an estimate of these costs.

Applying the principles of welfare economics, the benefit associated with the improved condition of SEQ waterways and Moreton Bay as a result of a reduction in the discharge of nitrogen and phosphorus should be assessed based on the community's willingness to pay (WTP) for the improvement in water quality and environmental conditions.[37] Estimating WTP with regards to changes in the condition of environmental assets typically requires the application of survey techniques or other non-market valuation methods as part of a contingent valuation approach.

As such an exercise is beyond the scope of this feasibility study, it is necessary to apply a 'proxy' value[38] to quantify the economic cost associated with the discharge of nutrients into Moreton Bay. There are three options in terms of the proxy value that can be applied to estimate the avoided cost of the discharge of nutrients under the shortlisted options:

- damage costs, being the cost that the discharge of nutrients are estimated to impose on waterways and water bodies;
- abatement costs, being the marginal cost of projects or activities aimed at reducing nutrient flows into waterways and water bodies; or
- fees levied on entities responsible for releasing nutrients into waterways and water bodies.

Attachment A sets out the information available to be applied to estimate the economic cost associated with the discharge of nitrogen and phosphorus into SEQ waterways and Moreton Bay under each of these approaches. The scope for each method to be applied in this feasibility is discussed below.

Using an estimate for the damage costs associated with the discharge of nutrients into waterways as a proxy value requires an estimate that is applicable to the region or water body to be affected by the project that is under consideration. This is necessary due to the difficulties associated with transferring damage cost estimates between different regions due to significant differences in environmental and ecological conditions. As no such study has been undertaken for Moreton Bay or SEQ, this approach was not considered appropriate.

The second option is to apply an estimate of the marginal abatement cost as the proxy value for the economic cost of nutrient releases. The rationale underpinning the use of marginal abatement costs as a proxy value is that this reflects the avoidance of the cost

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[37] Or alternatively, the community's willingness to accept (WTA) a deterioration in the condition of SEQ waterways and Moreton Bay.

[38] Proxy values are commonly used to value environmental assets or to value the impact of changes to environmental assets, where the value of those assets is primarily captured by non-market values.

that would otherwise be incurred in order to achieve a similar reduction in nutrient loads.[39]

A review of past studies and publications revealed significant variation in estimates of the cost of abating nutrient releases. In 2005, Central Queensland University conducted a study on the cost-effectiveness of reducing nutrients from point and diffuse sources in SEQ. The study was based on an assessment of the cost of reducing nutrient discharge through a combination of STP upgrades and activities aimed at reducing emissions in SEQ waterways. The study estimated average costs of point source load reduction of:

- $6,729 per tonne for nitrogen
- $5,400 per tonne for phosphorus.[40]

The above estimate for nitrogen abatement was not dissimilar to the estimate of $9,375 per tonne derived for the Luggage Point STP.[41]

These estimates are also not dissimilar to the following estimates published in a South Australian-based study on the cost of nutrient abatement in water pollution:

- for nitrogen, $2,700 to $8,200 per tonne
- for phosphorus, $2,700 to $5,500 per tonne.[42]

Finally, an ACIL Allen Consulting report from 2014 assessed the cost of various projects and activities that reduced nutrient loads in waterways and water bodies. The full list of projects and cost estimates is included in Attachment A. Table 14 contains the details for those projects and activities located in SEQ.

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[39] That is, the benefit of avoiding the release of nutrients into SEQ waterways and Moreton Bay would be equal to the cost that would be incurred in achieving the equivalent reduction in nutrient loads through other projects and activities.

[40] Rolfe, J., Donaghy, P,. et al (2005). Considering the economic and social impacts of protecting environmental values in specific Moreton Bay/SEQ, Mary River Basin/Great Sandy Strait Region and Douglas Shire Waters. Institute for Sustainable Regional Development, Central Queensland University.

[41] Hall, M. (2012). The Cost of Pollution: Supporting Cost-Effective Options Evaluation and Pollution Reduction. Urban Water Security Research Alliance Technical Report No. 61.

[42] BDA Group (2009). The full cost of landfill disposal in Australia. Department of the Environment, Water, Heritage and the Arts.

Table 14 Marginal Abatement Costs for nitrogen and phosphorus removal

Project details	Cost per tonne
Nitrogen	
Tertiary filtration at a small STP in SEQ, resulting in a 37-tonne reduction in nitrogen loads over 20 years	$195,139
Tertiary filtration at a large STP in SEQ, resulting in a 2,190-tonne reduction in nitrogen loads over 20 years	$81,309
Nutrient removal from a pine pulpwood plantation in SEQ; 0.08 tonnes per hectare p.a.	$35,416
Biological nutrient removal at an STP in SEQ, resulting in a 75-tonne reduction in nitrogen loads over 20 years	$18,584
Nutrient removal from a hay and sorghum rotation in SEQ; 0.517 tonnes per hectare p.a.	$10,951
Fencing and riparian revegetation in SEQ, resulting in an 87-tonne reduction in nitrogen loads per farm over 20 years	$3,784
Nutrient removal from a hay and sorghum rotation in SEQ; 0.517 tonnes per hectare p.a., over 2,793 hectares	$3,021
Biological nutrient removal at a large STP in SEQ, totalling 7,470 tonnes of nitrogen load reduction over 20 years	$696
Phosphorus	
Eucalypt sawlog plantation in SEQ; 0.003 tonnes per hectare p.a. over 19 hectares	$463,517
Eucalypt sawlog plantation in SEQ; 0.003 tonnes per hectare p.a. over 3,695 hectares	$123,790
WSUD – Swales in SEQ, resulting in a 1.81-tonne reduction in phosphorus loads over 20 years	$32,185
Biological nutrient removal at an STP in SEQ, resulting in a 22-tonne reduction in phosphorus loads over 20 years	$24,779
Tertiary filtration at a small STP in SEQ, resulting in a 29-tonne reduction in phosphorus loads over 20 years	$18,295
Tertiary filtration at a large STP in SEQ, resulting in an 876-tonne reduction in phosphorus loads over 20 years	$15,245
Sludge management and disposal works at a small STP in SEQ, resulting in a 183-tonne reduction in phosphorus loads over 20 years	$8,161
Sludge management and disposal works at a small STP in SEQ, resulting in a 657-tonne reduction in phosphorus loads over 20 years	$5,194
Sludge management at a large STP in SEQ, resulting in a 913-tonne reduction in phosphorus loads over 20 years	$3,739
Sludge management at a large STP in SEQ, resulting in a 3,285-tonne reduction in phosphorus loads over 20 years	$2,775
Biological nutrient removal at a large STP in SEQ, resulting in an 830-tonne reduction in phosphorus loads over 20 years	$783

Note: Cost estimates based on projects or works in SEQ have been highlighted.

Source: ACIL Allen Consulting (2014). Load-Based Licence Fee Comparison – Comparison of Load-Based Licence Fees with Marginal Abatement Costs (MAC) and Marginal External Costs (MEC) for Selected Pollutants.

The estimates reported in the table above reiterate the significant variability in the cost of different nutrient abatement projects and activities. For nitrogen, when the highest cost project is excluded (this project only resulted in a small reduction in nitrogen releases at high cost), the average cost of nitrogen abatement was $21,966 per tonne. For phosphorus, the average cost for projects that resulted in significant reductions in phosphorus releases was $5,983 per tonne.

QUU has recently undertaken a project aimed at abating the quantity of nutrients (in particular nitrogen) entering SEQ waterways and Moreton Bay. The details of this project are summarised in the box below.

Box 1 QUU Beaudesert nutrient offset project

QUU's Beaudesert nutrient offset project is a pilot project aimed at managing nutrient discharges into the Logan River. The purpose of the project was to undertake works to offset nutrient discharges from the Beaudesert STP, which was being placed under increased pressure due to local population growth.

The project has involved QUU investing around $1 million to repair approximately 500 metres of eroded riparian corridors located close to the Beaudesert STP. The works included structural bank stabilisation and riparian planting.

Modelling was used to determine the scale of works required to offset 5 tonnes of Total Nitrogen (TN) from entering the river on an annual basis. Historical erosion rates and riverbank erosion models were used to calculate average sediment erosion during high flow events and soil samples were taken to determine the percentage of nitrogen contained in the sediment. This produced an estimate of the sediment erosion avoided and the nutrient load avoided by the bank stabilisation activities.

The nitrogen savings made through the riparian works are to be used to counterbalance potential increases in nitrogen discharge from the STP that may occur during wet weather events. These nitrogen savings will allow the Beaudesert STP to continue to operate without expensive upgrades. The cost of the required upgrades had been estimated at around $8 million. In addition, the project will prevent over 11,000 tonnes of sediment from entering waterways and 8 tonnes of Total Phosphorus (TP), also on an annual basis.

The pilot study commenced in January 2014 and is to run for five years.

Sources: Department of Environment and Heritage Protection (2014). Flexible options for managing point source water emissions: A voluntary market-based mechanism for nutrient management; Water Services Association of Australia (2017). Case study 6 – Using nutrient offsets to improve the Logan River.

As detailed above, the scale of works for the Beaudesert nutrient offset project were determined based on the amount of sediment erosion that would need to be prevented to achieve a given reduction in nitrogen loads. This is due to nitrogen being the 'limiting' nutrient in the Lower Brisbane catchment and Moreton Bay.[43] As such, the primary focus of nutrient-related projects in SEQ is on reducing nitrogen loads, noting that reducing phosphorus loads also results in a significant environmental benefit.

Based on industry sources and review of a range of marginal abatement costs applied in practice, an estimate for the marginal cost of abating the discharge of nitrogen from STPs was assumed to be $23,000 per tonne per annum.[44] Whilst it is difficult to derive an estimate for the marginal cost of abatement of phosphorus loads (given the emphasis on nitrogen reduction as the 'limiting' nutrient), it is noted that the cost of phosphorus abatement is lower than the cost of nitrogen abatement. One option is to apply the percentage difference in the abatement cost estimates reported in the Central Queensland University study to the estimate of $23,000 per tonne for the cost of abating

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[43] This means that nitrogen is the nutrient that is depleted first in the production of algae in Moreton Bay.

[44] Noting that abatement costs vary based on the project and activity being undertaken.

nitrogen loads. This approach results in a marginal abatement cost for phosphorus of $18,400 per tonne.

Whilst it is noted that these costs are higher than the majority of marginal abatement cost estimates reported in previous studies and reports, this is considered to be consistent with the increasing environmental cost of nutrient loads in SEQ waterways and Moreton Bay and the increasing nutrient abatement costs faced by water utilities (noting that the abatement cost that has been applied as a 'proxy' value is potentially at the upper end of the range of nutrient abatement costs).

The final option in terms of a proxy value that can be applied to estimate the economic cost associated with nitrogen and phosphorus loads is to base the cost estimate on the fees that are levied by regulatory bodies on entities that are responsible for discharging nutrients into waterways or water bodies.

In June 2017, the Department of Environment and Heritage Protection (DEHP) released the Consultation Draft for the 'Point-Source Water Quality Offsets Policy', which is proposed for implementation under the *Environmental Protection Act 1994*.[45] This document, which is an update of the 2014 draft policy document, sets out the requirements for implementing a water quality offsets regime as a mechanism to manage point source discharges of nutrients and pollutants into Queensland waterways and water bodies. This will provide an opportunity for entities to manage their emission discharge requirements, to be set by government based on objectives and targets in relation to environmental and water quality outcomes, through a range of alternative investment options.

Once the regime is implemented, there is the potential for these water quality offsets to be purchased and traded. The price of these offsets could provide an indication as to the economic value of reducing the discharge of nutrients and pollutants into Queensland waterways and water bodies. However, given the regime is currently under development, it is necessary to consider regimes that have been established in other jurisdictions and whether it is appropriate for fees or levies in these jurisdictions to be applied as a proxy value for the discharge of nutrients into SEQ waterways and Moreton Bay.

Attachment A sets out the fee mechanisms for nutrient discharges that are applied in other jurisdictions. In summary, this approach is not considered appropriate for identifying a proxy value to be applied to estimate the benefit of avoiding nitrogen and phosphorus discharges into SEQ waterways and Moreton Bay. In addition to most of the

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[45] Department of Environment and Heritage Protection (2017). Have your say Consultation draft – Point-Source Water Quality Offsets Policy. Queensland Government.

fees being applied in international jurisdictions with significant differences to SEQ, there is also deemed to be insufficient relationship between the costs imposed by the discharge of nutrients into waterways and water bodies and the fees levied on entities (particularly in New South Wales, the closest potential comparator to SEQ).

Summary

Based on an assessment of the available data and information, it is considered that the marginal cost of abating the discharge of nutrients into waterways and water bodies is the most appropriate proxy for estimating the benefit of reducing the quantities of nitrogen and phosphorus that are discharged into SEQ waterways and Moreton Bay. Based on the studies and reports reviewed and information provided by industry sources, the following abatement cost estimates have been applied in quantifying this economic benefit under the shortlisted options:

- $23,000 per tonne for nitrogen
- $18,400 per tonne for phosphorus.

Given the inherent uncertainty associated with these values, sensitivity analysis has been performed on these estimates (see section 5.6.1).

Economic benefit under the shortlisted options

Table 15 sets out the annual and total economic benefit estimates (in PV terms) associated with the reduction in nutrients discharged into SEQ waterways and Moreton Bay under the shortlisted options, based on the assumptions and parameter estimates set out in the preceding sections.

Table 15 Economic benefits from reduced nutrient loads in Moreton Bay under shortlisted options

Option	Avoided nutrient loads (tonnes p.a.)		Annual economic benefit		Total benefit (PV terms)[a]
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	
Option A	454	323	$10.4m	$5.9m	$176.0 million
Option B	413	292	$9.5m	$5.4m	$159.8 million
Option C	391	275	$9.0m	$5.1m	$150.8 million
Option D	376	263	$8.6m	$4.8m	$144.5 million

a PV estimates have been calculated based on a real discount rate of 7 per cent and include a terminal value in year 30.

Note: It is important to note that benefits have been assessed over the entire evaluation period regardless of interruptions to supply. This means that the assumption has been adopted that under the base case, current discharge rates for nitrogen and phosphorus will remain unchanged, regardless of whether the WCRWS is re-commissioned for IPR. Were the infrastructure upgrades to be undertaken as part of the recommissioning process to include works to avoid the discharge of nutrients into SEQ waterways and Moreton Bay from these STPs, the economic benefits attributable to the shortlisted options would be reduced.

Source: Synergies modelling.

The above table shows that the total economic benefit from the reduction in nutrient discharges into SEQ waterways and Moreton Bay ranges from $144.5 million (Option D) to $176.0 million (Option A) (in PV terms). Benefits are impacted by the volume of wastewater effluent to be diverted from the STPs and the nitrogen and phosphorus content of wastewater effluent at each STP.

Due to the uncertainty associated with the economic value associated with avoided nutrient discharges, this benefit has been subject to sensitivity analysis (see section 5.6.1).

5.3.4 Increased environmental flows into the Murray Darling Basin

In recent decades, the combined impact of prolonged droughts and the overuse of water resources has resulted in a significant decline in the health of the MDB. A significant effort has been made over the past ten years to improve the condition of the MDB by increasing environmental flows. This has included significant changes to water planning and management frameworks and the government buy-back of water allocations.

A Basin-wide environmental watering strategy has been developed to support the environmental objectives of the MDB Plan. The watering strategy, which was released in 2014, aims to improve the condition of key water-dependent ecosystems in the MDB.[46] The benefits of increased environmental flows in the MDB include:

- increased river flows and connectivity between waterways in the Basin;
- maintenance and improvement of the condition of native vegetation and wetlands;
- maintenance of the diversity of native species, including water and migratory birds, and improved breeding; and
- improved populations and distribution of fish species.

Whilst the water to be supplied under the shortlisted options will be supplied to agricultural producers, the project will result in an increase in water availability in the region and therefore water flows into the MDB. For example, increased water application in the region as a result of the project will increase the volume of run-off into waterways.

In addition, under the scenario in which users do not apply the water from the project for productive use, water will be discharged into waterways (subject to water quality requirements being satisfied), which will also increase environmental flows in the MDB.

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[46] 'Basin-wide environmental watering strategy'; Murray-Darling Basin Authority; See: https://www.mdba.gov.au/managing-water/environmental-water/basin-wide-environmental-watering-strategy; DOA: 30 October 2017.

As the economic benefits from agricultural production have been quantified based on the full take-up of available volumes of recycled wastewater, it is not appropriate to attribute a value to the increased environmental flows under the shortlisted options. However, it should be noted that in the event that a proportion of available volumes are not applied for a beneficial re-use, the shortlisted options will improve environmental flows in the MDB.

5.3.5 Increased water security for other water users

As discussed in section 2.2, identified demand for water from the shortlisted options is limited to irrigated crop production. Whilst consultation was undertaken to assess potential demand from the intensive animal production sector, it was not possible to identify any sources of demand from these sectors, largely due to concerns over reliability of supply and water quality.[47]

Despite this, there is still scope for these sectors to derive benefit from the overall increase in water available in the region. By increasing total water availability across the region, the shortlisted options will increase the volume of water available for agricultural (or industrial) production, resulting in an increase in water security for all water users, including intensive animal producers.

As with the previous benefit, as the economic benefit from agricultural production has been estimated based on the full take-up of recycled wastewater volumes, the consideration of this benefit has been limited to a qualitative assessment.

5.3.6 Summary of economic benefits

Table 16 presents a summary of the economic benefits for each of the shortlisted options, based on the following assumptions:

- water demand for agricultural production in the Lockyer Valley of 7,500 ML per annum (i.e. estimated demand with current groundwater use), with remaining volumes available under the shortlisted options to be supplied to the Darling Downs;
- supply interruption probabilities provided by Seqwater; and
- the benefits from the reduction in nutrient discharges into SEQ waterways and Moreton Bay have been quantified based on the assumption that current nutrient

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[47] In addition, the industry representative for dairy farmers indicated that producers did not have sufficient capacity to pay for water from the project.

discharge rates continue over the duration of the evaluation period under the base case (i.e. regardless of the WCRWS being recommissioned for IPR).

Table 16 Present Value estimates of economic benefits for shortlisted options

Benefit	Option A	Option B	Option C	Option D
Economic value of agricultural production	$484.8m	$484.8m	$484.8m	$435.3m
Avoided 'care and maintenance' and 'hot standby' costs[a]	$16.5m	$10.2m	$1.6m	$12.3m
Reduced nutrient loads in Moreton Bay	$176.0m	$159.8m	$150.8m	$144.5m
Increased environmental flows in MDB	Qualitative	Qualitative	Qualitative	Qualitative
Increased water security	Qualitative	Qualitative	Qualitative	Qualitative
Total benefits	**$677.3m**	**$654.8m**	**$637.2m**	**$592.1m**

a Benefit estimates have been calculated taking into account the impact of the re-commissioning of the WCRWS for IPR using the multiplicative probabilistic approach.

Note: PV estimates are calculated based on a real discount rate of 7 per cent.

Source: Synergies modelling.

The above table demonstrates that Option A results in the highest total economic benefit, due to the diverted wastewater effluent to be diverted under this option having a higher nutrient content relative to the other shortlisted options. Option D has the lowest total economic benefit (around 13 per cent lower than for Option A), primarily due to the lower volume of recycled wastewater to be made available for agricultural production under this option.

As previously discussed, the estimated benefits are impacted by the volume of demand in the Lockyer Valley and the treatment of the probability of supply interruptions over the duration of the study period. Alternative assumptions in relation to these key factors are assessed in the sensitivity and scenario analysis (see section 5.6).

5.4 Costs

This section sets out the economic costs associated with the project options.

5.4.1 Capital costs

Whilst the shortlisted options aim to make use of currently under-utilised infrastructure developed as part of the WCRWS project, there are still significant infrastructure enhancements required for recycled wastewater to be supplied to agricultural producers in the Lockyer Valley and on the Darling Downs (including distribution pipeline networks in both regions). As such, there are significant capital costs associated with each option. Table 17 summarises the capital cost profiles for each shortlisted option (and the breakdown of costs between the Lockyer Valley and the Darling Downs).

Table 17 Capital cost profiles for shortlisted options

Option	2018	2019	2020	2021	Totals	Totals (PV terms)
Option A						
LV	$33.0m	$74.1m	$34.8m	$11.6m	$153.5m	**$132.8m**
DD	$443.5m	$997.4m	$468.8m	$156.3m	$2,066.0m	**$1,787.6m**
Total	$476.5m	$1,071.5m	$503.7m	$167.9m	$2,219.5m	**$1,920.4m**
Option B						
LV	$22.2m	$49.9m	$23.5m	$7.8m	$103.4m	**$89.5m**
DD	$349.2m	$785.3m	$369.1m	$123.0m	$1,626.7m	**$1,407.4m**
Total	$371.4m	$835.2m	$392.6m	$130.9m	$1,730.1m	**$1,496.9m**
Option C						
LV	$19.6m	$44.1m	$20.7m	$6.9m	$91.3m	**$79.0m**
DD	$322.3m	$724.8m	$340.7m	$113.6m	$1,501.4m	**$1,299.1m**
Total	$341.9m	$768.9m	$361.4m	$120.5m	$1,592.7m	**$1,378.0m**
Option D						
LV	$38.4m	$86.4m	$40.6m	$13.5m	$179.0m	**$154.9m**
DD	$361.6m	$813.1m	$382.2m	$127.4m	$1,684.2m	**$1,457.2m**
Total	$400.0m	$899.5m	$422.8m	$140.9m	$1,863.2m	**$1,612.1m**

Note: Annual cost estimates are in 2018 dollars. The Present Value estimates have been calculated based on a real discount rate of 7 per cent. Capital costs are assumed to be incurred over a construction period of three and a half years.

Source: Capital cost estimates have been developed by GHD.

As shown in the above table, Options B and C have the lowest levels of capital expenditure. This is due to the lower treatment requirements under each option. Capital costs are highest under Option A due to the greater infrastructure requirements associated with sourcing wastewater effluent under this option.

5.4.2 Operating, maintenance and energy costs

Under each of the shortlisted options, the following ongoing costs will need to be incurred to supply water to users in the Lockyer Valley and on the Darling Downs:

- treatment costs to be incurred in order to treat water to the specified water quality levels. The magnitude of these costs varies based on the quality of water that is to be supplied to users;
- the cost of operating and maintaining water treatment and pipeline infrastructure and equipment over the duration of the study period. This accounts for a relatively small proportion of total operating and maintaining costs; and
- the energy costs incurred in supplying recycled wastewater to users. These costs are considerably higher for water supplied to growers on the Darling Downs due to the significant energy requirements of pumping water over to the Darling Downs.

Table 18 sets out the annual per ML estimates for these costs. It is important to note that these costs are only attributable to the NuWater project in the periods in which water is being supplied to users (i.e. the costs will not be attributable to the project during periods in which the WCRWS is used for IPR). The costs have been broken down between the Lockyer Valley and the Darling Downs.

Table 18 Operating costs of shortlisted options (per ML per annum) (2018 dollars)

Cost	Option A	Option B	Option C	Option D
Lockyer Valley				
Energy	$904	$709	$709	$1,025
Treatment and O&M	$503	$311	$311	$410
Darling Downs				
Energy	$1,001	$806	$710	$795
Treatment and O&M	$512	$323	$75	$231

Note: All estimates are in 2018 dollars. Costs have been allocated between the regions based on allocators determined by GHD.
Source: Cost estimates and cost allocations provided by GHD.

The above table demonstrates the significant differences in terms of the variable cost of supplying water to users across the shortlisted options. This is primarily attributable to the differences in treatment costs across the options. As set out in section 4, Option A involves the supply of PRW to all users. As a result, this option has the higher treatment and total operating costs. Alternatively, Option C involves the supply of Class B/C water, with end-treatment solutions being implemented in the Lockyer Valley. The lower treatment requirements associated with this level of water quality results in treatment and other operating costs under this option being significantly lower than for the other shortlisted options.

Based on the breakdown of volumes of water to be supplied in section 2.2 and the estimated probability of supply interruptions over the duration of the study period, the total estimates (in PV terms) of operating, maintenance and energy costs for each of the shortlisted options are set out in Table 19.

Table 19 Total operating and maintenance costs (PV terms) by shortlisted option

Cost	Option A	Option B	Option C	Option D
Lockyer Valley				
Energy	$51.3m	$40.2m	$40.2m	$58.1m
Treatment and O&M	$28.5m	$17.6m	$17.6m	$23.2m
Total	**$79.8m**	**$57.8m**	**$57.8m**	**$81.3m**
Darling Downs				
Energy	$584.1m	$470.3m	$414.3m	$393.7m
Treatment and O&M	$298.7m	$188.5m	$43.8m	$114.4m
Total	**$882.8m**	**$658.8m**	**$458.1m**	**$508.1m**

Cost	Option A	Option B	Option C	Option D
Totals	**$962.6m**	**$716.6m**	**$515.9m**	**$589.4m**

Note: PV estimates are based on a real discount rate of 7 per cent and contain terminal values in year 30.

Source: Unit cost estimates provided by GHD. Total PV estimates derived based on Synergies modelling.

The differences in terms of the total operating and maintenance costs across the shortlisted options reflects the differences in unit cost estimates set out in Table 18. It is important to note that the supply disruptions due to the recommissioning of the WCRWS for IPR over the duration of the evaluation period has a significant impact on the total operating costs under the shortlisted options. For example, under Option A, removing the impact of supply disruptions results in a total operating cost estimate of $1,420.6 million (PV terms), around 47 per cent higher than the total cost with supply disruptions.

5.4.3 Cost of recommissioning WCRWS

As previously discussed, Seqwater has advised that the WCRWS is part of the long-term water security strategy for SEQ and that if Wivenhoe Dam falls below the pre-determined trigger point, the scheme is to be recommissioned for IPR. Seqwater has estimated the cost of recommissioning the WCRWS for IPR at $163.5 million, to be incurred over a two-year period. The annual probabilities of the WCRWS being required for IPR over the evaluation period are set out in section 5.3.1.

Seqwater has advised that if the WCRWS infrastructure is to be used for the transportation of water at a quality level below PRW, as is proposed under Options B and C, it is likely that additional costs will need to be incurred in undertaking the works and quality testing necessary to secure regulatory approvals for the infrastructure to be used for IPR.

It is important to note that only the additional cost incurred in recommissioning the WCRWS for IPR (i.e. incremental cost relative to the base case) as a result of the use of water to supply users in the Lockyer Valley and on the Darling Downs is to be attributed to the shortlisted options (i.e. cost of additional works and testing in addition to the $163.5 million estimated by Seqwater). As the recommissioning costs estimated by Seqwater are to be incurred regardless of whether the project proceeds, these costs are not to be attributed to the shortlisted options.

The additional cost of recommissioning the WCRWS for IPR under Options B, C and D has not been estimated in this analysis due to uncertainty over the nature of the works and quality testing that would be required. However, it is important to note that the recommissioning costs estimated by Seqwater include costs that would not be affected by the use of WCRWS infrastructure prior to the scheme being required for IPR. Whilst it is not possible to identify the specific cost items that would be affected, this is an important consideration in relation to the likely magnitude of the additional recommissioning costs that will be attributable to the shortlisted options.

In summary, whilst the additional recommissioning costs attributable to the shortlisted options cannot be quantified based on currently available information, it is understood that the additional cost will be significantly lower than Seqwater's estimate for the total WCRWS recommissioning costs of $163.5 million.[48] The magnitude of these costs are to be assessed as part of the development of the Detailed Business Case (noting that the cost is unlikely to be material relative to the scale of the project).

5.4.4 Cost of on-farm infrastructure enhancements

As detailed in section 5.3.1, water supplied to growers in the Lockyer Valley and on the Darling Downs under the shortlisted options would be used to increase the area of crop production (noting that the majority of water supplied to users on the Darling Downs would be applied to area that is currently under crop production). In some cases, this will involve increasing the intensity of planting on land that is currently under crop production (e.g. moving from skip row to full cotton planting or increasing the number of lettuce crops produced per annum).

However, in other cases, growers will expand crop production onto land that is not currently used for irrigated crop production. For some growers, this will necessitate capital investment in on-farm infrastructure improvements. The key infrastructure improvements that will be required are:

- additional on-farm storage capacity
- additional irrigation application equipment and water reticulation infrastructure.

In estimating the costs incurred in developing additional on-farm storage capacity, the following estimates and assumptions have been adopted:

- earthworks cost of $1.70 per cubic metre (i.e. $1,700 per ML);[49]
- additional storage capacity required by 25 per cent of growers; and

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[48] Noting that in addition to the cost of works and quality testing activities, there is a risk under these options that Seqwater may be unable to secure the necessary regulatory approvals for the WCRWS to be recommissioned for IPR.

[49] Based on estimated costs in previous economic assessments.

- of the growers requiring additional storage capacity, capacity is to be expanded by 25 per cent of the additional volume of water.

In estimating the cost of additional irrigation equipment and infrastructure, the following estimates and assumptions have been adopted:

- a cost of $100 per ML for reticulation infrastructure[50]
- a cost estimate for irrigation application infrastructure of $1,500 and $2,500 per hectare[51] for the Lockyer Valley and the Darling Downs respectively;[52] and
- it was assumed that 25 per cent of growers will need to invest in additional on-farm infrastructure reticulation and application infrastructure.

Table 20 sets out, based on the above estimates and assumptions, the cost estimates for the development of additional on-farm storage capacity and investment in additional irrigation equipment and infrastructure under the shortlisted options. Note that the costs are the same under Options A, B and C as the volume of water to be supplied is the same under these options.

Table 20 Cost of additional on-farm storage capacity and irrigation equipment and machinery (PV)

Option	Cost of on-farm storage (PV terms)[a]	Cost of irrigation infrastructure (PV terms)[a]	Total additional costs (PV terms)[a]
Options A, B and C	$6.9m	$11.4m	**$18.3m**
Option D	$5.9m	$9.8m	**$15.7m**

a Calculated based on a real discount rate of 7 per cent.

Note: It has been assumed that 25 per cent of growers in both regions will need to invest in additional on-farm storage capacity and additional irrigation equipment and infrastructure.

Source: Synergies modelling.

Additional on-farm costs could also potentially be imposed through:

- upgrades to farm storage and licenced discharge points arising from approvals for the supply of Class B/C recycled water; and
- additional ongoing salinity management costs arising from the salt content in recycled water.

At this stage, it has been assumed that existing closed system storage arrangements in the Darling Downs and provision for on-farm infrastructure costs provide sufficient

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[50] Based on estimated costs in previous economic assessments.

[51] Based on the use of lateral move irrigators on the Darling Downs and predominantly hand shift irrigation equipment in the Lockyer Valley.

[52] Smith, P., et al (2014). A Review of Centre Pivot and Lateral Move Irrigation Installations in the Australian Cotton Industry. NSW Department of Primary Industries.

coverage. Further assessment in this regard will be completed as part of the Detailed Business Case.

5.4.5 Summary of economic costs

Table 21 summarises the economic costs (in PV terms) for each of the shortlisted options.

Table 21 Summary of PV cost estimates by shortlisted option

Cost	Option A	Option B	Option C	Option D
Capital cost	$1,920.4m	$1,496.9m	$1,378.0m	$1,612.1m
Treatment and O&M costs	$327.2m	$206.1m	$61.4m	$137.6m
Energy costs	$635.4m	$510.5m	$454.5m	$451.8m
WCRWS re-commissioning costs		Unquantified	Unquantified	Unquantified
On-farm infrastructure enhancements	$18.3m	$18.3m	$18.3m	$15.7m
Total costs	**$2,901.3m**	**$2,231.8m**	**$1,912.2m**	**$2,217.2m**

Note: PV estimates derived based on a real discount rate of 7 per cent.
Source: Synergies modelling.

The above table shows there are significant differences in total costs across the shortlisted options. These differences are primarily driven by differences in the capital costs and ongoing treatment and operating costs under the various options, which are attributable to differences in water quality levels. For example, the total PV cost of Option A is 52 per cent higher than the total cost for Option C, despite both options resulting in the same volume of water being supplied to users. The differential in these costs is due to the additional capital expenditure and ongoing treatment costs required under Option A to supply PRW to all users.

5.5 Results of the economic analysis

Table 22 summarises the overall results from the economic analysis by shortlisted option. These results are based on:

- interruptions to supply based on estimates provided by Seqwater
- demand of 7,500 ML per annum for agricultural production in the Lockyer Valley (remaining volumes available under the shortlisted options to be supplied to the Darling Downs).

Table 22 Summary of results of economic analysis (PV terms)

Impact	Option A	Option B	Option C	Option D
Economic benefits				
Increased value of agricultural production (Lockyer Valley)	$157.8m	$157.8m	$157.8m	$157.8m
Increased value of agricultural production (Darling Downs)	$327.0m	$327.0m	$327.0m	$277.5m
Avoided environmental costs in Moreton Bay	$176.0m	$159.8m	$150.8m	$144.5m
Avoided ‘care and maintenance’ and ‘hot standby’ costs	$16.5m	$10.2m	$1.6m	$12.3m
Increased environmental flows in the Murray Darling Basin	Qualitative	Qualitative	Qualitative	Qualitative
Increased water security for other water users	Qualitative	Qualitative	Qualitative	Qualitative
Total economic benefits	**$677.3m**	**$654.8m**	**$637.2m**	**$592.1m**
Economic costs				
Capital costs	$1,920.4m	$1,496.9m	$1,378.0m	$1,612.1m
Treatment and O&M costs	$327.2m	$206.1m	$61.4m	$137.6m
Energy costs	$635.4m	$510.5m	$454.5m	$451.8m
WCRWS recommissioning costs		Unquantified	Unquantified	Unquantified
On-farm infrastructure costs	$18.3m	$18.3m	$18.3m	$15.7m
Total economic costs	**$2,901.3m**	**$2,231.8m**	**$1,912.2m**	**$2,217.2m**
NET PRESENT VALUE	**($2,224.0m)**	**($1,577.0m)**	**($1,275.0m)**	**($1,625.1m)**
Benefit Cost Ratio[a]	**0.23**	**0.29**	**0.33**	**0.27**

a The Benefit Cost Ratio is calculated by dividing the PV estimates for total benefits by total costs.

Note: PV estimates have been derived based on a discount rate of 7 per cent.

Source: Synergies modelling.

The above table shows that all shortlisted options result in a negative NPV. This result is driven by the significant capital costs incurred in developing the infrastructure required to supply recycled wastewater to users in the Lockyer Valley and on the Darling Downs in addition to the significant ongoing treatment and energy costs. Option C results in the most favourable NPV and Benefit Cost Ratio (BCR) results due to the lower up-front capital and ongoing treatment costs, however the BCR under this option is still significantly below 1. Option A is the option with the least favourable NPV, due to the significant capital costs and ongoing treatment costs incurred in supplying PRW to all users.

5.6 Sensitivity and scenario analysis

This section details the sensitivity analysis performed on key parameters and scenarios based on which the net economic impact of the shortlisted options has been assessed.

5.6.1 Sensitivity analysis

Sensitivity analysis shows how the results of the economic analysis are affected by changes to key parameters and assumptions. This provides decision makers with an indication of the level of certainty associated with the modelled results in addition to identifying critical parameters and assumptions in terms of the impact of the net economic impact of the project.

Parameters were identified for inclusion in the sensitivity analysis based on their significance in relation to the results of the cost-benefit analysis (i.e. the NPV and BCR estimates for the shortlisted options) and the level of uncertainty associated with the parameter estimates.

The following parameters have been subject to sensitivity analysis:

- discount rate
- capital cost
- economic value derived from agricultural production (i.e. return per ML)
- economic cost of discharge of nutrients into Moreton Bay.

It is noted that the economic return derived from water use varies across growers, depending on soil type and storage capacity, irrigation equipment and infrastructure, and production characteristics. As such, some growers may derive higher economic returns from the use of additional water than indicated by the crop modelling results. In addition, future productivity improvements are likely to result in an increase in the efficiency of irrigation water use, enabling growers to achieve higher crop yields without increasing water application rates. This will result in an increase in the economic value derived from every ML of water used for crop production. Changes in cropping mix, in particular an increase in horticultural production on the Darling Downs, also has the potential to increase the economic value derived from the use of irrigation water.

Modelling the economic impact of the shortlisted options under the scenario in which the economic value derived per ML of water use is increased by 50 per cent accounts for future increases in agricultural productivity, changes in cropping mix and also the potential for growers to achieve significant increases in crop prices over the evaluation period.

The results of the sensitivity analysis are set out in Table 23.

Table 23 Results of sensitivity analysis

Sensitivity	Present Value estimates (% change from base NPV)			
	Option A	**Option B**	**Option C**	**Option D**
Base NPV	($2,224.0m)	($1,577.0m)	($1,275.0m)	($1,625.1m)
Discount rate				
Low (4%)	($2,580.8m) (-16.0%)	($1,717.0m) (-8.9%)	($1,249.0m) (+2.0%)	($1,720.5m) (-5.9%)
High (10%)	($2,016.2m) (+9.3%)	($1,470.5m) (+6.8%)	($1,239.3m) (-2.8%)	($1,533.8m) (+5.6%)
Capital cost				
Low (-20%)	($1,839.9m) (+17.3%)	($1,277.6m) (+19.0%)	($999.3m) (+21.6%)	($1,302.7m) (+19.8%)
High (+20%)	($2,608.1m) (-17.3%)	($1,876.4m) (-19.0%)	($1,550.5m) (-21.6%)	($1,947.6m) (-19.8%)
Economic value from agricultural production				
Low (-50%)	($2,473.6m) (-11.2%)	($1,826.6m) (-15.8%)	($1,524.5m) (-19.6%)	($1,849.3m) (-13.8%)
High (+50%)	($1,974.4m) (+11.2%)	($1,327.4m) (+15.8%)	($1,025.3m) (+19.6%)	($1,401.0m) (+13.8%)
Cost of nutrient discharges into Moreton Bay				
Low (-50%)	($2,312.0m) (-4.0%)	($1,656.9m) (-5.1%)	($1,350.3m) (-5.9%)	($1,697.4m) (-4.4%)
High (+50%)	($2,136.0m) (+4.0%)	($1,497.1m) (+5.1%)	($1,199.5m) (+5.9%)	($1,552.9m) (+4.4%)

Source: Synergies modelling.

The above table demonstrates that whilst several parameter estimates have a material impact on the NPV under several options, in particular the discount rate and capital cost, the impact is not significant under any of the scenarios assessed. Applying an increase of 50 per cent to the economic value derived from the use of water for agricultural production resulted in only a marginal improvement in the NPVs of the shortlisted options (i.e. 11.2 per cent to 19.6 per cent).

5.6.2 Scenario analysis

Scenario analysis is used to assess the impact of changes to parameters or assumptions beyond changing single parameter estimates. This enables an assessment of the impact of changes in multiple parameters or the timing of events on the net economic impact of the shortlisted options. For this analysis, two key factors were identified for scenario analysis due to their significance to the analysis and the level of uncertainty associated with the base parameters applied in the economic modelling:

- the level of demand for water in the Lockyer Valley – the modelling assumed annual demand of 7,500 ML, based on the continuation of existing groundwater management arrangements. However, as previously discussed, there is considerable uncertainty associated with future groundwater use in the region; and

- the interruptibility of supply attributable to the WCRWS being recommissioned for IPR – the modelling was conducted based on the annual probabilities of supply disruption provided by Seqwater. In addition to the uncertainty associated with these probabilities, there is also uncertainty in relation to the extent to which the WCRWS will be used for IPR over the evaluation period.

In relation to demand in the Lockyer Valley, an alternative scenario has been modelled under which annual demand for water in the region is 25,000 ML. This estimate is based on discussions with growers regarding likely water demand if volumetric entitlements were to be established for groundwater use resulting in a significant reduction in water availability for growers.

In relation to the interruptibility of supply, two alternative scenarios have been modelled:

- based on annual probability estimates 50 per cent less than those provided by Seqwater (i.e. a 50 per cent reduction applied to the probability of supply disruption in each year of the evaluation period); and
- no supply interruptions over the study period.

The results of the scenario analysis are presented in Table 24.

Table 24 Results of scenario analysis

Scenario	**Option A NPV (% change)**	**Option B NPV (% change)**	**Option C NPV (% change)**	**Option D NPV (% change)**
Base NPV	($2,224.0m)	($1,577.0m)	($1,275.0m)	($1,625.1m)
Demand in the Lockyer Valley				
25,000 ML demand in the Lockyer Valley	($1,915.1m) (+13.9%)	($1,267.7m) (+19.6%)	($1,011.2m) (+20.7%)	($1,384.4m) (+14.8%)
Probability of supply disruptions				
50% reduction in probabilities of disruptions (7,500 ML demand in Lockyer Valley)	($2,321.7m) (-4.4%)	($1,622.2m) (-2.9%)	($1,280.7m) (-0.4%)	(1,650.0m) (-1.5%)
50% reduction in probabilities of disruptions (25,000 ML demand in Lockyer Valley)	($1,939.5m) (+12.8%)	($1,239.6m) (+21.4%)	($954.4m) (+25.1%)	($1,352.1m) (+16.8%)
No supply disruptions over the evaluation period (7,500 ML demand in Lockyer Valley)	($2,352.9m) (-5.8%)	($1,626.2m) (-3.1%)	($1,279.9m) (-0.4%)	($1,625.3m) (-0.0%)
No supply disruptions over the evaluation period (25,000 ML demand in Lockyer Valley)	($1,897.5m) (+14.7%)	($1,170.2m) (+25.8%)	($891.0m) (+30.1%)	($1,270.4m) (+21.8%)

Source: Synergies modelling.

The results presented in the table above show that, of the scenarios modelled, demand in the Lockyer Valley has the most significant impact on the NPVs of the shortlisted options. For example, under Option C, increasing demand in the Lockyer Valley from 7,500 ML to 25,000 ML per annum results in an improvement to the NPV of this option of 20.7 per cent under the base assumptions and up to 30.1 per cent when the probabilities of supply disruptions are reduced to zero. This result is due to the high returns estimated for the use of water for horticultural production in the Lockyer Valley (noting that the NPV of all options was still negative under all scenarios modelled).

It is noted that under the scenario in which demand in the Lockyer Valley is maintained at 7,500 ML per annum and the probabilities of supply disruptions are lowered by 50 per cent, the NPVs of the shortlisted options worsen marginally (with the exception of Option C). This is due to the ongoing treatment, energy and O&M costs incurred in supplying water to users exceeding the economic benefits derived from the increased agricultural production and reduction in nutrient discharges into SEQ waterways and Moreton Bay under Options A, B and D.

In summary, whilst the results of the economic analysis are somewhat sensitive to the strength of demand for additional water in the Lockyer Valley, the NPVs of the shortlisted options remain significantly negative for all shortlisted options across all scenarios modelled.

6 Financial and commercial analysis

The purpose of this section is to present the findings from the financial and commercial analysis completed in relation to the shortlisted options.

It is important to note that the governance arrangements and commercial framework for the NuWater project are currently in an early stage of development. As such, the analysis contained in this chapter should be viewed as preliminary. The assumptions, inputs and parameters applied in the financial and commercial modelling of the shortlisted options will be subject to further critical analysis as part of the Detailed Business Case.

6.1 Purpose and approach

The objective of financial and commercial analysis is to assess the financial implications and budgetary impacts of the shortlisted options by assessing the cashflows for each option. This includes an assessment of the risks associated with the identified cashflows and, where possible, the quantification of the impact of the identified risks on the financial and commercial viability of the project. This enables the shortlisted options to be rated in terms of their financial and commercial impact and also ranked against each other.

The approach adopted to conducting the financial and commercial analysis of the shortlisted options was as follows:

- establish the key assumptions and inputs to be used in undertaking the financial and commercial analysis, including the discount rate to be applied, the demand and water use assumptions to be adopted, and the pricing framework to be applied;
- identify all revenues and costs, including capital costs, one-off operating costs and ongoing operating and maintenance costs, for all shortlisted options;
- model the financial cashflows for each shortlisted option in order to calculate the Financial NPV (FNPV) by applying an appropriate discount rate;
- adjust the FNPV results to account for key risks to revenues and costs;
- consider budgetary impacts of the project based on the results of the financial and commercial analysis in addition to potential funding sources; and
- report the results of the analysis, including the FNPV and risk-adjusted FNPV for each of the shortlisted options.

6.2 Key assumptions, limitations and data sources

The key assumptions applied in the financial and commercial model are as follows:

- a 30-year evaluation period, consistent with both the economic analysis and the Building Queensland Guidelines;
- a three-year construction period for each option, based on estimates provided by GHD;
- a nominal discount rate of 9.7 per cent;[53]
- an inflation rate of 2.5 per cent, being the mid-point of the Reserve Bank of Australia's long-term inflation target; and
- water use assumptions have been based on the findings of the demand assessment report.

6.3 Pricing assumptions

6.3.1 Pricing framework

A key consideration for the financial and commercial analysis is the pricing framework to apply to the supply of water to users in the Lockyer Valley and on the Darling Downs. There are two options available in terms of the pricing approach to be adopted:

- users pay for water allocations up-front (i.e. a capital contribution to the project), in addition to an annual charge in the years in which water is available from the project; or
- users pay an annual 'take-or-pay' charge for water, with users required to pay the charge and take the required volumes in years in which water is available from the project.

Noting that the former is the more commonly applied approach for projects aimed at delivering water to agricultural producers, based on the key characteristics of the project, in particular the interruptibility of supply and high ongoing operating costs required to supply water to users, levying an annual charge under 'take-or-pay' agreements is

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[53] This was calculated by applying the Fisher equation to the real discount rate of 7 per cent applied in the economic analysis. It is noted that in the Building Queensland PBC Guidelines, it is stated that Queensland Treasury is to be contacted regarding the appropriate discount rate to be applied. It is proposed that Queensland Treasury be consulted with regarding the discount rate to be applied for the financial and commercial analysis to be undertaken as part of the Detailed Business Case.

considered the preferred option. In particular, it was considered that the risk of regular and prolonged supply disruptions would mean that users are likely to be reluctant to purchase up-front water allocations from the project.[54] Several growers consulted with during the demand assessment noted the difficulties associated with up-front payments for water allocations given the likelihood of supply disruptions.

The cost of supplying water varies between the Lockyer Valley and Darling Downs across the different options, in terms of both the capital requirements and ongoing costs of supply (i.e. treatment and energy costs) (see section 5.4.2).

Typically, where the cost of supplying rural water users varies across regions, differential pricing is applied (i.e. users in regions in which the cost of supply is higher pay higher prices). If this principle were to be applied to the shortlisted options, the prices applied in the two regions would vary based on the water quality levels under each option (noting that electricity costs incurred in supplying users on the Darling Downs are higher under all shortlisted options).

However, the following are important factors to consider in assessing the potential for differential pricing for this project:

- the significant capital requirements and ongoing operating costs mean that water users in both regions do not have sufficient willingness or capacity to pay prices commensurate with the cost of supply; and
- the project's viability is subject to water users taking the full volume of water available in every year in which water is available from the project. Water demand in the Lockyer Valley is insufficient for this requirement to be satisfied (i.e. the project must supply users on the Darling Downs to satisfy this requirement).

Given these considerations, differential pricing has not been applied in this feasibility study. Rather, a uniform annual price per ML has been applied to all users to be supplied from the NuWater project. The potential for differential pricing to be applied may be further investigated as part of the Detailed Business Case.

6.3.2 Price levels

The financial and commercial modelling has been undertaken based on the following prices, to be levied on users annually and on a take-or-pay basis:[55]

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[54] The preferred pricing approach, both from the perspective of NuWater and water users, is to be further investigated as part of the development of the Detailed Business Case, potentially as part of a formal Expression of Interest process.

[55] Noting that charges would not be levied on water users during periods in which water was not available due to the WCRWS being required for IPR.

- $300 per ML per year
- $400 per ML per year
- $500 per ML per year.

These prices are based on growers' indications of their willingness to pay in the survey responses received and the results from the modelling of on-farm returns undertaken as part of the demand assessment. The survey responses and crop modelling results both indicate that at prices of over $500 per ML, demand for water from the project would be limited (particularly on the Darling Downs). It is recommended that the Detailed Business Case include further investigation of water users' willingness to pay for water from the project, potentially as part of a formal Expression of Interest process.

6.3.3 National Water Initiative compliance

The National Water Initiative (NWI) pricing principles state that for new or replacement bulk water supply assets, water charges should be set to achieve full cost recovery, including a return of and on the capital cost of the project.[56] As noted above, water users have insufficient willingness or capacity to pay a price commensurate with the full project cost under all shortlisted options.

However, it is important to note that a key driver of the project is the need to reduce nutrient loads in SEQ waterways and Moreton Bay to improve water quality and environmental outcomes. Given that addressing this project driver results in benefits for the wider community, it is not necessary for the commercial and pricing arrangements underpinning the project to be compliant with this principle.

6.4 Financial costs

This section assesses all financial costs to be incurred under the shortlisted options.

6.4.1 Capital expenditure

The capital expenditure estimates for each shortlisted option are set out in section 5.4.1. The total costs are the same in PV terms for the financial and commercial analysis as for the economic analysis, being:

- $1,920.4 million under Option A
- $1,496.9 million under Option B

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[56] National Water Initiative Pricing Principles, Principle 1.

- $1,378.0 million under Option C
- $1,612.1 million under Option D.[57]

6.4.2 One-off operating costs

The sole one-off operating cost to be considered in the financial and commercial analysis of the shortlisted options is the additional cost of recommissioning the WCRWS for IPR that is attributable to the supply of water to users in the Lockyer Valley and on the Darling Downs. Section 5.4.3 contains a detailed discussion on this impact and the magnitude of this cost.

In terms of assessing the treatment of this cost in the financial and commercial analysis, it is important to note the following:

- the additional recommissioning cost that is to be attributable to the shortlisted options is likely to be a small proportion of the total recommissioning cost;[58] and
- whilst additional recommissioning costs are to be imposed on Seqwater under the shortlisted options, Seqwater will also benefit from cost savings due to the avoidance of ‘care and maintenance’ and ‘hot standby’ costs in the periods during which the WCRWS is not required for IPR.

Based on these considerations, the incremental recommissioning cost attributable to the shortlisted options has not been included in the financial and commercial analysis. The magnitude of these costs and the commercial framework to apply to the project are to be subject to further consideration in the Detailed Business Case.

6.4.3 Ongoing operating and maintenance costs

The ongoing operating and maintenance expenditure required to supply water to users under the shortlisted options is set out in section 5.4.2. As with the capital expenditure, the PV cost estimates are the same for the financial and commercial analysis as for the economic analysis. The totals for each shortlisted option are as follows:

- $833.5 million under Option A
- $620.5 million under Option B

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[57] Capital cost estimates provided by GHD.

[58] Noting that an estimate for the incremental recommissioning costs attributable to the shortlisted options is yet to be developed.

- $446.7 million under Option C
- $510.4 million under Option D.[59]

6.4.4 Total costs

Table 25 summarises the PV estimates for the financial cost of each shortlisted options. Cost estimates are based on the assumption that demand in the Lockyer Valley totals 7,500 ML per annum, with the remaining volumes under each option to be supplied to users on the Darling Downs.

Table 25 Total financial costs for shortlisted options (PV terms)

Cost category	Option A	Option B	Option C	Option D
Capital costs				
Lockyer Valley	$132.8m	$89.5m	$79.0m	$154.9m
Darling Downs	$1,787.6m	$1,407.4m	$1,299.1m	$1,457.2m
Operating and maintenance costs				
Lockyer Valley	$69.1m	$50.1m	$50.1m	$70.5m
Darling Downs	$764.4m	$570.4m	$396.6m	$439.9m
Totals costs	**$2,753.9m**	**$2,117.4m**	**$1,824.7m**	**$2,122.5m**

Note: PV estimates have been calculated based on a nominal discount rate of 9.7 per cent (consistent with the real discount rate of 7 per cent applied in the economic analysis). Based on demand of 7,500 ML per annum for the Lockyer Valley.

Source: Synergies modelling based on cost estimates provided by GHD.

The ongoing costs of water supply, being treatment and O&M costs and energy costs, are impacted by the level of demand in the Lockyer Valley, as the cost of supplying users varies compared to the cost of supplying users on the Darling Downs. Under all options, the energy costs incurred in supplying the Lockyer Valley is significantly lower than the Darling Downs, whilst the differential in terms of treatment and O&M costs varies across the shortlisted options based on the water quality to be supplied to users.[60]

At this stage of the assessment, complexities in relation to the costing of different infrastructure elements and processes have prevented the allocation of treatment and O&M and energy costs to users in the Lockyer Valley and on the Darling Downs across the shortlisted options. The allocation of these costs and the implications of different levels of demand in the Lockyer Valley for the total financial cost of water supply is to be assessed in the Detailed Business Case.

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[59] Operating and maintenance cost estimates provided by GHD.

[60] For example, under Option A, PRW is to be supplied to users in both regions and thus water treatment costs are similar under this option. Alternatively, under Option D, lower quality water is to be supplied to users on the Darling Downs, whilst PRW is to be supplied to the Lockyer Valley. Under this option, water treatment costs are likely to be significantly higher for the Lockyer Valley.

6.5 Residual values

As the lives of the assets will exceed the 30-year evaluation period, it is necessary to include an allowance for the residual value of assets in the financial and commercial analysis of the shortlisted options. The residual values are calculated at the conclusion of year 30 and are discounted back at the discount rate (9.7 per cent nominal) to derive the PV estimate for the residual value of the assets. The estimates derived for the residual values are as follows:

- $137.0 million under Option A
- $106.8 million under Option B
- $98.3 million under Option C
- $115.0 million under Option D.[61]

6.6 Revenues

This section identifies the revenue streams to be derived under the shortlisted options. Two potential revenue sources have been identified – water charges levied on water users and an up-front capital contribution from an external party.

6.6.1 Revenue received from water users

The approach to determining the revenue to be derived from water charges levied on water users under the shortlisted options was as follows:

- growers were asked to provide an indication of their willingness to pay for water from the project by nominating their volume of demand at several prices from $200 to $1,200 per ML per annum; and
- modelling was undertaken to determine the net on-farm return from the use of water from the project. This provides an upper bound for growers' capacity to pay for water.

Based on the outcomes of this assessment, it was concluded that the price at which it would be viable for end users to purchase water from the project was likely to range from $300 to $500 per ML per annum.[62] As stated in section 6.3, the financial modelling

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[61] Residual values were calculated assuming an average asset life across the asset base of 50 years.

[62] The estimated economic return per ML for all crops in the demand profile exceeded $400 per ML per annum. Crops for which the economic return was estimated at below $400 per ML per annum were excluded from the demand profile.

was undertaken based on a uniform price applying to all water users (noting that cost of supply will differ across the customer base, particularly based on the region in which users are located).

As with the economic benefits derived from the use of water for agricultural production (see section 5.3.1), it is necessary to account for the probability of supply disruptions in estimating the revenue to be derived from the supply of water to users (as water charges would not be levied during periods in which the WCRWS is required for IPR). To account for this, revenue projections have been adjusted based on the annual probabilities provided by Seqwater (see section 5.3.1).

As a uniform water price is to be levied across all users, the break-down in water use between the regions does not impact on the total revenue that is derived. A base price of $400 per ML has been applied in the financial and commercial modelling. Table 26 sets out the total revenue (in PV terms) to be derived under each shortlisted option at each potential water price, adjusted for the annual probabilities of supply disruption.

Table 26 Total revenue (PV terms) by shortlisted option by water price

Option	**Annual water price**		
	$300 per ML	**$400 per ML**	**$500 per ML**
Options A, B and C	$166.3m	$221.7m	$277.2m
Option D	$143.4m	$191.1m	$238.9m

Note: PV estimates calculated based on a nominal discount rate of 9.7 per cent (consistent with the real discount rate of 7 per cent applied in the economic analysis).

Source: Synergies modelling.

The above table shows that the revenue derived under Option D is lower than is the case for Options A, B and C, due to the lower volume of water to be supplied to users under Option D.

6.6.2 Capital contributions

There are a wide range of potential beneficiaries from the project, including existing infrastructure owners and large industrial water users. It is common for beneficiaries to make up-front contributions to the capital cost of major water supply projects. Whilst it has not been possible to identify parties willing to contribute to the up-front capital cost of the project as part of this preliminary business case, there is the potential for revenue to be derived from up-front contributions from external parties (in particular large industrial water users). To the extent that such contributions are secured, this would need to be reflected in the revenues for the project options and thus the assessment of the financial and commercial viability of the project options.

6.7 Financial NPV

Table 27 sets out the results of the financial and commercial analysis under the scenario in which demand in the Lockyer Valley is estimated at 7,500 ML per annum (with remaining volumes being supplied to the Darling Downs).

Table 27 Results of the financial analysis of shortlisted options (PV terms)

Costs and revenues	Option A	Option B	Option C	Option D
Costs				
Capital costs	$1,920.4m	$1,496.9m	$1,378.0m	$1,612.1m
Treatment and O&M costs	$283.4m	$178.5m	$53.2m	$119.2m
Energy costs	$550.1m	$442.0m	$393.5m	$391.2m
TOTAL COSTS	**$2,753.9m**	**$2,117.4m**	**$1,824.7m**	**$2,122.5m**
Revenues				
Revenue from water users	$221.7m	$221.7m	$221.7m	$191.1m
TOTAL REVENUES	**$221.7m**	**$221.7m**	**$221.7m**	**$191.1m**
FINANCIAL NPV	**($2,532.2m)**	**($1,895.7m)**	**($1,603.0m)**	**(1,931.4m)**

Note: PV totals have been calculated based on a nominal discount rate of 9.7 per cent (consistent with the real discount rate of 7 per cent applied in the economic analysis).

Source: Synergies modelling.

The similarities in revenues across the shortlisted options means that the differentials in the FNPVs is attributable to differences in the financial costs incurred, primarily the capital costs. As with the results of the economic analysis (see section 5.5), the significant negative FNPVs are driven by the significant costs associated with developing the necessary infrastructure and supplying recycled wastewater to growers. As discussed further below, this means that the project will require a significant external contribution to be commercially viable.

As noted in section 6.4.4, it has not been possible as part of this preliminary assessment to appropriately allocate costs between the Lockyer Valley and Darling Downs. Hence, it is not possible to present the results of the financial and commercial analysis for the scenario in which there is greater demand in the Lockyer Valley (noting that revenues will remain unchanged due to the application of a uniform water price). As previously noted, the impact of increasing supply to the Lockyer Valley above 7,500 ML on financial costs is to be assessed in the Detailed Business Case.

6.8 Financial risk assessment

In assessing the financial and commercial viability of a project it is important to identify the key commercial risks and to assess the potential impact of the risks on the viability of the project, having regard to the likelihood of the risk materialising.

The key financial and commercial risks identified in relation to the shortlisted options are as follows:

- capital cost overrun
- increases to energy costs
- a shortfall in the revenue derived from water users, due to user default.

A quantitative risk assessment involves assessing the financial consequences of an identified risk occurring based on the likelihood (i.e. probability) of financial costs and revenues differing from their expected values and the consequences of the identified risk.[63]

A quantitative assessment was undertaken for each of the above risks by assessing the impact of the materialisation of these risks on the FNPVs of the shortlisted options. The results of this assessment are set out in Table 28.

Table 28 Results of financial risk assessment for the shortlisted options

Risk	**Financial NPV**			
	Option A	**Option B**	**Option C**	**Option D**
Base FNPV	($2,532.2m)	($1,895.7m)	($1,603.0m)	($1,931.4m)
Capital costs				
25% cost overrun	($3,012.3m) (-19.0%)	($2,269.9m) (-19.7%)	($1,947.5m) (-21.5%)	($2,334.3m) (-20.9%)
50% cost overrun	($3,492.4m) (-37.9%)	($2,644.2m) (-39.5%)	($2,292.0m) (-43.0%)	($2,737.3m) (-41.7%)
Energy costs				
25% cost increase	($2,669.7m) (-5.4%)	($2,006.2m) (-5.8%)	($1,701.4m) (-6.1%)	($2,029.2m) (-5.1%)
50% cost increase	($2,807.3m) (-10.9%)	($2,116.7m) (-11.7%)	($1,799.8m) (-12.3%)	($2,127.0m) (-10.1%)
Default risk				
25% user default	($2,587.6m) (-2.2%)	($1,951.1m) (-2.9%)	($1,658.4m) (-3.5%)	($1,979.1m) (-2.5%)
50% user default	($2,643.0m) (-4.4%)	($2,006.6m) (-5.9%)	($1,713.8m) (-6.9%)	($2,026.9m) (-5.0%)

Note: PV totals have been calculated based on a nominal discount rate of 9.7 per cent (consistent with the real discount rate of 7 per cent applied in the economic analysis).

Source: Synergies modelling.

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[63] It is noted that the likelihood and consequences of risks differs under different delivery models. The governance and commercial arrangements for the NuWater project are still in their early stage of formation. The impact of different delivery models on the financial and commercial risks is to be considered further in the Detailed Business Case.

The results presented in the table above demonstrate that an overrun in capital costs is the key financial risk under all four shortlisted options. Whilst increases to energy costs and default from water users does adversely impact on the FNPV under the shortlisted options, the magnitude of the impact of these risks is minimal relative to an overrun in capital costs (particularly an overrun of up to 50 per cent). Minimising the risk of a capital cost overrun should be a key focus area for the Detailed Business Case and is to be considered in the project design, selection of delivery model and commercial framework for the development of the infrastructure.

6.9 Funding sources and budgetary impacts

The results from the financial and commercial analysis demonstrate that, for all shortlisted options, the revenues derived from the project will be insufficient to recover the financial costs to be incurred. The project will therefore require significant government funding in order to be financially viable (noting that no additional revenue sources beyond water users have been identified).

The environmental benefits from the reduction in nutrient discharges into SEQ waterways and Moreton Bay, in addition to the positive regional economic impacts associated with the shortlisted options, provide a basis on which government funding could be provided to the project.

The NWIDF is a potential source of funding for the project. The capital component of the NWIDF has been established to support long-term regional economic growth and development by providing secure and affordable water through investments in economically viable water infrastructure to be managed in accordance with the NWI. The provision of funding under the NWIDF is contingent upon several criteria being met, including that projects be 'construction ready' and that funding applications have the support of the State Minister responsible for water.

As noted above, the FNPVs of the shortlisted options range from ($1,603.0 million) to ($2,532.2 million). As such, the project is likely to require significant government funding in addition to funds likely to be available under the NWIDF. The magnitude of this funding requirement will be subject to:

- the option that is adopted
- the level of demand in the Lockyer Valley
- the funding received under the NWIDF.

Further assessment is to be undertaken in relation to the amount of government funding that would be required for the project to be financially viable as part of the Detailed

Business Case (including assessing the financial impacts of different levels of demand in the Lockyer Valley). In addition, the commercial arrangements for the provision of government funding to the project, including the form and timing of the funding (e.g. up-front grant, ongoing subsidy) are to be assessed in the Detailed Business Case.

6.10 Summary of financial and commercial analysis

In summary, the results of the financial modelling show that significant government funding is required for the project to be financially viable, with the shortlisted options resulting in FNPVs ranging from ($1,603.0 million) to ($2,532.2 million).[64] For the project to be financially viable, this shortfall would need to be addressed through the provision of government funding.[65]

In terms of the financial risks relevant to the commercial options, a quantitative assessment of the identified risks demonstrates that a capital cost overrun is the most significantly financial risk under all four shortlisted options. Ensuring that this risk is minimised should be a key focus area in the development of the Detailed Business Case.

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[64] Noting that the level of demand in the Lockyer Valley will also impact on the financial cost of the shortlisted options and hence the government funding required, however it has not been possible as part of this preliminary assessment to allocate costs between the two regions.

[65] In addition to capital contributions from external parties.

7 Summary and conclusions

This report presents the outcomes of the economic and financial and commercial analyses of the four shortlisted options for the supply of recycled wastewater to agricultural producers in the Lockyer Valley and on the Darling Downs. The shortlisted options vary in terms of the infrastructure to be developed to supply water to users, the capital cost associated with the required infrastructure, the operating cost of supplying water, and the volumes of recycled wastewater to be supplied.

The key economic benefits of the project are:

- the increase in agricultural production, being horticultural crops in the Lockyer Valley and broadacre crops on the Darling Downs. This benefit is estimated at $484.8 million under Options A, B and C, and $435.3 million under Option D (all estimates in PV terms). The supply disruptions attributable to the recommissioning of the WCRWS for IPR have a negative impact on the magnitude of this benefit;
- the avoidance of 'care and maintenance' costs incurred by Seqwater in maintaining the WCRWS whilst it is not required for IPR. This benefit ranges from $1.6 million to $16.5 million (in PV terms) under the shortlisted options; and
- a reduction in nutrient loads in SEQ waterways and Moreton Bay, and hence the avoidance of the adverse water quality and environmental impacts associated with nutrient build-up. This benefit was quantified based on the estimated cost of abating the quantity of nutrients that will be diverted from waterways and Moreton Bay through alternative activities. This resulted in a total benefit estimate ranging from $144.5 million to $176.0 million (in PV terms) under the shortlisted options.

The shortlisted options could also increase environmental flows in the MDB, thereby improving environmental outcomes, and will provide additional water security for other users. As the benefits from increased agricultural production were quantified based on the full take-up of water under the shortlisted options, these benefits were not quantified in this analysis.

The economic costs associated with the shortlisted options are:

- capital costs, ranging from $1,378.0 million to $1,920.4 million (in PV terms);
- operating, maintenance and energy costs, ranging from $515.9 million to $962.6 million (in PV terms); and
- cost of on-farm infrastructure enhancements, estimated at $18.3 million under Options A, B and C and $15.7 million under Option D (all in PV terms).

There is also the potential for the shortlisted options to result in additional costs in the recommissioning of the WCRWS for IPR. This cost was not quantified in this analysis due to uncertainty in relation to the magnitude of the cost.

Based on the above economic benefits and costs, the NPVs of the shortlisted options range from ($1,275.0 million) (Option C) to ($2,224.0 million) (Option A). The corresponding BCRs range from 0.33 to 0.23. The key drivers of these results are the significant capital requirements under the shortlisted options and the significant ongoing cost incurred in supplying water to users.

Several parameters were subject to sensitivity analysis, including the discount rate, capital expenditure and value of agricultural production. NPVs remained significantly negative across all shortlisted options for all sensitivities and scenarios tested.

A financial and commercial analysis was undertaken of the shortlisted options to assess their financial viability and the potential funding requirements and budgetary impacts. The revenues under the shortlisted options were modelled based on three different water prices - $300, $400 and $500 per ML per annum. These prices were identified based on the outcomes of the water demand assessment.

The results of the financial and commercial analysis were similar to the economic analysis, with the negative FNPVs driven by the high capital and ongoing costs under the shortlisted options. The sole source of revenue included in the financial and commercial analysis was water charges levied on water users. Subject to the price per ML at which water is supplied to users, this resulted in total revenue estimates of $143.4 million to $277.2 million (in PV terms). Whilst it is also possible that up-front capital contributions may be provided by project beneficiaries, it was not possible to identify any contributions for inclusion in the Preliminary Business Case.

Based on these revenue sources and the estimated capital and ongoing operating and maintenance costs, the FNPVs of the shortlisted options range from ($1,603.0 million) to ($2,532.2 million). As a result, the project requires significant funding from government in order to be commercially viable.

A Valuing the economic cost of nutrient discharges

This attachment contains the information available for estimating the economic cost of nitrogen and phosphorus discharges into SEQ waterways and Moreton Bay under the three approaches set out in section 5.3.3.

A.1 Damage cost studies

Various studies have been completed in overseas jurisdictions that have assessed the damage costs incurred as a result of the discharge or release of nutrients into waterways or water bodies. In 2005, the Danish Ministry for the Environment undertook a study of the damage costs associated with nutrient discharges into the Baltic Sea. The study involved deriving estimates of the willingness to pay to avoid nutrient discharges. A stated preference method was applied. The estimates produced by the study were as follows:

- for nitrogen, a lower bound of $1,600 per tonne and an upper bound of $29,000 per tonne; and
- for phosphorus, a lower bound of $29,000 per tonne and an upper bound of $119,000 per tonne.[66]

The transferability of these estimates is limited given that environmental conditions, ecology and the profile of use of receiving waterways and water bodies is likely to be substantially different to SEQ and Moreton Bay.

In 2015, the United States Environmental Protection Agency (US EPA) produced a compilation of cost data to assess the adverse impacts of nutrient pollution. This involved the collection and detailed review of relevant cost data and information from a range of published, peer-reviewed journals, government-funded research reports, academic studies and other quality studies over the period 2000 to 2012.[67] This report identified two major costs with respect to excessive nutrient loading to waterbodies, i.e. costs with reducing excess nutrients from its sources and costs to the environment (external costs).

The findings in the US EPA report highlighted that external costs can cause significant economic losses across a number of sectors and scales. Many studies included in the report, for example, revealed significant costs in tourism and recreation, commercial

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[66] Danish Ministry for the Environment (2005). Economic Analysis of Waste Water Charge, Revised Edition, Environmental Project 976.

[67] Environmental Protection Agency (EPA) (2015). *A complication of cost data associated with the impacts and control of nutrient pollution*. Office of Water, United States.

fishing, property values, human health, drinking water treatment costs, mitigation and restoration. Whilst it is difficult to compare studies of the economic impact of nutrient discharges due to their different methodologies, assumptions and locations, they do provide an indication of the magnitude of the costs of not controlling nutrient pollution. Some findings on the economic cost of nutrient pollution from US studies are given in the Box below.

External costs associated with nutrient pollution impacts – US studies (figures in $US)

- *Tourism and recreation* – persistent algal bloom in an Ohio lake caused $37 million to $47 million in lost local tourism revenue over two years;
- *Commercial fishing* – harmful algal bloom outbreak on the Maine coast prompted shellfish bed closures, leading to losses of $2.5 million in soft shell clam harvests and $460,000 in mussel harvests;
- *Property values* – in New England, a one metre difference in water clarity is associated with property value changes up to $61,000 and in Minnesota, property values changed up to $85,000;
- *Human health* – a study from Florida documented increased emergency room costs for respiratory illnesses resulting from algal blooms, costing more than $130,000 in high algal bloom years;
- *Drinking water treatment costs* – a study in Ohio documents expenditures of more than $13 million in two years to treat drinking water from a lake affected by algal blooms;
- *Mitigation* – in-lake measures to mitigate nutrient loadings, with costs ranging from $11,000 for a single year of barley straw treatment to more than $28 million in capital and $1.4 million in annual operations and maintenance for a long-term dredging and alum treatment plan; and
- *Restoration* - there are substantial costs associated with restoring impaired waterbodies, such as developing total maximum daily loads, catchment plans and nutrient trading and offset programs. For example, one developed for the Great Miami River Watershed in Ohio for nitrogen and phosphorus had estimated costs of more than $2.4 million across 3 years.

Source: Environmental Protection Agency (EPA) (2015). A complication of cost data associated with the impacts and control of nutrient pollution. Office of Water, United States, p. ES2-ES3.

The US EPA study concluded that nitrogen and phosphorus may be expensive to control after they are released to the environment, and that preventing them from entering the system is potentially a more cost-effective strategy for addressing nutrient pollution and its impacts.

A.2 Marginal nutrient abatement costs

Applying the cost of marginal abatement measures results in the valuation of the economic cost of nutrient releases into Moreton Bay based on costs that have previously been incurred on projects or activities undertaken to reduce or avoid nutrient releases. These cost estimates can be applied as a proxy value for the avoided cost attributable to reducing nutrient discharges as it provides an indication as to the cost that the community is prepared to incur to reduce nutrient loads in waterways and water bodies.[68]

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[68] If reductions to nutrient levels were not valued at least as high as the cost of the nutrient-reducing projects and works, the cost associated with these works would not have been incurred.

In 2005, the Central Queensland University undertook an assessment of the cost-effectiveness of reducing nutrients from point and diffuse sources in SEQ. The point source cost estimates were based on forward estimates of planned works provided by local governments. Around 50 per cent of the costs were assumed to be allocated to wastewater treatment plant upgrades to accommodate projected population growth with the other 50 per cent allocated to reducing nutrient emissions to SEQ waterways. This study found an average annual cost of point source load reduction of:

- $6,729 per tonne per annum for nitrogen
- $5,400 per tonne per annum for phosphorus.[69]

Studies in other sectors have also assessed the cost of nutrient abatement in water pollution. For example, a South Australian study on the cost of waste disposal estimated explicit values of the environmental cost of water emissions attributable to resource extraction, processing, transport and manufacturing activities, as well as the handling or reprocessing of waste. The study relied upon estimates of the abatement or clean-up costs associated with water pollution. The cost estimates produced in this study were as follows:

- for nitrogen pollution, cost ranging from $2,700 to $8,200 per tonne (mid-point of $5,450 per tonne); and
- for phosphorus pollution, cost ranging from $2,700 to $5,500 per tonne (mid-point of $4,100 per tonne).[70]

It is noted that these estimates are broadly consistent with those produced in the 2005 Central Queensland University study.

A report prepared by ACIL Allen Consulting in 2014 assessed the cost associated with various projects and activities that have reduced nutrient loads (including nitrogen and phosphorus) in waterways and water bodies. The table below sets out the cost estimates derived for the projects and activities identified.

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[69] BDA Group (2005). Scoping Study on a Nutrient Trading Program to Improve Water Quality in Moreton Bay. Report to Environment Protection Agency. Final Report.

[70] BDA Group (2009). The full cost of landfill disposal in Australia; BDA Group & MMA (2006). South Australia's Waste Strategy 2005-2010, Ex-ante Benefit Cost Assessment.

Marginal Abatement Costs for nitrogen and phosphorus removal

Project details	Cost per tonne
Nitrogen	
Fence/alternative water supply on grazing land	$268,049
Treatment process improvements at STPs in South Australia	$243,681
Tertiary filtration at a small STP in SEQ, resulting in a 37-tonne reduction in nitrogen loads over 20 years	$195,139
Constructed wetlands in Port Phillip Bay	$97,472
Tertiary filtration at a large STP in SEQ, resulting in a 2,190-tonne reduction in nitrogen loads over 20 years	$81,309
Constructed wetlands in South Australia	$73,104
Nutrient removal from a pine pulpwood plantation; 0.08 tonnes per hectare p.a.	$70,468
Best practice crop production measures in Victoria	$67,012
Compost study	$63,966
Improved treatment processes at STPs in Port Phillip Bay, Victoria	$60,920
Runoff re-use program	$60,920
Wetland and water recycling project	$60,920
Runoff re-use program	$48,736
Methanol dosing at STP	$40,207
Nutrient removal from a pine pulpwood plantation in SEQ; 0.08 tonnes per hectare p.a.	$35,416
Methanol dosing at STP	$30,460
Methanol dosing at STP	$25,586
Methanol dosing at STP	$21,931
Biological nutrient removal at an STP in SEQ, resulting in a 75-tonne reduction in nitrogen loads over 20 years	$18,584
Development of buffer strips on horticultural land in New South Wales	$18,276
Construction of a settlement pond	$15,230
Projects aimed at other point sources in South Australia	$14,621
Enhanced denitrification at STP	$14,621
Constructed wetlands and riparian restoration in New South Wales	$12,184
Nutrient removal from a hay and sorghum rotation in SEQ; 0.517 tonnes per hectare p.a.	$10,951
Fencing and riparian revegetation, resulting in a 35-tonne reduction in nitrogen loads per farm over 20 years	$9,461
Pushed denitrification at STP	$7,310
Modifying fertiliser use by horticultural producers in New South Wales and Victoria	$6,092
Riparian restoration in South Australia	$6,092
Advanced denitrification at STP	$6,092
Fencing and riparian revegetation in SEQ, resulting in an 87-tonne reduction in nitrogen loads per farm over 20 years	$3,784
Nutrient removal from a hay and sorghum rotation in SEQ; 0.517 tonnes per hectare p.a., over 2,793 hectares	$3,021
Biological nutrient removal at a large STP in SEQ, totalling 7,470 tonnes of nitrogen load reduction over 20 years	$696
Phosphorus	
Tertiary clarification at an STP	$977,159

Project details	Cost per tonne
Tertiary clarification at an STP	$721,295
Eucalypt sawlog plantation in SEQ; 0.003 tonnes per hectare p.a. over 19 hectares	$463,517
Runoff re-use project	$450,809
Compost study	$402,809
Runoff re-use project	$347,245
Polishing contact filtration at an STP	$341,153
Polishing contact filtration at an STP	$269,267
Wetland and water recycling project	$240,635
Settlement pond project	$134,024
Eucalypt sawlog plantation in SEQ; 0.003 tonnes per hectare p.a. over 3,695 hectares	$123,790
Fencing and riparian revegetation, resulting in a 5.8 tonne reduction in phosphorus loads per farm over 20 years	$76,526
Fencing and riparian revegetation, resulting in an 8.6 tonne reduction in phosphorus loads per farm over 20 years	$51,131
WSUD – Swales in SEQ, resulting in a 1.81-tonne reduction in phosphorus loads over 20 years	$32,185
Biological nutrient removal at an STP in SEQ, resulting in a 22-tonne reduction in phosphorus loads over 20 years	$24,779
Fencing and alternative water supply solutions	$21,322
Tertiary filtration at a small STP in SEQ, resulting in a 29-tonne reduction in phosphorus loads over 20 years	$18,295
Tertiary filtration at a large STP in SEQ, resulting in an 876-tonne reduction in phosphorus loads over 20 years	$15,245
Sludge management and disposal works at a small STP in SEQ, resulting in a 183-tonne reduction in phosphorus loads over 20 years	$8,161
Sludge management and disposal works at a small STP in SEQ, resulting in a 657-tonne reduction in phosphorus loads over 20 years	$5,194
Sludge management at a large STP in SEQ, resulting in a 913-tonne reduction in phosphorus loads over 20 years	$3,739
Sludge management at a large STP in SEQ, resulting in a 3,285-tonne reduction in phosphorus loads over 20 years	$2,775
Biological nutrient removal at a large STP in SEQ, resulting in an 830-tonne reduction in phosphorus loads over 20 years	$783

Note: Cost estimates based on projects or works in SEQ have been highlighted.

Source: ACIL Allen Consulting (2014). Load-Based Licence Fee Comparison – Comparison of Load-Based Licence Fees with Marginal Abatement Costs (MAC) and Marginal External Costs (MEC) for Selected Pollutants.

In summary:

- the study found significant variation in marginal abatement costs for projects aimed at reducing nutrient loads, including for projects located in SEQ. For example, a tertiary filtration project undertaken at a large STP in SEQ resulted in a 2,190-tonne reduction in nitrogen loads over a 20-year period, at a per tonne cost of nitrogen removal of $81,309 per tonne. Alternatively, several projects resulted in a significant reduction in nitrogen loads at abatement costs of less than $10,000 per tonne; and

- several large projects were undertaken to achieve significant reductions in phosphorus loads in SEQ, with the average cost per tonne estimated at $5,983 per tonne.

A.3 Nutrient discharge fees

The final approach to identifying a proxy value to be applied to estimate the economic cost associated with the discharge of nitrogen and phosphorus into SEQ waterways and Moreton Bay is to use a fee that is levied on entities that are responsible for discharging nutrients into waterways or water bodies.

In June 2017, the Department of Environment and Heritage Protection released the Consultation Draft for the 'Point-Source Water Quality Offsets Policy', which is proposed for implementation under the Environmental Protection Act 1994.[71] This document is an update of the 2014 draft policy document released by the Queensland Government.

This document sets out the requirements for implementing a water quality offsets regime as a mechanism to manage point source discharges of nutrients and pollutants into Queensland waterways and water bodies. This will provide an opportunity for entities to manage their emission discharge requirements, to be set by government based on objectives and targets in relation to environmental and water quality outcomes, through a range of alternative investment options.

Once the regime is implemented, there is the potential for these water quality offsets to be traded following implementation of the regime (which would provide an indication as to the economic value of reducing the discharge of nutrients and pollutants into Queensland waterways and water bodies). However, given the regime in Queensland is currently under development, it is necessary to consider regimes that have been established in other jurisdictions and whether it is appropriate for fees or levies applied in these jurisdictions to be applied as a proxy value for the discharge of nutrients into SEQ waterways and Moreton Bay.

New South Wales adopts 'load based licensing' (LBL) requirements for certain activities which set limits on pollutant loads that can be emitted and an annual licence fee made up of:

- an administrative fee based on the type and scale of licensed activity; and

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[71] Department of Environment and Heritage Protection (2017). Have your say Consultation draft – Point-Source Water Quality Offsets Policy. Queensland Government.

- a load-based fee proportional to the quantity and types of pollutants discharged and the conditions of the receiving environment.

Load-based fees may be regarded as pollution taxes as they provide an incentive for licensees to reduce pollution. However, the fee may or may not be set to reflect the economic impact of the pollution, depending on the objective of the scheme (for example, some may be more directed towards cost recovery than efficient price signalling of pollution costs).

For the NSW LBL scheme it was recognised when it was introduced that the load-based fees would, at least initially, be set below the value of the health and environmental (externality) impacts of discharges. However, the fees were designed to reflect the relative external impacts of pollutants and the State's priorities for reductions in these pollutants from licensed sources. The scheme focuses on the amount of pollution released to the environment and the load fee is calculated on the potential environmental impact of that pollution - the lower the potential for environmental impact, the lower the fee.[72] The NSW LBL fees for 2012-13 for the water pollutants of nitrogen and phosphorous were as follows:[73]

- nitrogen - $26 per tonne (low) to $588 per tonne (high)
- phosphorus - $0 per tonne (low) to $17,389 per tonne (high).[74]

It is important to reiterate that these NSW LBL fees do not represent an estimate of the externality cost of these water pollutants, but rather are indicative of relative impacts and the State’s priorities for pollutant reduction.

Noting the significant differences across a range of key factors (e.g. ecology, community preferences), the fees levied in overseas jurisdictions can also provide an indication of the value that is placed on nutrient discharges. The figure below shows the highest fee rates per tonne of nitrogen and phosphorous emitted for countries that charge levies for these pollutants.

This shows that rates for nitrogen and phosphorous water emissions are highest in Denmark, where a tonne emitted of each from wastewater treatment plants and industries with direct discharges attracts a charge of $4,144 and $22,794 per tonne for

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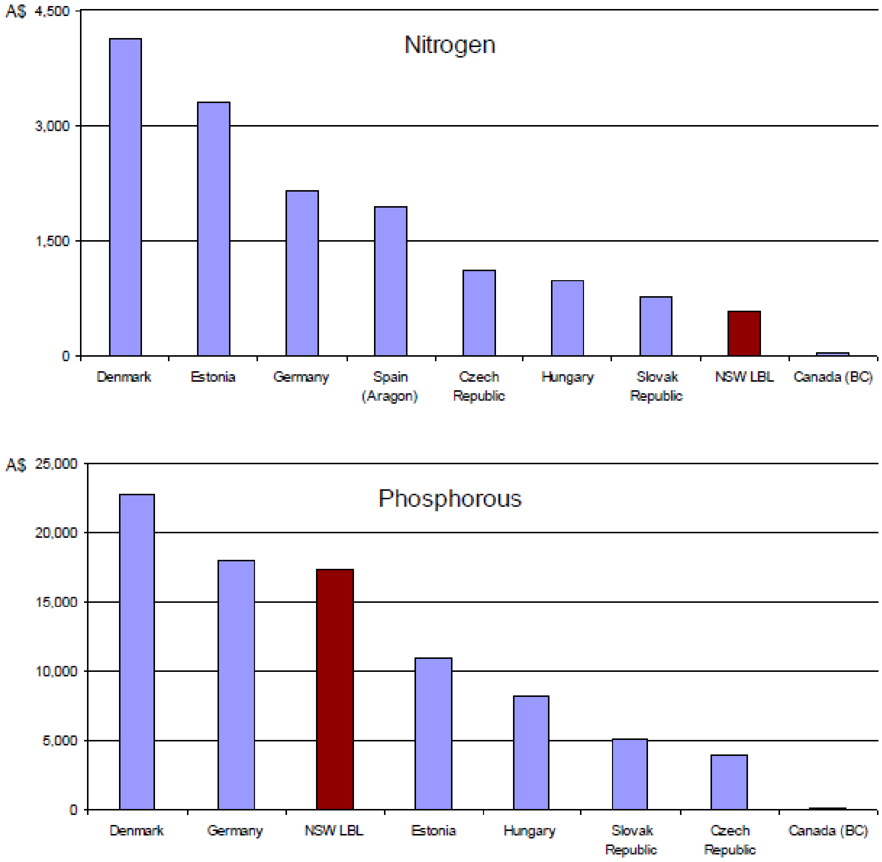
[72] NSW EPA (2016). NSW EPA’s Load-based Licensing Scheme. Overview of facts about load-based licensing, October 2016, p. 1.

[73] The fee range typically indicates fee rates below and above the fee rate threshold. In the case of nitrogen and phosphorus emissions to water, the range also accounts for whether the discharge is to open or enclosed waters. For these pollutants, variations are also due to critical zone weightings.

[74] BDA Group (2014). Comparative review of load-based licensing fee systems. Final Report. Prepared for the NSW Environment Protection Authority.

nitrogen and phosphors respectively. In several jurisdictions, the fees levied for the discharge of nutrients represent nominal fees (i.e. are not necessarily related to the cost associated with nutrient discharges).

Nitrogen and phosphorous water emission fees by country (A$/tonne)



Data source: BDA Group (2014). Comparative review of load based licensing fee systems. Final Report. Prepared for the NSW Environment Protection Authority, 30 April 2014, p. 9.

Appendix I – Review of Environmental Factors

Queensland Farmers' Federation Ltd

NuWater Project Feasibility Study
Review of Environmental Factors

March 2018

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

Executive summary

This “NuWater Project” proposes to use recycled water from the South-East Queensland Western Corridor Recycled Water Scheme (WCRWS) for irrigation in the Lockyer Valley and Darling Downs. This document supports a Preliminary Business Case for the projects four options.

The four options are:

1. Option A: Western Corridor Recycled Water Scheme (WCRWS) pipeline and construction of Heathwood pump station (PS) and upgrade of Gibson Island advanced water treatment plant (AWTP), including pipelines from Redcliffe sewage treatment plant (STP) to Sandgate STP and from Sandgate STP to Luggage Point STP. New pipeline and pump stations from Lowood to top of Toowoomba Range plus distribution networks to Lockyer Valley and Darling Downs agricultural areas. Water product is Purified Recycled Water.
2. Option B: WCRWS pipeline and construction of Heathwood PS and upgrade of Gibson Island AWTP. New pipeline and pump stations from Lowood to top of Toowoomba Range plus distribution networks to Lockyer Valley and Darling Downs agricultural areas. Water product is Class A+ water.
3. Option C: WCRWS pipeline and construction of Heathwood PS. New pipeline and pump stations from Lowood to top of Toowoomba Range plus distribution networks to Lockyer Valley and Darling Downs agricultural areas. Water product is Class B/C water.
4. Option D: WCRWS pipeline (current operating capacity) and pipeline from Bundamba AWTP to Lowood Booster PS. New pipelines and pump stations from Lowood to top of Toowoomba Range plus distribution networks to Lockyer Valley and Darling Downs agricultural areas. Water product is Purified Recycled Water and Class B/C Water.

Table 1 provides a summary of the potential environmental impacts from each option and potential costs associated with further investigations or mitigation measures. Table 2 provides a summary of approvals potentially triggered by the project options.

Table 1 Environmental impacts and potential costs

Option	Environmental impact	Potential costs: Investigations required or potential mitigation
All options	Pipeline easement will sterilise some portions of public and private property.	Compensation to land owners.
Option A	Pipeline will potentially impact on a legally secured offset area for Option A (section 13).	Investigation required into avoidance of the offset area or options to replace.
All options	Potential erosion and sedimentation impacts during construction and operation.	Implementation of erosion and sediment control plan.
Option C	Increased salinity hazard through the application of Class B/C water.	Salinity investigation and management

Option	Environmental impact	Potential costs: Investigations required or potential mitigation
All options	Net benefit to Moreton Bay from reuse of water from the STPs and AWTPs.	Net benefit
All options	Pipeline crossings of between 78 and 90 waterways for waterway barrier works. Erosion and sedimentation impacts reducing water quality during construction.	Potential approval requirements Requirements for HDD and bores to minimise environmental impacts.
Option B and C	Storage of Class A+ or Class B/C water in storage dams in the Lockyer Valley. This water has the potential to discharge into nearby waterways during high rainfall events. The storage of Class B/C water poses a human health risk through exposure, spray drift and the public potentially accessing the dam.	Management plans for the storage of Class A+ or Class B/C water.
All options	Recycling Brisbane's water will be a benefit. It will improve and secure reliable water supplies and reduce current reliance on surface and groundwater. This will decrease stress on natural systems within the Lockyer Valley and Darling Downs.	Net benefit
All options	Vegetation clearing and excavation will lead to: Removal or impacts to REs or TECs as a result of vegetation clearing. Impacts on connectivity. Weed invasion potential. Disturbance to essential habitat for koala and wallum froglet.	Species management programmes will be required for disturbance to breeding places. Potential approval and offset requirements. Weed and pest management implementation. Fauna spotter required. Rehabilitation costs.
Option A	Removal, destruction or damage to a marine plant	Potential approval and offset requirements.
All options	Temporary waterway barrier works leading to short-term impacts to aquatic ecology, and to fish passage. Fauna injury and mortality. Disruption to fauna behaviour.	Species management programmes will be required for disturbance to breeding places (Aust. Lungfish, Mary River Cod, Silver Perch).

Option	Environmental impact	Potential costs: Investigations required or potential mitigation
All options	Short-term localised dust impacts during construction.	Standard air quality management measures.
All options	Short-term localised noise impacts during construction. Potential pump station noise impacts during operation.	Standard noise and vibration management measures. Option A may require additional measures in residential areas. Noise assessment for pump station
All options	Short-term, localised visual impacts as a result of clearing and excavation works.	Rehabilitation of cleared Right of Way.
All options	There are a significant amount of Indigenous Cultural Heritage sites within the buffer zone of the project. Option A has additional Cultural Heritage parties and a section of coastal environment that contains a high number of Cultural Heritage sites.	Development of Cultural Heritage Management Plan (CHMP). Negotiations with traditional owner groups required. Additional traditional owner groups for Option A.
All options	Based on searches of relevant national and state heritage registers, one item of historical heritage is located within 300m of the project area for all options.	Heritage listed items will be avoided during route selection. Construction impacts include vibration and management will be put in place during this stage.
Option A	There were six items of historical heritage within proximity to Option A (sections 13 and 14).	Heritage listed items will be avoided during route selection. Construction impacts include vibration and management will be put in place during this stage.
Option D	There were numerous heritage listings for Option D in Ipswich and surrounds however it is assumed that the pipeline in this section will follow the existing WCRWS easement and impact the historical heritage through vibration will be minimised.	Heritage listed items will be avoided during route selection. Construction impacts include vibration and management will be put in place during this stage.

Table 2 Approvals Summary

Approval	Option A	Option B	Option C	Option D
EPBC Referral	✓	✓	✓	✓

Approval	Option A	Option B	Option C	Option D
Assessment if deemed a controlled action: Controlled action – to be assessed on preliminary documentation or by EIS.	✓	✓	✓	✓
Infrastructure Designation	Approvals pathway option	Approvals pathway option	Approvals pathway option	Approvals pathway option
Material Change of Use (if no Infrastructure Designation)	✓	✓	✓	✓
Reconfiguration of a Lot (if no Infrastructure Designation)	✓	✓	✓	✓
Environmental Authority for an Environmentally Relevant Activity (ERA)	✓	✓	✓	✓
Regulated structure and Hazardous waste dam. Regulated under the Environmental Authority for ERA 64 above.	X	✓	✓	X
Operational work for constructing or raising a waterway barrier works or compliance with the accepted development guideline	✓	✓	✓	✓
Operational work for clearing of native vegetation	✓	✓	✓	✓
Operational works for tidal works (prescribed tidal works), or work within a coastal management district.	✓	X	X	X
Operational work for the removal, destruction or damage of a marine plant	✓	X	X	X
Development permit for the removal of quarry material in a watercourse	TBD	TBD	TBD	TBD
Operational works for taking or interfering with water from a watercourse, lake or spring	TBD	TBD	TBD	TBD
Building work	✓	✓	✓	✓
High-Risk Species Management Programme	✓	✓	✓	✓
Cultural Heritage Management Plan (CHMP) compliance Duty of care compliance	✓	✓	✓	✓

Approval	Option A	Option B	Option C	Option D
Riverine protection permit	Yes unless exemption can be met	Yes unless exemption can be met	Yes unless exemption can be met	Yes unless exemption can be met
Quarry material allocation notice	TBD	TBD	TBD	TBD
Permit to clear native plants (NC Act) or exemption notifications	✓	✓	✓	✓
Offsets	✓	✓	✓	✓
Filling or excavation under the local planning scheme for on farm dam storages	X	✓	✓	X
Referable dam development approval	X	X	X	X

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Table index

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Glossary

Abbreviation	Definition
AWTP	Advanced Water Treatment Plant
BPA	Biodiversity Planning Assessments
CDIL	Central Downs Irrigators Limited
CHMP	Cultural Heritage Management Plan
DATSIP	Department of Aboriginal and Torres Strait Islander Partnerships
DBC	Detailed Business Case
DEE	Department of the Environment and Energy
DEHP	Department of Environment and Heritage Protection
DILGP	Department of Infrastructure, Local Government and Planning
EIS	Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
IAA	Important Agricultural Areas
LGA	Local Government Area
MCU	Material Change of Use
MLES	Matters of Local Environmental Significance
MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
NC Act	*Nature Conservation Act 1992*
NWIDF	National Water Infrastructure Development Fund
PBC	Preliminary Business Case
PMST	Protected Matters Search Tool
PS	Pump station
QCMC	Queensland Chicken Meat Council
QFF	Queensland Farmers’ Federation
RE	Regional ecosystem
REF	Review of Environmental Factors
REF	Review of Environmental Factors
SPP	State Planning Policy
STP	Sewage treatment plant
TEC	Threatened Ecological Community
TSBE	Toowoomba and Surat Basin Enterprise
WCRWS	Western Corridor Recycled Water Scheme

1. Introduction

The Queensland Farmers' Federation (QFF), on behalf of an unofficial consortium, were successful in applying for funding under the National Water Infrastructure Development Fund (NWIDF) to undertake a feasibility study and prepare a Preliminary Business Case (PBC). The feasibility study aims to test the viability of using recycled water from the South-East Queensland Western Corridor Recycled Water Scheme (WCRWS) for irrigation in the Lockyer Valley and Darling Downs. This is referred to as the "NuWater Project" (project). The consortium includes QFF industry members, namely Cotton Australia, Central Downs Irrigators Limited (CDIL), Growcom and the Queensland Chicken Meat Council (QCMC), Agforce, Lockyer Valley Growers, Toowoomba and Surat Basin Enterprise (TSBE) and Queensland Urban Utilities (QUU).

The Review of Environmental Factors (REF) informs the feasibility study and supports the development of a PBC for the project.

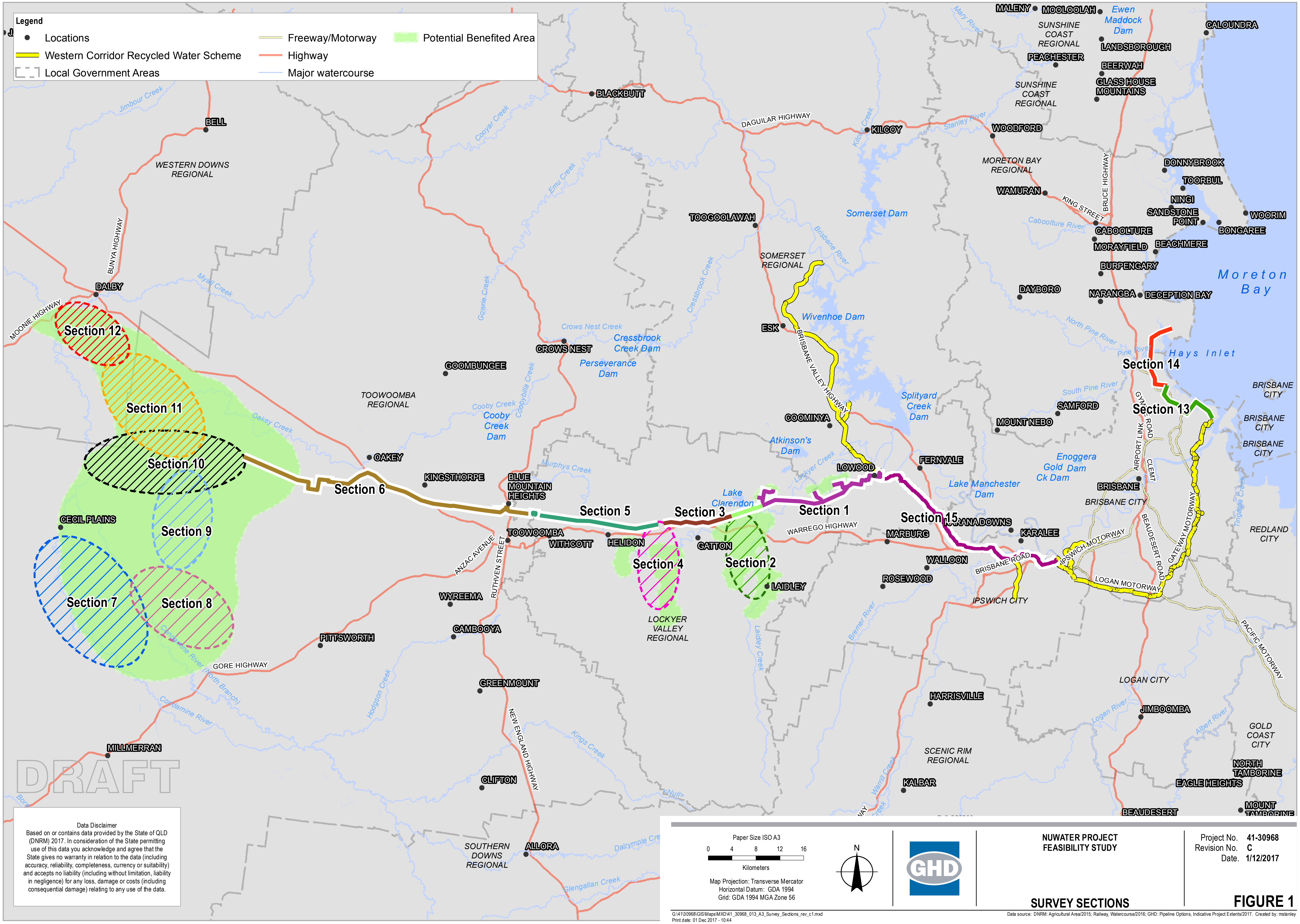
The project is based on the following options as shown in Figure 1:

1. Option A: Western Corridor Recycled Water Scheme (WCRWS) pipeline and construction of Heathwood pump station (PS) and upgrade of Gibson Island advanced water treatment plant (AWTP), including pipelines from Redcliffe sewage treatment plant (STP) to Sandgate STP and from Sandgate STP to Luggage Point STP. New pipeline and pump stations from Lowood to top of Toowoomba Range plus distribution networks to Lockyer Valley and Darling Downs agricultural areas. Water product is Purified Recycled Water. Includes sections 1 to 14 (Figure 1).
2. Option B: WCRWS pipeline and construction of Heathwood PS and upgrade of Gibson Island AWTP. New pipeline and pump stations from Lowood to top of Toowoomba Range plus distribution networks to Lockyer Valley and Darling Downs agricultural areas. Water product is Class A+ water. Includes sections 1 to 12 (Figure 1).
3. Option C: WCRWS pipeline and construction of Heathwood PS. New pipeline and pump stations from Lowood to top of Toowoomba Range plus distribution networks to Lockyer Valley and Darling Downs agricultural areas. Water product is Class B/C water. Includes sections 1 to 12 (Figure 1).
4. Option D: WCRWS pipeline (current operating capacity) and pipeline from Bundamba AWTP to Lowood Booster PS. New pipelines and pump stations from Lowood to top of Toowoomba Range plus distribution networks to Lockyer Valley and Darling Downs agricultural areas. Water product is Purified Recycled Water and Class B/C Water. Includes sections 1 to 12 and 15 (Figure 1).

1.1 Purpose of this report

The purpose of this REF is to provide a description of the existing environment and environmental values within and surrounding the project footprint. The report provides a desktop review of environmental factors and seeks to supplement and consolidate previous environmental investigations and reference material with current State and Commonwealth environmental data layers to provide a description of the existing environment and environmental values within and surrounding the project footprint.

An environment and planning approvals register based on Commonwealth, State and local government legal and regulatory considerations identified throughout the environmental assessment is provided in Section 4.



Data Disclaimer
Based on or contains data provided by the State of QLD (DNRM) 2017. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data.

Paper Size ISO A3
0 4 8 12 16
Kilometers
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NUWATER PROJECT
FEASIBILITY STUDY

Project No. **41-30968**
Revision No. **C**
Date. **1/12/2017**

SURVEY SECTIONS

FIGURE 1

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Print date: 01 Dec 2017 - 10:44

Data source: DNRM: Agricultural Area/2015; Railway, Watercourse/2016; GHD: Pipeline Options, Indicative Project Extents/2017. Created by: mstanley

1.2 Methodology

The following desktop environmental database searches have been undertaken for the proposed options:

- Australian Heritage database
- The Commonwealth Department of the Environment and Energy (DEE) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool (PMST) (line search with 1km buffer) (search results on file)
- Queensland Government Wildlife Online Database (Latitude -25.3494, Longitude 151.9191, 10 km buffer) (search results on file)
- Department of Aboriginal and Torres Strait Islander Partnerships (DATSIP) cultural heritage database (search results on file)
- Department of Environment and Heritage Protection (DEHP) Biodiversity and Conservation Values Report – Biodiversity Planning Assessments (BPA) and Aquatic Conservation Assessments
- DEHP Matters of State Environmental Significance Report (MSES)
- DEHP Regional Ecosystem Biodiversity Status Report
- DEHP Protected Plants Flora Survey Trigger mapping
- Department of Infrastructure, Local Government and Planning (DILGP) Development Assessment (DA) mapping system
- DILGP State Planning Policy (SPP) interactive mapping system
- The Queensland Heritage Register

No site investigation has been undertaken to verify the desktop searches.

1.2.1 Search extents

The alignment of the project was separated into 15 sections to allow for accurate environmental searches to be undertaken. The 15 sections are used to describe areas throughout the report as shown on Figure 1. The central coordinates alongside the radiuses of the sections are located in Table 3.

Table 3 Search extents

Section	Latitude	Longitude	Radius (km)
1	-27.5066	152.4845	12
2	-27.5996	152.3715	9
3 and 4	-27.5339	152.2472	12
5	-27.5301	152.0603	6
6	-27.4563	151.7185	24
7	-27.6348	151.2860	14
8	-27.6369	151.3680	11
9	-27.5263	151.3880	7

Section	Latitude	Longitude	Radius (km)
10	-27.4506	151.4009	14
11	-27.3528	151.3438	10
12	-27.2322	151.2553	10
13 (option A only)	-27.352	153.0984	5
14 (option A only)	-27.2866	153.0452	6
15 (option D only)	-27.5333	152.6915	13

1.3 Scope and limitations

This report: has been prepared by GHD for Queensland Farmers' Federation Ltd and *may only be used and relied on by Queensland Farmers Federation for the purpose agreed between GHD and the Company as set out in section 1.1 of this report.*

GHD otherwise disclaims responsibility to any person other than Queensland Farmers' Federation Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Queensland Farmers' Federation Ltd and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Environmental assessment

2.1 Planning and Land Use

The project traverses six local government areas (LGAs); Brisbane City Council LGA, Moreton Bay Regional Council LGA, Somerset Regional Council LGA, Lockyer Valley Regional Council LGA, Toowoomba Regional Council LGA and Western Downs Regional Council LGA.

The proposed alignments are intended to be located within existing easements or on freehold land. The pipeline easement will sterilise portions of public and private property. The majority of the changes to land access will occur during the construction phase.

2.1.1 Tenure

The distribution pipelines will traverse a range of tenures. The majority of the properties the pipeline passes through are freehold, with some leasehold and reserve tenure. Watercourses are mapped as unallocated state land. The pipeline passes to the south of the Lockyer National Park. The route selection will attempt to remain within road reserves or along property boundaries.

Option A (section 13) is located within Hays Inlet which is a marine park, declared fish habitat area and protected area (nature refuge).

Option A (section 14) is located near the Brisbane Airport and traverses through a legally secured offset area for the Sisters of Mercy as well as traverses a small area of marine park.

2.1.2 Local Planning Schemes

The project falls under the jurisdiction of planning schemes of six councils:

- Brisbane City Council Planning Scheme 2014
- Moreton Bay Regional Council Planning Scheme 2015
- Somerset Regional Council Planning Scheme 2016
- Gatton Shire Planning Scheme 2007
- Laidley Shire Planning Scheme 2003
- Toowoomba Regional Council Planning Scheme 2017
- Western Downs Regional Council Planning Scheme 2017

2.1.3 Native Title

For all options, the Native Title claim groups include:

- Yuggera Ugarapul People
- Jagera People #2
- Western Wakka Wakka People
- Barunggam People

Option A (sections 13 and 14) also includes the Jagera People and the Turrbal People.

2.1.4 Land use/agriculture

Land use within the project study area (distribution network) is predominantly agricultural, comprising a mixture of grazing, cropping and irrigated horticulture Option A includes pipelines from Redcliffe STP to Sandgate STP and Sandgate STP to Luggage Point WTP. The land use in this area is residential and includes the Brisbane Airport.

The alignment is located within mapped Important Agricultural Areas (IAAs) except for the Option A additional pipelines Redcliffe STP to Sandgate STP and Sandgate STP to Luggage Point WTP which are not within IAAs.

IAAs are mapped by Department of Agriculture and Fisheries (DAF) and defined as land that has all of the requirements for agriculture to be successful and sustainable, is part of a critical mass of land with similar characteristics and, is strategically significant to the region or the state.

2.2 Property Impacts

The pipeline easement will sterilise portions of public and private property. The alignment will follow existing easements or roads where feasible.

The pipeline will cross roads, rail, power lines and other pipelines. Where required, the pipeline will be bored or horizontally directionally drilled under existing infrastructure.

2.3 Topography, Geology and Soils

Erosion and sediment control will be managed through standard environmental management controls during construction and operation of the pipeline.

A contaminated land assessment has not been conducted.

Topography

The topography of the alignment is comprised of relatively hilly terrain with a steep climb between sections 3 and 5 (in the vicinity of the Toowoomba range) before becoming relatively flat onwards in a westerly direction. The terrain for sections 13 and 14 is relatively flat however; it intersects a number of tidal waterways, including a RAMSAR site and marine park (Section 5.2).

Geology

The proposed alignment is located over a number of different geological areas. The dominant rock types identified along the alignment are comprised of arenite-mud rock, alluvium, mixed mafites and felsites and sedimentary rocks.

Soils

Option A (section 14) located in Hays Inlet is within a mapped erosion prone area (Moreton Bay Regional Council Planning Scheme Overlay Maps and Brisbane City Council interactive mapping). Options A (section 13) is also mapped within an erosion prone area on the Brisbane City Council interactive mapping.

Option C involves the application of Class B/C water to crops. There is the potential for exacerbated soil salinity issues from the use of Class B/C water in this region.

2.4 Water resources

2.4.1 Surface water

The alignment crosses a number of major waterways identified in Table 4. Major waterways could be bored or horizontally directionally drilled (HDD) to reduce environmental risks associated with open trenching or cofferdam construction. Waterway crossing risks to be minimised through route selection at suitably stable locations and following construction sites are to be appropriately stabilised and revegetated.

Table 4 indicates the waterway crossings and the zoning colour for determining waterway barrier works development approval triggers.

The zoning colours are green (low), amber (moderate), red (high), purple (major) and tidal (major). Table 5 provides the number of waterway crossings for each crossing by waterway barrier works zoning colour. Note that these crossings are based on the current route which is yet to undergo a route selection process and these numbers will therefore alter once the route is finalised.

Table 4 Waterways located along alignment

Section	Waterways	Waterways for Waterway Barrier Works zoning colour
1	Tributaries of Brisbane River	Amber (moderate) Green (low)
	Lockyer Creek	Purple (major)
	Plain Creek	Red (high)
	Tributaries of Lockyer Creek and Plain Creek	Green – three crossings Amber Purple Amber Green – two crossings Red
2	Unnamed Tributary	Green
	Lockyer Creek	Purple
	Tributary of Laidley Creek	Amber
	Sandy Creek	Purple
	Laidley Creek	Purple
	Unnamed Creek	Red - four crossings
3	Unnamed Tributary	Green – two crossings
	Redbank Creek	Red
	Tributaries of Redbank Creek	Amber Green – three crossings
4	Tributaries of Lockyer Creek	Green – three crossings Amber
	Lockyer Creek	Purple – two crossings
	Ma Ma Creek	Purple

Section	Waterways	Waterways for Waterway Barrier Works zoning colour
	Tenthill Creek	Purple – two crossings
5	Sandy Creek	Purple
	Tributaries of Sandy Creek	Amber- two crossings Green – two crossings
	Tributaries of Lockyer Creek	Green – four crossings Amber
	Lockyer Creek	Purple – two crossings
	Sheep Station Creek	Red
	Tributaries of Sheep Station Creek	Amber Green
	Six Mile Creek	Red
	Tributaries of Six Mile Creek	Green – two crossings
	Rocky Creek	Purple – four crossings Red
6	Gowrie Creek	Red
	Tributaries of Gowrie Creek	Green – four crossings Amber – three crossings Red
	Gowrie Creek	Purple – two crossings
	Oakey Creek	Purple
	Doctor Creek	Amber
7	N/A	N/A
8	Condamine River	Purple
	Unnamed tributary	Red Amber
9	Unnamed tributary	Red
10	N/A	N/A
11	Oakey Creek	Purple
12	Tributary of Myall Creek	Amber

Section	Waterways	Waterways for Waterway Barrier Works zoning colour
13 (option A only)	Unnamed tributaries	Amber – two crossings Red
13 (option A only)	Serpentine Creek	Amber
	Kedron Brook Floodway	Red/ Tidal Waterway
	Nundah Creek	Red/ Tidal Waterway
	Nudgee Creek	Tidal Waterway
	Jacksons Creek	Tidal Waterway
14 (option A only)	Pine River	Tidal Waterway
	Hayes Inlet	Tidal Waterway
	Cabbage Tree Creek	Tidal Waterway
15 (option D only)	Bundamba Creek	Purple
	Bremer River	Tidal waterway
	Tributary of Sandy Creek	Green
	Mustering Gully	Green
	Sandy Creek	Red
	Fairnie Brook	Green – two crossings Red – two crossings
	Tributary of Fairnie Brook	Amber
	Ferny Gully	Amber
	Tributary of Brisbane River	Green

Table 5 Number of waterway crossings for each option

Waterway Barrier Works zoning colour	Option A	Option B	Option C	Option D
Green	28	28	28	33
Amber	18	15	15	17
Red	16	13	13	16
Purple	22	22	22	23
Tidal	5	0	0	1

Waterway Barrier Works zoning colour	Option A	Option B	Option C	Option D
Total crossings	**89**	**78**	**78**	**90**

Options B and C propose to store 1GL of water in turkey nests in the Lockyer Valley. This has the potential to impact water quality in nearby creeks during high rainfall events that overtop the turkey nests. Option C poses the greatest risk as this option stores Class B/C water. Class B/C water poses a human health risk through exposure, spray drift and if the public accessed the dam.

2.4.2 Groundwater

Pipeline construction can impact groundwater. There is a risk that intercepted groundwater can be diverted along the backfilled trench creating scour and erosion. A groundwater assessment will be required to inform detailed design, this will include bored and HDD waterway crossings and water storages for options B and C.

2.5 Hydrology

The alignment is located within the Pine Catchment, the Brisbane Catchment and the Balonne-Condamine Catchment.

Together, the Water (Moreton) Plan 2007 (Moreton WRP) and Moreton Resource Operations Plan (Moreton ROP) provide the strategic and operational framework for sustainable management of water resources in the Moreton plan area. Water resources in the Moreton plan area comprise three large water storages: the Somerset, Wivenhoe and North Pine Dams, and six water supply schemes that supply water for irrigation and urban purposes. Unsupplemented water and overland flow are also managed under the Moreton WRP, while groundwater is also extensively managed within the plan area through the regulation of groundwater take in three defined groundwater management areas.[1]

The Central Lockyer Valley WSS was established in the 1980's and comprises two off-stream storages (Lake Clarendon and Bill Gunn Dam) and nine recharge weirs that together function as infrastructure to support irrigation in the Central Lockyer Valley. The two storages are filled by diverting water from nearby creeks during significant flow events. The scheme supplies water for the Morton Vale Pipeline, recharges groundwater areas adjacent to Lockyer and Laidley creeks, and supplies downstream surface water entitlements. Seqwater own and operate the scheme and manage the infrastructure according to the rules and requirements of an Interim Resource Operations Licence (IROL).

The water supply scheme supplies approximately 315 water entitlements, comprising 115 interim water allocations to take surface water, 150 licences to take groundwater, and 50 landowners on the Morton Vale pipeline (supplied under water supply agreements with Seqwater).

Groundwater entitlement holders in Implementation Area 1 outside the supplemented area are regarded as unsupplemented and are managed by the department.

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[1] *Statement of Proposals to amend the Water Resource (Moreton) Plan 2007 and Moreton Resource Operations Plan 2009*, Queensland Government (DNRM), October 2015 P2

2.6 Flora and Fauna

2.6.1 Terrestrial Ecology

Remnant Vegetation

Regional ecosystems (REs) mapped within the footprint of the pipeline are provided in Table 6 and comprises of nine ‘endangered’ REs, thirteen ‘of concern’ REs and sixteen ‘least concern’ REs. Sections 13 and 14 intersect the highest amount of REs with each section intersecting eight REs, most of which are of concern or least concern REs. These sections are within Option A only.

The alignment of the project is located within the Southeast Queensland (SEQ) bioregion and the Brigalow Belt bioregion. Regional ecosystems mapped for the project are provided in Table 6.

Table 6 Regional ecosystems identified along the alignment

Regional Ecosystems	1	2	3	4	5	6	7	8	9	10	11	12	13 (option A only)	14 (option A only)	15 (option D only)
Endangered															
12.5.2													X		
12.5.3													X	X	
12.9-10.6	X	X													
12.9-10.11a		X													
11.3.21										X	X	X			
11.3.24										X					
12.1.2													X		
12.3.3			X		X										X
12.8.21					X										
12.8.9					X										
Of Concern															
12.9-10.7		X	X	X	X										X
12.9-10.3															X
11.3.2												X			

Regional Ecosystems	1	2	3	4	5	6	7	8	9	10	11	12	13 (option A only)	14 (option A only)	15 (option D only)
11.3.25						X						X			
11.3.4												X			
11.8.11						X									
12.1.1													X	X	
12.3.11													X	X	
12.3.5														X	
12.3.6													X	X	
12.3.8	X	X													
Least Concern															
12.9-10.5a				X	X										
12.9-10.2		X	X	X	X										X
11.3.25						X		X							
11.9.2															
11.8.3						X									
11.8.4						X									
11.8.5						X									

Regional Ecosystems	1	2	3	4	5	6	7	8	9	10	11	12	13 (option A only)	14 (option A only)	15 (option D only)
12.1.2														X	
12.1.3													X	X	
12.3.5a													X		
12.3.6														X	
12.8.17					X										
12.3.7			X												X
12.3.7B															X

Threatened Ecological Communities

There are nine threatened ecological communities (TECs) located along the alignment:

- Brigalow (*Acacia harpophylla* dominant and codominant)
- Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions
- Lowland Rainforest of Subtropical Australia
- Natural grasslands on basalt and fine textured alluvial plains of Northern New South Wales and south Queensland
- Semi-evergreen vine thickets of the Brigalow belt (north and south) and Nandewar regions
- Subtropical and temperate coastal saltmarsh
- Swamp Tea-tree (*Melaleuca irbyana)* Forest of South East Queensland
- Weeping Myall Woodlands
- White Box-Yellow Box- Blakely's Red Gum Grassy Woodland and Derived Native Vegetation

The Brigalow (*Acacia harpophylla* dominant and codominant) TEC, listed as Endangered under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), was identified as known to occur within the study area based on database search results. This TEC is defined by 16 regional ecosystems (6.4.2, 11.3.1, 11.4.3, 11.4.7, 11.4.8, 11.4.9, 11.4.10, 11.5.16, 11.9.1, 11.9.5, 11.9.6, 11.11.14, 11.12.21, 12.8.23, 12.9-10.6, 12.12.26). RE 12.9-10.6 *Acacia harpophylla* open forest on sedimentary rocks has been identified to occur in sections 1 and 2 through desktop searches. There is the potential for this TEC to occur within the alignment, a survey will need to be undertaken to confirm this.

The Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregoins TEC, listed as endangered under the EPBC Act, was identified as 'may occur' within the study area based on database search results. This TEC is defined by five regional ecosystems (11.3.3, 11.3.15, 11.3.16, 11.3.28, 11.3.37) which are not mapped as occurring within or in proximity to the proposed alignment. It is unlikely for this TEC to occur within the alignment.

The Lowland Rainforest of subtropical Australia TEC, listed as critically endangered under the EPBC Act, was identified as 'may occur' within the study area based on database search results. This TEC is defined by nine regional ecosystems (12.3.1, 12.5.13, 12.8.4, 12.8.13, 12.11.1, 12.11.10, 12.12.1, 12.12.16) which are not mapped as occurring within or in proximity to the proposed alignment. It is unlikely for this TEC to occur within the alignment.

The Natural grasslands on basalt and fine textured alluvial plains of Northern New South Wales and south Queensland TEC, listed as critically endangered under the EPBC Act, was identified as 'likely to occur' within the study area based on database search results. This TEC is defined by two regional ecosystems (11.3.21, 11.3.24). RE 11.3.21 *Dichanthium sericeum* and/or *Astrebla* spp. Grassland on alluvial plains has been identified to occur in sections 10.12 and 13 through desktop searches. There is the potential for this TEC to occur within the alignment, a survey will need to be undertaken to confirm this.

The Semi-evergreen vine thickets of the Brigalow belt (north and south) and Nandewar regions TEC, listed as endangered under the EPBC Act, was identified as 'likely to occur' within the study area based on database search results. This TEC is defined by ten regional ecosystems

(11.2.3, 11.3.11, 11.4.1, 11.5.15, 11.8.3, 11.8.6, 11.8.13, 11.9.4, 11.9.8, 11.11.18). RE 11.8.3 Semi-evergreen vine thicket and microphyll vine forest on Cainozoic sedimentary rocks has been identified to occur in section 11 through desktop searches. There is the potential for this TEC to occur within this alignment, a survey will need to be undertaken to confirm this.

The Subtropical and temperate coastal saltmarsh TEC, listed as vulnerable under the EPBC Act, was identified as ‘likely to occur’ within the study area based on database search results. This TEC is defined by one regional ecosystem (12.1.2). RE 12.1.2 Saltpan vegetation including grassland and herbland on marine clay plains has been identified to occur in section 16 through desktop searches. There is the potential for this TEC to occur within the alignment, a survey will need to be undertaken to confirm this.

The Swamp Tea-tree (*Melaleuca irbyana)* Forest of South East Queensland TEC, listed as critically endangered under the EPBC Act, was defined as ‘likely to occur’ within the study area based on database search results. This TEC is defined by two regional ecosystems (12.3.3c, 12.9-10.11) which are not mapped as occurring within or in proximity to the proposed alignment. It is unlikely for this TEC to occur within the alignment.

The Weeping Myall Woodlands TEC, listed as endangered under the EPBC Act, was defined as ‘likely to occur’ and ‘may occur’ within the study area based on database search results. This TEC is defined by two regional ecosystems (11.3.2, 11.3.28). RE 11.3.2 *Eucalyptus populnea* woodland on alluvial plains has been identified to occur in sections 10, 11 and 14 through desktop searches. There is the potential for this TEC to occur within the alignment, a survey will need to be undertaken to confirm this.

The White Box-Yellow Box- Blakely’s Red Gum Grassy Woodland and Derived Native Vegetation, listed as critically endangered under the EPBC Act, was defined as ‘likely to occur’ and ‘may occur’ within the study area based on database search results. This TEC is defined by ten regional ecosystems (11.8.2a, 11.8.8, 11.9.9a, 13.3.1, 13.11.8, 13.12.8, 13.12.9, 13.3.4, 13.11.3, 13.11.4) which are not mapped as occurring within or in proximity to the proposed alignment. It is unlikely for this TEC to occur within the alignment.

Offsets for the TECs may be required under the EPBC Act.

Connectivity

The project area includes connectivity areas that are prescribed regional ecosystems. The most extensive areas of interconnected habitat exist in section 3, 4, 5, 13 and 14 (in particular where the alignment goes through Hays Inlet Conservation Park).

As a result of the construction of the pipeline, vegetation clearing of the direct impact area and a buffer area will need to be undertaken, resulting in clearing of habitat connectivity in some areas, especially around sections 5 and 14. However, as the pipeline is servicing agricultural areas, majority of the land being impacted for the construction of the pipeline is already cleared land and therefore will not have habitat connectivity impacts as a result of clearing and construction.

Weed invasion

Weed invasion will be the biggest influence in re-establishing pre-disturbance RE’s in areas of clearance for construction works. The ground surface that would be revealed as a result of construction activities would enable areas of land to be colonised by opportunistic weeds. Timing may enable desirable species (native or pastoral) to have a better chance at becoming established first.

Essential habitat

Essential habitat for the koala (*Phascolarctos cinereus)* and the Wallum Froglet (*Crinia tinnula)* is mapped as occurring along the alignment. The Wallum Froglet essential habitat is located in sections 13 and 14. The koala essential habitat is located in sections 1, 2, 3, 4, 5, 13, 14 and 15. Offsets may be required for the essential habitat areas that are impacted.

Section 14 is located within a Priority koala assessable development area of which the areas are mapped as medium value bushland habitat and have medium and low value for suitability for rehabilitation. The *Nature Conservation (Koala) Conservation Plan 2017* (Koala Plan 2017) maps the project area within Moreton Bay, Brisbane, Ipswich and Lockyer Valley as Koala district A. Toowoomba and the Western Downs are mapped at Koala District C. Sequential clearing requirements apply to koala district A and koala spotters are required.

Conservation significant flora

Desktop searches identified 22 conservation significant flora species that have the potential to occur within the study area. These species are listed under the EPBC Act and/or the NC Act. All these species have been recorded within the buffer areas for each section of the alignment.

Offsets may be required under the Queensland *Environmental Offsets Act 2014*, and the EPBC Act Environmental Offsets Policy for EPBC Act listed species, if a significant residual impact on these species or their habitat is predicted.

The study area alignment is within a number of flora survey trigger areas and therefore there is a requirement for flora surveys to be undertaken.

Table 7 Flora species that have the potential to occur within the study area

Species	Common Name	EPBC Act Listing	NC Act Listing	Section species identified in
Bothriochloa erianthoides	Satin top grass	V	LC	5, 6
Callitris baileyi	Baileys Cypress	-	NT	1, 8, 9, 10
Causti blakei subsp. Macrantha	-	-	V	3, 4
Cymbonotus maidenii	-	-	E	7 - 12
Dichanthium Queenslandicum	King Blue-grass	E	V	7, 11
Digitaria porrecta	-	-	NT	6 - 12
Eucalyptus taurina	Helidon Ironbark	-	V	3 - 5
Grevillea quadricauda	-	V	V	3, 4
Homopholis belsonii	-	V	E	7 - 12

Species	Common Name	EPBC Act Listing	NC Act Listing	Section species identified in
Leionema obtusifolium	-	V	V	3, 4
Leucopogon sp. (Coolmunda D. Halford Q1635)	-	E	E	14
Melaleuca irbyana	-	-	E	2
Notleaea lloydii	Lloyd's Native Olive	V	V	1
Paspalidium grandispiculatum		V	V	3, 4
Picris barbarorum	-	-	V	9 - 12
Picris evae	-	V	V	6 - 10
Rhaponticum australe	-	V	V	1, 2, 6, 7, 8, 9, 10, 13, 14
Sarcochilus weinthalii	Blotched sarcochilus	-	E	5
Solanum papaverifolium	-	-	E	6, 9, 10, 11, 12
Sophora fraseri	Brush Sophora	V	V	1, 6
Southern corynocarpus	Southern Corynocarpus	-	V	1
Thesium australe	Toadflax	V	V	2, 5, 7, 8, 9, 10, 11, 12, 13

Conservation significant fauna

Desktop searches identified 102 conservation significant fauna species that have the potential to occur within the study area. This comprises of;

- 21 birds
- 8 reptiles
- 8 mammals
- 62 migratory birds
- 5 other

These species are listed under the EPBC Act and/or the NC Act. All these species have been recorded within the buffer areas for each section of the alignment.

A species management program (SMP) may be required for conservation significant fauna when an animal breeding place is identified and activities are required to tamper with the breeding place in order to complete the scope of works e.g. bird nests and tree hollows as well as amphibian and reptile habitat where breeding takes place. This may be an SMP for low risk of impacts for least concern animals (excluding special least concern of colonial breeders) or an SMP for high risk of impacts for all other protected animals including special least concern animals and colonial breeders. Offsets may be required under the Queensland *Environmental Offsets Act 2014*, and the EPBC Act Environmental Offsets Policy, if a significant residual impact on these species or their habitat is predicted.

Table 8 Fauna species that have the potential to occur within the study area

Species	Common Name	EPBC Act Listing	NC Act Listing	Relevant alignment section
Birds				
Anthochaera Phrygia	Regent Honeyeater	CE	E	11, 12
Ardenna pacifica	Wedge-tailed Shearwater	-	V	3, 4, 11, 12, 14
Botaurus poiciloptilus	Australasian bittern	E	C	1, 2, 3, 10-15
Botaurus poiciloptilus	Red Knot	E	E	13, 14
Calidris ferruginea	Curlew sandpiper	CE	E	2, 3, 4, 6, 13, 14
Calidris tenuirostris	Great Knot	CE	E	13, 14
Calyptorhynchus lathami	Glossy black cockatoo	E	V	3, 4
Calyptorhynchus lathami lathami	Glossy black cockatoo (eastern)	E	V	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 14, 15
Charadrius leschenaultia	Greater Sand Plover	V	V	13, 14
Charadrius mongolus	Lesser Sand Plover	E	E	13, 14
Erythrotriorchis radiates	Red Goshawk	V	E	1, 2, 3, 4, 5, 6, 8, 9, 10, 15
Falco hypoleucos	Grey falcon	-	V	1, 3, 4, 5

Species	Common Name	EPBC Act Listing	NC Act Listing	Relevant alignment section
Geophaps scripta scripta	Squatter pigeon (southern subspecies)	V	V	1 - 7
Grantiella picta	Painted honeyeater	V	V	3,4, 6, 8 - 12
Lathamus discolor	Swift parrot	E	CE	1, 2, 3, 4, 5, 6
Limosa lapponica baueri	Western Alaskan bar-tailed Godwit	V	V	1, 14
Lophochroa leadbeateri	Major Mitchel's cockatoo	-	V	1, 6, 9
Ninox strenua	Powerful owl	-	V	1, 3, 4, 5
Numenius madagascariensis	Eastern Curlew	CE	E	13, 14
Rostratula albiscapa	Australian painted snipe	V	E	1, 3, 4, 5, 13, 14
Turnix melanogaster	Black-breasted button quail	V	V	1, 5, 6, 15
Reptiles				
Acanthophis antarcticus	Common Death Adder	-	V	13
Anomalopus mackayi	Long legged worm skink	V	E	6 - 12
Anomalopus mackayi	Five-clawed worm-skink	V	E	6 - 12
Delma torquata	Collared Delma	V	V	3, 4, 5, 6, 15
Furina dunmalli	Dunmall's Snake	V	V	12
Hemiapsis damelii	Grey snake	-	E	2, 10, 11
Strophurus taenicauda	Golden-tailed Gecko	-	NT	11, 12

Species	Common Name	EPBC Act Listing	NC Act Listing	Relevant alignment section
Tympanocryptis condaminensis	Condamine earless dragon	E	E	7 - 12
Mammals				
Dasyurus maculatus maculatus	Spot-tailed quoll	E	V	1, 6, 12, 14
Ornithorhynchus anatinus	Platypus	-	SL	3, 4, 14
Petauroides Volans volans	Southern Greater Glider	V	V	1, 3, 4, 13, 15
Petrogale penicillata	Brush-tailed Rock wallaby	V	V	3 – 5, 11, 12
Phascolarctos cinereus	Koala	V	V	1 - 15
Potorous tridactylus tridactylus	Long-nosed Potoroo	V	V	3, 4
Pteropus poliocephalus	Grey Headed Flying Fox	V	C	1 - 15
Tachyglossus aculeatus	Short-beaked Echidna	-	SL	1 - 15
Migratory Species				
Actitis hypoleucos	Common Sandpiper	-	SL	1, 2, 3, 4, 5 13, 14
Anas querquedula	Garganey	-	SL	13
Apus pacificus	Fork-tailed Swift	-	SL	1 - 15
Ardenna tenuirostris	Short-tailed Shearwater	-	SL	13, 14
Arenaria interpres	Ruddy Turnstone	-	SL	1, 13, 14
Bulweria bulwerii	Bulwer’s Petrel	-	SL	6
Calidris acuminata	Sharp-tailed Sandpiper	-	SL	1 - 15

Species	Common Name	EPBC Act Listing	NC Act Listing	Relevant alignment section
Calidris alba	Sanderling	-	SL	13, 14
Calidris canutus	Red Knot	E	SL, E	13, 14
Calidris melanotos	Curlew Sandpiper	CE	CE	1, 2, 13, 14
Calidris melanotos	Pectoral Sandpiper	-	SL	1, 6, 13, 14
Calidris ruficollis	Red-necked Stint	-	SL	1, 2, 3, 4, 6, 11, 13, 14
Calidris tenuirostris	Great Knot	CE	E	13, 14
Calonectris leucomelas	Streaked Shearwater	-	SL	13, 14
Charadrius bicinctus	Double-banded Plover	-	SL	1, 2, 13, 14
Charadrius leschenaultia	Greater Sand Plover	V	V	13, 14
Charadrius mongolus	Lesser Sand Plover	E	E	1, 13, 14
Charadrius veredus	Oriental Plover	-	SL	1, 3, 4, 12, 14
Chlidonias leucopterus	White-winged Black Tern	-	SL	1, 2, 3, 4, 5, 6, 13
Cuculus optatus	Oriental cuckoo	-	SL	1, 3, 4, 5, 13, 14, 15
Esacus magnirostris	Beach stone-curlew	-	V	13, 14
Fregata ariel	Lesser Frigatebird	-	SL	13, 14
Fregata minor	Greater Frigatebird	-	SL	14
Gallinago hardwickii	Latham’s Snipe	-	SL	1 - 15
Gallinago megala	Swinhoe’s Snipe	-	SL	13, 14

Species	Common Name	EPBC Act Listing	NC Act Listing	Relevant alignment section
Gallinago stenura	Pin-tailed Snipe	-	SL	13, 14
Gelochelidon nilotica	Gull-billed Tern	-	SL	1, 2 ,3, 4, 6 - 15
Glareola maldivarum	Oriental Pratincole	-	SL	1, 15
Hirundapus caudacutus	White-throated Needletail	-	SL	1 - 15
Hirundo rustica	Barn Swallow	-	SL	5, 14
Hydroprogne caspia	Caspian Tern	-	SL	1, 2, 3, 4, 13, 14, 15
Limicola falcinellus	Broad-billed Sandpiper	-	SL	1, 13, 14
Limnodromus semipalmatus	Asian Dowitcher	-		13, 14
Limosa lapponica	Bar-tailed Godwit	-		13, 14
Limosa limosa	Black-tailed Godwit	-	SL	1, 3, 4, 6, 14
Monarcha melanopsis	Black-faced Monarch	-	SL	1 - 15
Monarcha trivirgatus	Spectacled Monarch	-	SL	1 - 6, 13, 14, 15
Motacilla flava	Yellow Wagtail	-		15
Myiagra cyanoleuca	Satin Flycatcher	-	SL	1 - 15
Numenius madagascariensis	Eastern Curlew	CE		13, 14
Numenius minutus	Little Curlew	-	SL	1, 2, 11, 12, 13, 14, 15
Numenius phaeopus	Whimbrel	-	SL	3, 4, 13, 14
Pandion cristatus	Eastern Osprey	-	SL	1, 2, 3, 4, 13, 14, 15
Pandion haliaetus	Osprey	-	SL	2 - 5, 13 - 15

Species	Common Name	EPBC Act Listing	NC Act Listing	Relevant alignment section
Phaethon lepturus	White-tailed tropicbird	-	SL	3, 4
Phalaropus lobatus	Red-necked Phalarope	-	SL	3, 4
Philomachus punax	Ruff	-	SL	2, 13, 14
Plegadis falcinellus	Glossy Ibis	-	SL	1 - 15
Pluvialis fulva	Pacific Golden Plover	-	SL	1, 2, 3, 4, 13, 14
Pluvialis sqautarola	Grey Plover	-	SL	2, 13, 14
Rhipidura rufifrons	Rufous Fantail	-	SL	1 - 15
Stercorarius parasiticus	Arctic Jaeger	-	SL	14
Stercorarius pomarinus	Pomarine Jaeger	-	SL	14
Sterna hirundo	Common Tern	-	SL	13, 14
Sterna sumatrana	Black-naped Tern	-	SL	14
Sternula albifrons	Little Tern	-	SL	1, 2, 13, 14
Thalasseus bergii	Crested Tern	-	SL	13, 14, 15
Tringa brevipes	Grey-tailed Tattler	-	SL	14
Tringa glareola	Wood Sandpiper	-	SL	1, 2, 3, 4, 9, 10, 13, 14
Tringa incana	Wandering Tattler	-	SL	13, 14
Tringa nebularia	Common Greenshank	-	SL	1, 2, 3, 4, 14
Tringa stagnatilis	Marsh Sandpiper	-	SL	1 - 15

Species	Common Name	EPBC Act Listing	NC Act Listing	Relevant alignment section
Xenus cinereus	Terek Sandpiper	-	SL	13, 14
Other				
Adclarkia cameroni	Brigalow Woodland Snail	E	V	10
Adclarkia dulacca	Dulacca Woodland Snail	E	E	12
Adelotus brevis	Tusked Frog	-	V	13, 14, 15
Crinia tinnula	Wallum Froglet	-	V	14
Jalmenus eubulus	Pale Imperial Hairstreak	-	V	11, 12

2.6.2 Aquatic ecology

Wetlands

There are areas of mapped wetlands on the vegetation management wetlands map. The alignment sections that may impact these wetlands will be section 1 (all options), 13 and 14 (option A). Further assessment is required to determine if these wetlands will be impacted by the project.

Conservation significant species

Desktop species identified five conservation significant aquatic fauna species that have the potential to occur within the inland waters of the study area and eight conservation significant aquatic fauna species that have the potential to occur within tidal waters of the study area.

The inland aquatic species include; the Australian Lungfish (*Neoceratodus forsteri*), the Mary River Cod (*Maccullochella mariensis)* and the Silver Perch (*Bidyanus bidyanus)*. The Australian Lungfish is listed as vulnerable the Mary River Cod as endangered and the Silver Perch as critically endangered under the EPBC Act. These species are not listed as threatened under the Queensland NC Act however taking the species is prohibited under the Queensland Fish and Oyster Act 1914.

A species management program would be required for the above identified species. Offsets may be required under the EPBC Act Environmental Offsets Policy for EPBC listed species, if a significant residual impact on these species or habitat is anticipated.

Connectivity of waterway habitats may be fragmented during the construction period of the project however will not be impacted during the operation period, as the pipe will be located underground.

The marine species include:

- Humpback whale (*Megaptera novaeangliae)* – Vulnerable
- Loggerhead Turtle (*Caretta caretta)* – Endangered

- Leatherback Turtle (*Dermochelys coriacea)* – Endangered
- Hawksbill Turtle (*Eretmochelys imbricata)* – Vulnerable
- Olive Ridley Turtle (*Lepidochelys olivacea*) – Endangered
- Flatback Turtle (*Natator depressus)* – Vulnerable
- Green Turtle (*Chelonia mydas*) - Vulnerable
- White Shark (*Carcharodon carcharias)* – Vulnerable

The Loggerhead, Leatherback and Olive Ridley Turtles are listed as endangered under the EPBC Act and the Humpback whale, Hawksbill, Flatback and Green Turtles and the white shark are listed as vulnerable under the EPBC Act.

The construction works within the tidal waterways may have indirect impacts (such as potential to degrade water quality or interfere with nesting habitat) on the marine species (turtles in particular) and therefore will require appropriate mitigation measures. The humpback whale and white shark are notably transient through the marine coastal areas and unlikely to be impacted as a result of the project.

2.7 Climate and Air Quality

Project construction may be dictated by seasonal variations. If fauna species are found to be breeding within the right of way at certain times of the year, construction may need to occur outside of these times or alternative appropriate mitigation, management and/or offset measures proposed.

The project will provide improved water security for agriculture and reduce reliance on surface water and catchment flows influenced by catchment rainfall and variable climatic patterns.

There may be impacts to air quality during the construction of the pipeline; however, these issues will be managed through standard construction environmental management measures.

2.8 Noise and Vibration

The major noise impact arising from the project will occur during the construction of the pipeline as a result of truck movements, excavating and clearing. These impacts will cease once construction has been undertaken. During the operation phase, there is potential for some noise impacts to occur around the pump stations; however, these are likely to be minor, as they are located in semi-rural locations with minimal residential properties surrounding them. Pump stations associated with pipeline construction will consider the locations of potential sensitive receptors and incorporate appropriate noise reducing design features (where applicable).

2.9 Landscape and Visual Amenity

The construction phase of the project is likely to create visual amenity impacts as a result of truck movements, excavating and clearing. The pipeline will be buried underground. The projects operational impacts on visual amenity will be from the maintenance of a cleared easement for the pipeline. However, the project will utilise existing easements where possible minimising the impact to visual amenity.

2.10 Cultural Heritage

Historical Heritage

Based on searches of relevant national and State heritage registers, one item of historical heritage is located within 300m of the project area for all options. There were six items of historical heritage within proximity to Option A (sections 13 and 14). There were numerous listings for Option D in Ipswich and surrounds however it is assumed that the pipeline in this section will follow the existing WCRWS easement and impact to the historical heritage through vibration will be minimised.

Further information on the nature of the historical heritage identified is provided in Table 9. Heritage listed items will be avoided during route selection. Construction impacts include vibration and appropriate management measures will be put in place during this stage.

Searches of the planning schemes for local heritage showed numerous local heritage listings along the alignment, particularly for Option A in Brisbane City Council LGA and Moreton Bay Regional Council LGA.

Table 9 Historical heritage

Option	Item	Register	Description	Images from Queensland Heritage Register, 2016
All options	Dental Surgery	Queensland Heritage Register	The small timber building was constructed in 1902 and is important to demonstrate Queensland history. It is located at 12 Railway St, Lowood.	
A	Sandgate Post Office	Queensland Heritage Register	Former Sandgate Post Office erected in 1886-87. Located at 1 Bowser parade, Sandgate	
A	Sandgate War Memorial park	Queensland Heritage Register	8 Seymour St, Sandgate	
A	Sandgate Town Hall	Queensland Heritage Register	5 Brighton Road, Sandgate	

Option	Item	Register	Description	Images from Queensland Heritage Register, 2016
A	Drew Residence (former)	Queensland Heritage Register	20 Wharf Street, Shorncliffe	
A	RAN Station 9, Pinkenba (Myrtletown)	Queensland Heritage Register	Sandmere Road, Pinkenba	
A	Pinkenba War Memorial	Queensland Heritage Register	Eagle Farm Road, Pinkenba	
D	There are numerous listings in Ipswich however the pipeline will follow the existing WCRWS corridor	Queensland Heritage Register	Ipswich and surrounds	

Aboriginal Cultural Heritage

The Traditional Owner groups for the project area (all options) include:

- Yuggera Ugarapul People (Cultural Heritage Party)
- Jagera People #2 (Cultural Heritage Party)
- Western Wakka Wakka People
- Barunggam People

Option A (sections 13 and 14) also includes:

- Turrbal People
- Alex Davidson and Ors on behalf of the Kabi Kabi Undambi Area Claim and State of Queensland.

There are a significant number of Indigenous Cultural Heritage sites identified within the buffer zone of the project (search results on file). Option A has additional Cultural Heritage parties and a section of coastal environment that contains a high amount of Cultural Heritage sites.

A Cultural Heritage Management Plan (CHMP) will be required where impacts to Indigenous Cultural Heritage is likely to occur. The CHMP will set out procedures for mitigating any negative impacts from the construction of the pipeline and associated activities on areas of cultural significance to Traditional Owners.

2.11 Waste Management

Excavating the alignment will create considerable amounts of excess spoil. The spoil will be stockpiled and reused during the final stages of construction to cover the pipeline. Any vegetation that is cleared will be mulched and utilised onsite.

Standard waste management strategies during the construction phase will apply, including utilising recycling and general waste bins and removing all rubbish from site prior to completion of the pipeline.

The operation phase of the pipeline will produce minimal waste.

3. Environmental Impacts

Table 10 provides a summary of the environmental, land and cultural heritage values and indicates impacts associated with each option in relation to the activities and stage of the project. The Sewage Treatment Plants and Advanced Water Treatment Plant approvals are not considered here as it assumed that existing operational licenses are in place.

Table 10 Impact Assessment

Values	Activity	Stage	Option A	Option B	Option C	Option D
Land Use and Property	Construction of the pipeline.	Construction	Pipeline easement will sterilise some portions of public and private property. Pipeline will potentially impact on a legally secured offset area for Option A (section 13).	Pipeline easement will sterilise some portions of public and private property.	Pipeline easement will sterilise some portions of public and private property.	Pipeline easement will sterilise some portions of public and private property.
Topography, geology and soils	Works within a waterway or within an erosion prone area.	Construction	Potential erosion and sedimentation impacts.	Potential erosion and sedimentation impacts.	Potential erosion and sedimentation impacts. Increased salinity hazard through the application of Class B/C water.	Potential erosion and sedimentation impacts.
Water resources	Works within a waterway.	Construction	Crosses 89 mapped waterways for waterway barrier works. Erosion and sedimentation impacts reducing water quality during construction. Major waterways could be bored or horizontally directionally drilled (HDD) to reduce environmental risks e.g. Hays inlet.	Crosses 78 mapped waterways for waterway barrier works. Potential injury or mortality to aquatic flora and fauna during construction. Major waterways could be bored or horizontally directionally drilled (HDD) to reduce environmental risks.	Crosses 78 mapped waterways for waterway barrier works. Potential injury or mortality to aquatic flora and fauna during construction. Major waterways could be bored or horizontally directionally drilled (HDD) to reduce environmental risks.	Crosses 90 mapped waterways for waterway barrier works. Potential injury or mortality to aquatic flora and fauna during construction. Major waterways could be bored or horizontally directionally drilled (HDD) to reduce environmental risks.
	Storage dams in the Lockyer Valley.	Operation	Not applicable, no storage dams proposed.	Discharge of Class A+ water during a high rainfall event into nearby waterways.	Discharge of Class B/C water during a high rainfall event into nearby waterways. Class B/C water poses a human health risk through exposure, spray drift and the public potentially accessing the dam.	Not applicable, no storage dams proposed.
	Output to Moreton Bay from the STPs and AWTPs	Operation	Benefit - reduces output to Moreton Bay from the Redcliffe STP and Sandgate STP. Water treated to PRW standard. The RO is treated (denitrification process) and the biosolid disposed of offsite. Net benefit to Moreton Bay.	To treat to Class A+ uses less source water than Option A to produce the same quantity of water. The water is reused and discharge to Moreton Bay is reduced providing a net benefit.	To treat to Class B/C uses less source water than Option A to produce the same quantity of water. The water is reused and discharge to Moreton Bay is reduced providing a net benefit.	A portion of water treated to PRW level. The RO is treated and the biosolid disposed of offsite. Net benefit to Moreton Bay. The Class B/C water to Darling Downs reduces discharge to Brisbane River and ultimately Moreton Bay.
	Recycling water	Operation	Recycling Brisbane's water will be a benefit. It will improve and secure	Recycling Brisbane's water will be a benefit. It will improve and secure	Recycling Brisbane's water will be a benefit. It will improve and secure	Recycling Brisbane's water will be a benefit. It will improve and secure

Values	Activity	Stage	Option A	Option B	Option C	Option D
			reliable water supplies and reduce current reliance on surface and groundwater. This will decrease stress on natural systems within the Lockyer Valley and Darling Downs.	reliable water supplies and reduce current reliance on surface and groundwater. This will decrease stress on natural systems within the Lockyer Valley and Darling Downs.	reliable water supplies and reduce current reliance on surface and groundwater. This will decrease stress on natural systems within the Lockyer Valley and Darling Downs.	reliable water supplies and reduce current reliance on surface and groundwater. This will decrease stress on natural systems within the Lockyer Valley and Darling Downs.
Terrestrial Ecology	Vegetation clearing and excavation.	Construction	Removal or impacts to REs or TECs as a result of vegetation clearing. Impacts on connectivity. Weed invasion potential. Weed management required. Disturbance to essential habitat for koala and wallum froglet. Removal or destruction of marine plants Species management programmes will be required for disturbance to breeding places.	Removal or impacts to REs or TECs as a result of vegetation clearing. Impacts on connectivity. Weed invasion potential. Weed management required. Disturbance to essential habitat for koala and wallum froglet. Species management programmes will be required for disturbance to breeding places.	Removal or impacts to REs or TECs as a result of vegetation clearing. Impacts on connectivity. Weed invasion potential. Weed management required. Disturbance to essential habitat for koala and wallum froglet. Species management programmes will be required for disturbance to breeding places.	Removal or impacts to REs or TECs as a result of vegetation clearing. Impacts on connectivity. Weed invasion potential. Weed management required. Disturbance to essential habitat for koala and wallum froglet. Species management programmes will be required for disturbance to breeding places.
Aquatic Ecology	Temporary Waterway Barrier Works.	Construction	Short term impacts to aquatic ecology, and to fish passage. Fauna injury and mortality. Disruption to fauna behaviour. Species management programmes will be required for disturbance to breeding places (Aust. Lungfish, Mary River Cod, Silver Perch).	Short term impacts to aquatic ecology, and to fish passage. Fauna injury and mortality. Disruption to fauna behaviour. Species management programmes will be required for disturbance to breeding places (Aust. Lungfish, Mary River Cod, Silver Perch).	Short term impacts to aquatic ecology, and to fish passage. Fauna injury and mortality. Disruption to fauna behaviour. Species management programmes will be required for disturbance to breeding places (Aust. Lungfish, Mary River Cod, Silver Perch).	Short term impacts to aquatic ecology, and to fish passage. Fauna injury and mortality. Disruption to fauna behaviour. Species management programmes will be required for disturbance to breeding places (Aust. Lungfish, Mary River Cod, Silver Perch).
Climate and Air quality	Clearing and construction of the pipeline.	Construction	Increased dust emissions. Managed through standard environmental management measures.	Increased dust emissions. Managed through standard environmental management measures.	Increased dust emissions. Managed through standard environmental management measures.	Increased dust emissions. Managed through standard environmental management measures.
Noise and Vibration	Clearing, excavation and the movement of vehicles. Operation of pump stations.	Construction Operation	Noise impacts to surrounding community and environment as a result of excavation and clearing for the pipeline, as well as increased traffic. This will be a short-term, localised impact. Option A has additional pipelines within residential areas that will required additional noise management.	Noise impacts to surrounding community and environment as a result of excavation and clearing for the pipeline, as well as increased traffic. This will be a short-term, localised impact. Potential pump station noise impacts during operation.	Noise impacts to surrounding community and environment as a result of excavation and clearing for the pipeline, as well as increased traffic. This will be a short-term, localised impact. Potential pump station noise impacts during operation.	Noise impacts to surrounding community and environment as a result of excavation and clearing for the pipeline, as well as increased traffic. This will be a short-term, localised impact. Potential pump station noise impacts during operation.

Values	Activity	Stage	Option A	Option B	Option C	Option D
			Potential pump station noise impacts during operation.			
Landscape and visual amenity	Vegetation clearing. Maintenance of cleared easement.	Construction Operation	Short-term, localised visual impacts as a result of clearing and excavation works. Maintenance of a cleared easement for the pipeline during operation.	Short-term, localised visual impacts as a result of clearing and excavation works. Maintenance of a cleared easement for the pipeline during operation.	Short-term, localised visual impacts as a result of clearing and excavation works. Maintenance of a cleared easement for the pipeline during operation.	Short-term, localised visual impacts as a result of clearing and excavation works. Maintenance of a cleared easement for the pipeline during operation.
Indigenous Cultural Heritage	Excavation and disturbance	Construction	CHMP requirement and compliance. Negotiations with traditional owner groups required. Additional traditional owner groups for Option A.	CHMP requirement and compliance. Negotiations with traditional owner groups required.	CHMP requirement and compliance. Negotiations with traditional owner groups required.	CHMP requirement and compliance. Negotiations with traditional owner groups required.
Historical Heritage	Excavation and compaction	Construction	Based on searches of relevant national and state heritage registers, one item of historical heritage is located within 300m of the project area for all options. There were six items of historical heritage within proximity to Option A (sections 13 and 14). Heritage listed items will be avoided during route selection. Construction impacts include vibration and management will be put in place during this stage.	Based on searches of relevant national and state heritage registers, one item of historical heritage is located within 300m of the project area for all options. Heritage listed items will be avoided during route selection. Construction impacts include vibration and management will be put in place during this stage.	Based on searches of relevant national and state heritage registers, one item of historical heritage is located within 300m of the project area for all options. Heritage listed items will be avoided during route selection. Construction impacts include vibration and management will be put in place during this stage.	Based on searches of relevant national and state heritage registers, one item of historical heritage is located within 300m of the project area for all options. There were numerous listings for Option D in Ipswich and surrounds however it is assumed that the pipeline in this section will follow the existing WCRWS easement and impact the historical heritage through vibration will be minimised. Heritage listed items will be avoided during route selection. Construction impacts include vibration and management will be put in place during this stage.
Waste Management	Clearing and excavation works.	Construction	Waste material to be disposed of or reused on site. Excavated soil will be stockpiled and used to backfill pipeline. Flora that has been cleared will be mulched and utilised on site.	Waste material to be disposed of or reused on site. Excavated soil will be stockpiled and used to backfill pipeline. Flora that has been cleared will be mulched and utilised on site.	Waste material to be disposed of or reused on site. Excavated soil will be stockpiled and used to backfill pipeline. Flora that has been cleared will be mulched and utilised on site.	Waste material to be disposed of or reused on site. Excavated soil will be stockpiled and used to backfill pipeline. Flora that has been cleared will be mulched and utilised on site.

4. Legislation and permit requirements

A high-level assessment of legislation potentially applicable to the project and subsequent approval requirements is presented below. This assessment is based on the existing environment information presented above, together with industry experience and knowledge. This assessment will require review once further design and development information (ownership, timeframes, routes, etc.) is made available.

The following legislation was considered:

- Commonwealth
  - *Environment Protection and Biodiversity Conservation Act 1999*
  - *Native Title Act 1993*
- State
  - *Aboriginal Cultural Heritage Act 2003*
  - *Environmental Offsets Act 2014*
  - *Environmental Protection Act 1994*
  - *Fisheries Act 1994*
  - *Nature Conservation Act 1992*
  - *Planning Act 2016*
  - *Regional Planning Interests Act 2014*
  - *Queensland Heritage Act 1992*
  - *State Development and Public Works Organisation Act 1971*
  - *Vegetation Management Act 1999*
  - *Water Act 2000*
  - *Water Supply (Safety and Reliability) Act 2008*
- Local Government

Table 11 Regulatory Approvals Plan

Approval	Relevant Legislation	Why it applies	Approving Authority	Application requirements	Approval timeframe	Approval required
Commonwealth						
EPBC Referral and assessment if deemed a controlled action	EPBC Act	EPBC Act referral is required when a project may potentially impact upon MNES (e.g. koala). A referral will be required for all options. If significant impacts are considered likely, and the action is deemed to be a controlled action, then the referral will proceed to environmental assessment and approval. This is likely to be assessment by Environmental Impact Statement (EIS).	Department of Environment and Energy (DEE)	Referral form Assessment against the Matters of National Environmental Significance Significant impact guidelines 1.1 Public notification and consultation is required.	Referral assessment – 20 business days. EIS – 18 -24 months.	Yes – all options
State – development applications						
Material Change of Use (MCU)	Brisbane City Council Planning Scheme Moreton Bay Regional Council Planning Scheme Somerset Regional Council Planning Scheme Lockyer Valley Regional Council Planning Scheme Toowoomba Regional Council Planning Scheme Western Downs Regional Council Planning Scheme	A material change of use is required for the start of a new use. Therefore, an MCU for any pipeline or pump station construction will be required. If an Infrastructure Designation is sought and granted then an MCU is not required.	Brisbane City Council Moreton Bay Regional Council Somerset Regional Council Lockyer Valley Regional Council Toowoomba Regional Council Western Downs Regional Council	Owners consent Application forms Detailed site plan Detail associated environmental management procedures and mitigation measures. Depending on land zones traversed assessment may be code or impact assessable. If impact assessable, public notification is required.	6 months	Yes – all options
Reconfiguration of a lot	*Planning Regulation 2017*, Planning schemes above	A development permit for reconfiguration of a lot is required if made assessable under the relevant council's planning scheme. The project would be exempt from RoL if undertaken as part of an Infrastructure Designation process.	Brisbane City Council Moreton Bay Regional Council Somerset Regional Council Lockyer Valley Regional Council Toowoomba Regional Council Western Downs Regional Council	Owners consent Application forms Supporting reports.	6 months	Yes – all options Exemption if an Infrastructure Designation is received.
Infrastructure Designation	Planning Act Planning Regulation	The infrastructure designation proves gives infrastructure entities a streamlined, considered, whole-of-government response on a request for community-supporting infrastructure and avoids later approvals that	DILGP	Impact assessment and supporting reports. Minimum 15 business days public consultation requirement.	12 months	This is a potential approval pathway for all options.

Approval	Relevant Legislation	Why it applies	Approving Authority	Application requirements	Approval timeframe	Approval required
		would otherwise be required under the Planning Act. Community consultation and assessment of environmental impacts is still required.				
MCU for an Environmental Relevant Activity	EP Act, Planning Act, Planning Regulation	The following ERAs may be triggered under the Planning Act: ERA 8 chemical storage ERA16 Extractive and screening activities ERA 64 Water treatment for advanced treatment of B/C water for end of pipe treatment in the Lockyer Valley – Option C (more than 5ML/day).	SARA	DA Forms 1 & 2 Attachment for an application for an environmental authority (EHP) Land owners consent Drawings Details of ERA EMP Assessment against relevant State Development Assessment Provisions (SDAP) State code s	3 – 4 months	Yes – all options - if thresholds are exceeded for chemical storage or extractive and screening activities. Options B and C for end of pipe treatment of water will require ERA64 if treating more than 5ML/day.
Regulated structure and Hazardous waste dam. Regulated under the Environmental Authority for ERA64 above.	*Environmental Protection Act 1994*	Regulated structure means a structure that is assessed as being a regulated structure under the 'Manual for assessing consequence categories and hydraulic performance of structures' published by EHP. Regulated structures are dams or levees constructed as part of ERAs. The on farm storage dams may be classed as regulated structures. A hazardous waste dam is defined under the *Water Supply (Safety and Reliability) Act 2008*: 2. The term includes a dam that is used, or after its construction will be used, to prevent contamination of the environment by storing waste or a contaminant within the meaning of the EP Act. Waste under the EP Act is anything that is left-over from a commercial or domestic activity. Class B/C water would be considered a contaminant.	EHP	Design plan Certification Design storage allowance Consultation with affected persons Consequence assessment	Submitted with EA application	TBD following consequence category and hydraulic performance assessment of the dams
Referable dam	*Water Supply (Safety and Reliability) Act 2008* *Planning Act 2016*	A dam is referable if a failure impact assessment demonstrates there would be people at risk if the dam was to fail. Referable dams by definition do not include dams containing hazardous waste. It is assumed that the on farm storage dams will not be referable dams as they will not meet the design criteria for a failure impact assessment.	Department of Energy and Water Supply	Failure impact assessment. As per the guidance on referable dams planning July 2017	3-4 months	No

Approval	Relevant Legislation	Why it applies	Approving Authority	Application requirements	Approval timeframe	Approval required
Operational work for clearing of native vegetation	VM Act, Planning Regulation	The project will impact nine 'endangered' REs, thirteen 'of concern' REs and sixteen 'least concern' REs. This will require operational work for clearing of native vegetation and offsets will be required.	SARA DNRM	DA Form 1 Assessment against SDAP State Code 16: native vegetation clearing	3-4 months	Yes – all options
Operational work for constructing or raising a waterway barrier works.	Fisheries Act, Planning Act, Planning Regulation	Temporary waterway barrier works required during construction will require a development approval for waterway barrier works or are to comply with DAF *Accepted development requirements for operational work that is constructing or raising a waterway barrier works.*	SARA/DAF (Queensland Fisheries)	DA Form 1 DA Form Template 4 – Waterway Barrier Works SDAP State Code 18: Constructing or raising waterway barrier works in fish habitats	3 – 4 months	Temporary works will trigger an approval or are to be constructed in accordance with the DAF accepted development requirements.
Operational works for tidal works (prescribed tidal works), or work within a coastal management district.	Planning Act	Option A (Pipeline from Redcliffe STP to Sandgate STP to LP WTP) is within the Coastal Management District and crosses tidal waterways.	EHP	DA Form 1 RPEQ drawings State code 8: Coastal development and tidal works	6 months	Yes for option A (Redcliffe STP to Sandgate STP to LP WTP sections)
Operational work for the removal, destruction or damage of a marine plant	*Fisheries Act 1994*	Removal, destruction or damage of a marine plant will require a development approval unless the works meet the Accepted development requirements for operational work that is the removal, destruction or damage of marine plants, July 2017. This is applicable to option A. Options B to D are not within tidal areas and will not encounter marine plants.	DAF (Queensland Fisheries)	DA Form 1 SDAP State code 11 Removal, destruction or damage of marine plants Offsets calculation and management plan	3-4 months	Yes for option A (Redcliffe STP to Sandgate STP to LP WTP sections)
Development permit for the removal of quarry material in a watercourse	*Water Act 2000,* Planning Act, Planning Regulation.	Removal of quarry material in a watercourse or lake requires a permit if the quarry material removed from a watercourse or lake is sold or used for any productive purpose, such as for manufacturing, building, or as fill. NuWater will need to confirm if material is to be removed from the dam or watercourse for the works.	EHP	DA Form 1 SDAP State Code 15: Removal of quarry material from a watercourse or lake	3-4months	TBC
Operational works for taking or interfering with water from a watercourse, lake or spring	Water Act, Planning Regulation	Under the *Planning Regulation 2017*, a development permit is required for operational work that involves taking or interfering with water. It is not likely that permanent works would take or interfere with water from a watercourse, lake or spring. A development will not be required. Temporary, construction water take requirements are to be determined.	DNRM	Notification required for construction water take.	Notification – 10 business days	TBC
Building work	Planning Act	Building work approval will be required for new pump station buildings.	Certifier	Self-assessable	Self-assessable	Yes – all options

Approval	Relevant Legislation	Why it applies	Approving Authority	Application requirements	Approval timeframe	Approval required
Filling or excavation	Relevant Planning Scheme	Approval under the relevant local planning scheme for filling or excavation for the on farm water storages for Options B and C.	Local government	As per the local planning scheme.	2 months	Yes for options B and C
State – non development applications						
Complying with agreed Aboriginal Cultural Heritage Management Plans (CHMP)	*Aboriginal Cultural Heritage Act 2003*	A CHMP will be prepared for construction where impacts to Indigenous Cultural Heritage is likely to occur. The CHMP will set out procedures for mitigating any negative impacts from the construction of the pipeline and associated activities on areas of cultural significance to Traditional Owners.	DATSIP	Engagement with traditional owner groups will be required and a Duty of Care Assessment undertaken by a specialist to confirm duty of care obligations.	Not Applicable	Duty of Care Guidelines Development of CHMP
Riverine protection permit	*Water Act 2000*	A permit is required to excavate or place fill in a watercourse, unless such works are otherwise authorised or exempt. The purpose of the Riverine protection permit exemption requirements is to outline when it is permitted to excavate or place fill in a watercourse, lake or spring without the need for a riverine protection permit under section 814 of the *Water Act 2000*. Exemptions are listed under section 814 of the Water Act. RPP does not apply to the excavation or placing of fill that happens as a necessary and unavoidable part of the construction of works that are accepted development and involve the taking or interfering with water in a watercourse, lake or spring. If the pipeline is constructed by a Water Service Provider under the *Water Supply (Safety and Reliability) Act 2008* then the exemption requirements can be utilised.	DNRM	Application for a riverine protection permit form. Adjacent owner approval if applicable.	No set statutory timeframe.	Yes – all options - unless exemption requirements can be utilised.
Quarry material allocation notice	Water Act, Planning Act, Planning Regulation.	An allocation notice is required for the removal of quarry material in a watercourse. Required as part of the - development permit for the removal of quarry material in a watercourse. For any works within a watercourse, the material removed will be considered 'quarry material' unless it is removed from the watercourse as 'waste'.	DNRM	DNRM Application for quarry material allocation.	10 business days	TBD
Permit to clear native plants	*Nature Conservation Act 1992* *Nature Conservation (Administration) Regulation 2006*	A licence, permit or authority (issued under the NC Act) or an exemption is required to 'take' protected plants. This relates to almost all native plants within Queensland. The alignment is mapped within a high-risk site for protected plants (NC Act). Therefore, flora surveys are	EHP	Application Form Prescribed application fee Supporting info – maps, eco assessment etc. The supporting information should also consider	3 months The statutory timeframe for a decision on an application for a clearing	TBD following flora survey

Approval	Relevant Legislation	Why it applies	Approving Authority	Application requirements	Approval timeframe	Approval required
		required along the alignment. A clearing permit would be required if a person becomes aware that listed species are present and require clearing.		the scope of the activity, and any proposed mitigation or offsets (see the Department of Environment and Heritage Protection's information sheet Clearing Permit). Landowner statement/ consent	permit is 40 business days (assuming no information requests or public notification requirements): Nature Conservation (Administration) Regulation 2006 (Qld) section 29.	
Species management programme (SMP) (removal and relocation of wildlife)	NC Act *Nature Conservation (Administration) Regulation 2006* *Nature Conservation (Wildlife Management) Regulation 2006*	For large impacts, particularly where potential breeding places of endangered, vulnerable, near threatened or least concern species, or essential habitat for these species, is involved, a high-risk SMP will be required. An SMP cannot be provided for the koala as koalas do not use a habitual breeding place. The clearing of vegetation in which koalas are present should be viewed as clearing of koala habitat rather than clearing of a koala breeding place.	EHP	Application Form Prescribed application fee Supporting info – maps, eco assessment etc. The supporting information should also consider the scope of the activity, and any proposed mitigation or offsets (see the Department of Environment and Heritage Protection's information sheet Clearing Permit). Landowner statement/ consent	1-3 months	High-risk and low-risk SMPs likely to be required for all options.
Koala clearing requirements	*Nature Conservation (Koala) Conservation Plan 2017*	The *Nature Conservation (Koala) Conservation Plan 2017* (Koala Plan 2017) maps the project area within Moreton Bay, Brisbane, Ipswich and Lockyer Valley as Koala district A. Toowoomba and the Western Downs are mapped at Koala District C. The Koala Plan 2017 requires any clearing in koala district A to be undertaken in accordance with the sequential clearing conditions and in the presence of a suitably qualified koala spotter.	n/a	n/a	n/a	Koala spotter and sequential clearing conditions compliance for all options.

5. Offsets

In Queensland, the environmental offsets framework comprises of the:

- *Environmental Offsets Act 2014*
- *Environmental Offsets Regulation 2014*
- Queensland Environmental Offsets Policy version 1.4.

Environmental offsets are required where a prescribed activity (Schedule 1 of the Regulation) is likely to have a significant residual impact on prescribed environmental matters (Schedule 2 of the Regulation) following consideration of avoidance and mitigation and management measures.

Offsets may be delivered as:

- A financial settlement
- A proponent driven offset which includes a land based offset and/or the delivery of actions in a Direct Benefit Management Plan
- A combination of a financial settlement and a proponent driven offset.

Under Commonwealth legislation, the EPBC Act Environmental Offsets Policy governs offsets in relation to significant residual impacts on MNES.

5.1 Prescribed Activities

The prescribed activities as defined in section 9 of the *Environmental Offsets Act 2014* are listed in Table 12 and it is noted whether the project triggers the prescribed activity..

Table 12 Prescribed Activities

Prescribed Activity	Triggered	Reasoning
A resource activity carried out under an environmental authority under the *EP Act* for which an amendment application, a site-specific application or a variation application was made under the act	No	Not a resource activity
A prescribed ERA under the *EP Act*	Yes	May trigger ERA8 and ERA16.
The carrying out of works authorised under the *Marine Parks Act 2004* in a marine park within the meaning of that Act	Yes – option A	Option A, Section 15 and 16 may impact on Bramble Bay and Hays Inlet Marine Park area
An activity conducted under an authority granted, made, issued or given under the *NC Act* section 34, 35, 38, 42AD or 42AE in a protected area	No	Not within a protected area.

Prescribed Activity	Triggered	Reasoning
Taking a protected plant within the meaning of the *NC Act* under a protected plant-clearing permit granted under the *NC (Administration) Regulation 2006*.	Yes	The alignment is within numerous protect plant areas for each option
Development for which an environmental offset may be required under any of the following modules of the repealed State development assessment provisions made under the repealed *SP Regulation 2009*.	n/a	n/a
Development for which an environmental offset may be required under any of the following State Codes of the State development assessment provisions –	-	-
(a) State Code 8 (Coastal development and tidal works)	Yes	Option A (Section 16) is located within a coastal area and tidal waterways
(b) State Code 9 (Great Barrier Reef wetland protection areas)	No	It is not within the Great Barrier Reef wetland protection area
(c) State Code 11 (Removal, destruction or damage of marine plants)	Potential	Option A (Sections 15 and 16) cross over tidal waterways and may impact marine plants
(d) State Code 12 (Development in a declared fish habitat)	Yes	Option A (Section 16) is within a fish habitat area (FHA)
(e) State Code 16 (Native Vegetation Clearing)	Yes	Native vegetation clearing may be required for all options
(f) State Code 18 (Constructing or raising waterway barrier works in fish habitats)	Yes	Potential for temporary WWBW during construction for all options
(g) State Code 22 (Environmentally relevant activities)	Yes	May trigger ERA8 and ERA16 for all options.

Prescribed Activity	Triggered	Reasoning
Development for which an environmental offset may be required under any of the following -	-	-
(a) A local planning instrument	TBD	TBD
(b) The *Planning Regulation 2017*, schedule 11	TBD (Koala)	Likely that a development application will be triggered within a koala habitat area for an MCU and RoL
(c) The repealed South East Queensland Koala Conservation State Planning Regulatory Provisions	n/a	n/a

5.2 Prescribed Environmental Matters

Prescribed environmental matters are defined as:

- Matters of national environmental significance (MNES) as identified in the EPBC Act
- Matters of state environmental significance (MSES) as identified in the *Environmental Offsets Regulation 2014*
- Matters of local environmental significance (MLES) as identified in a local planning instrument.

Table 13 Prescribed Environmental Matters

Prescribed matters	Triggered	Reasoning
Animal that is endangered wildlife or vulnerable wildlife	Yes	PMST and WildlifeOnline identified species listed as endangered potentially occurring along the alignment for all options.
Category B area	Yes	There are mapped areas of Category B vegetation located along the alignment for all options.
Essential habitat	Yes	There is essential habitat mapped in Options A (section 13 and 14) for the Koala and Wallum Froglet.
Plant that is endangered wildlife or vulnerable wildlife	Yes	PMST and WildlifeOnline identified species listed as endangered potentially occurring

Prescribed matters	Triggered	Reasoning
		along the alignment for all options.
Regional ecosystem	Yes	There is mapped REs located along the alignment for all options.
Regulated vegetation	Yes	There are mapped areas of regulated vegetation located along the alignment for all options.
Remnant vegetation	Yes	There are mapped areas of remnant vegetation located along the alignment for all options.
Connectivity	Yes	The linear pipeline will impact connectivity.
Waterway barriers	Yes	Each option crosses multiple mapped waterways.
Legally secured offset area	Option A	Option A traverses a secured environmental offset area.
Marine Park	Option A	Option A traverses marine park
Declared fish habitat area	Option A	Option A is within a declared fish habitat area
Nature refuge	Yes	Option A and all options for Section 7 traverse a protected area (nature refuge)

MNES

The following MNES TECs are identified as having the potential to occur within the alignment.

- Brigalow (*Acacia harpophylla* dominant and co-dominant) - Endangered
- Lowland Rainforest of Subtropical Australia – Critically Endangered
- Swamp Tea-tree (*Melaleuca irbyana)* Forest of Southeast Queensland – Critically Endangered
- White-box Yellow-box Blakely’s Red Gum Grassy Woodland and Derived Native Grassland – Critically Endangered
- Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions – Endangered
- Natural grasslands on basalt and fine-textured alluvial plains of northern NSW and southern QLD – Critically Endangered
- Weeping Myall Woodlands – Endangered

- Semi-evergreen vine thickets of the Brigalow belt (North and South) and Nandewar bioregions – Endangered
- Sections 15 and 16 (Option A) are located within the Moreton Bay Ramsar Site.

The MNES species identified to have the potential to occur within the alignment are described in Table 7 and Table 8.

MSES

There is the potential for the following MSES to be present along the alignment:

- Myall Park Nature Refuge located near section 7
- Options A (Section 15) is located within Hays Inlet which is a marine park, declared fish habitat area and protected area (nature refuge).
- Option A (Section 16) is located near the Brisbane Airport and traverses through a legally secured offset area for the Sisters of Mercy as well as traverses a small area of marine park.

Since the project is a prescribed activity, then a significance of residual impacts assessment will need to be undertaken in accordance with the guidelines for potential impacts to the above MSES. The significance of the residual impact will guide the determination of offset requirements.

MLES

MLES are prescribed in local planning schemes. The relevant planning schemes for the alignment include those identified in section 2.1. Currently only Brisbane City Council prescribes MLES.

The significance of residual impacts needs to be determined in accordance with the Queensland Environmental Offsets Policy Significant Residual Impact Guidelines (the guidelines) for impacts to MSES and MLES for approvals sought under the EP Act and NC Act.

5.3 Conclusion

An assessment should be undertaken against the Matters of National Environmental Significance Significant impact guidelines 1.1 to determine whether significant impacts to MNES species is likely to result from the proposed options. Offsets in relation to significant residual impacts on MNES are to be determined under the EPBC Act Environmental Offsets Policy.

The significance of residual impacts will need to be determined in accordance with the Queensland Environmental Offsets Policy Significant Residual Impact Guideline for impacts to MSES and MLES for approvals sought under the EP Act and NC Act.

6. Conclusion

Options A, B, C and D have been assessed at a desktop level to determine potential environmental impacts for each of the options.

The environmental impacts for options B and C are considered to be very similar and include potential impacts on endangered flora and fauna, as well as a number of regional ecosystems. Option A has the same impacts as the options B and C, however, it also impacts on a marine park, tidal waterways, fish habitat area and a legally secured offset area. Option D impacts on additional areas of vegetation and additional watercourse crossings.

The mitigation of environmental impacts will require an effective management framework and implementation. The project will require detailed EMPs.

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Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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Appendix J – Power Options Review

Queensland Farmers' Federation Ltd

NuWater Project Feasibility Study

Power Options Review

March 2018

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1. Introduction

1.1 Overview and purpose of this document

This document presents an investigation into the power supply options for the NuWater project.

The assessment has been undertaken in two components:

1. Grid connection options
2. Power supply options

The findings from the consideration of these two components are presented in Section 2 and Section 3 respectively.

1.2 Basis – pump stations

The project has identified eleven pumping stations in the supply network. The size and operating profile of the pump stations to be considered are presented in Table 1.

Table 1 Pump stations

Site Description	Maximum Load	Load Profile
Heathwood PS	2,000 kW	24 hours pumping
Lowood Booster PS	800 kW	24 hours pumping
Gatton Interim Booster PS	15,100 kW	24 hours pumping
Toowoomba Range PS	13,083 kW	24 hours pumping
Redcliffe STP Transfer PS	225 kW	24 hours pumping
Sandgate STP Transfer PS	350 kW	24 hours pumping
Luggage Point STP Transfer PS (aka Effluent Diversion PS)	360 kW	24 hours pumping
Bundamba Booster PS (Lockyer Valley)	1,600 kW	24 hours pumping
Lowood Booster PS (Lockyer Valley)	390 kW	24 hours pumping
Gatton Booster PS (Lockyer Valley)	1050 kW	24 hours pumping
Upper Tenthill PS (Lockyer Valley)	74 kW	24 hours pumping

1.3 Electricity network services in the area

Energex is the only Distribution Network Services Provide (DNSP) in the proximity of the proposed pipeline and pump stations for the NuWater irrigation project. There is no known merchant source of renewable energy generation in the area under consideration.

A solar PV plant of approximately 3.275 MW has been constructed for the University of Queensland's – Gatton Solar Research Facility. This supplies power to UQ's Gatton campus.

2. Connection options

2.1 Method

The requirements to be able to connect four of the pump stations to the grid were assessed. Gatton Interim Booster PS and Toowoomba Range PS were selected because they are the two largest installations and combined comprise 80% of the total demand. Heathwood PS and Lowood Booster PS were selected as conservatively representative of the other urban and rural pumping stations.

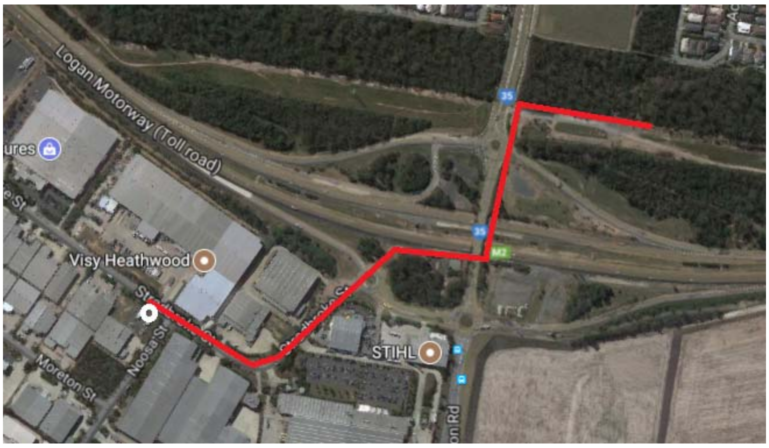
Requirements at other pumping stations were assumed to be the same as for the Heathwood and Lowood Booster pumping stations.

For all sites it was assumed the pumping station would connect directly to the Energex substation and would therefore qualify for Energex’s NTC4000 tariff. This is the lowest published tariff and is discussed further in section 3.3.

2.2 Heathwood Pump Station

The likely location of the Heathwood PS is along the Logan Motorway near Heathwood. The nearest substation is Energex Heathwood Substation located on Noosa Street. From the Energex Distribution Annual Planning Report (DAPR), the Heathwood Substation currently has a capacity rating of 52 MVA and is loaded up to 28.2 MVA.

The maximum demand at Heathwood PS is 2,000 kW. This load can be supplied at 11 kV from Heathwood Substation. The tentative location and the proposed cable route is shown on the map below. The underground cable route length is approximately 2 km.



2.3 Lowood Booster Pump Station

The nearest grid supply point for Lowood PS is Energex Lowood Substation, located on Lindemans Road. From the Energex DAPR, the Lowood Substation currently has a capacity rating of 9.6 MVA and is loaded up to 3.3 MVA.

The maximum demand at Lowood PS is 938 kW. This load can be supplied at 11 kV from Lowood Substation. The approximate cable route length is 1 km.

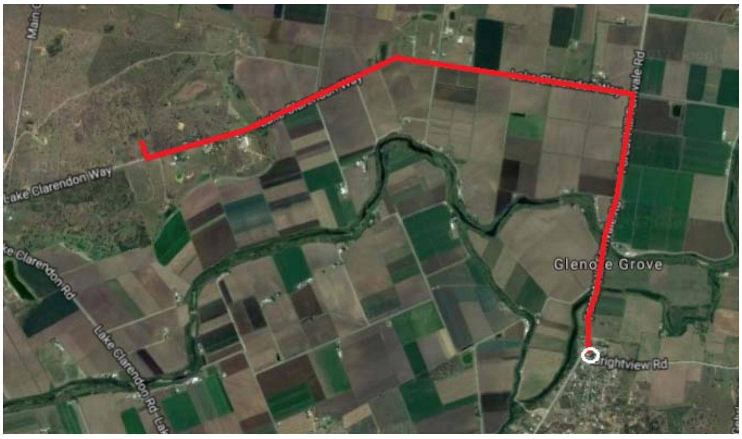
2.4 Gatton Pump Station

The Gatton PS can be connected to Energex Glenore Groove Substation located on Fernvale Road.

This site has a number of overhead line feeders connecting to it and it is possible to connect the Gatton PS to the substation through a new 33 kV overhead line. The proposed 33 kV line route is shown on the map below. Transmission line routes typically follow existing roads to facilitate line easements and construction access.

The maximum demand at Gatton PS is 12,980 kW. It is assumed that this can be supplied through a 33 kV overhead line from Glenore Groove Substation.

From the Energex DAPR, the Glenore Groove Substation currently has a capacity rating of 17.1 MVA and is loaded up to 11 MVA. It is noted that this rating is at the 11 kV side of the substation. The available capacity at the 33 kV side has not been evaluated, and has been assumed to be sufficient for this exercise. This should be evaluated and confirmed in subsequent phases of work.

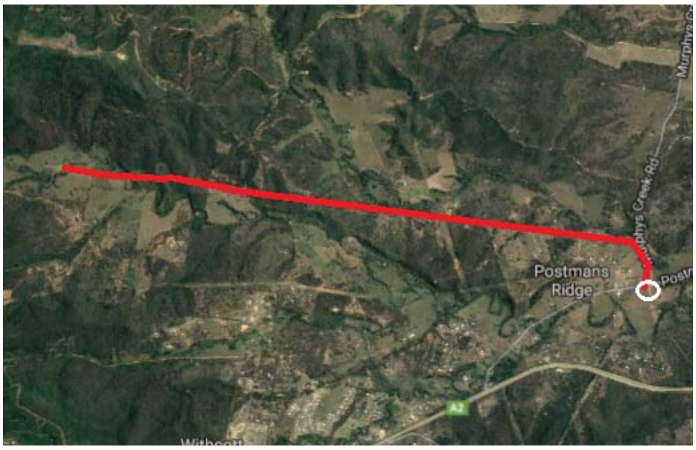


2.5 Toowoomba Range Pump Station

The Toowoomba Range PS can be connected to Energex Postmans Ridge Substation located on Postmans Ridge Road. This site has a number of overhead line feeders connecting to it and it is possible to connect the Toowoomba PS to the substation through a 33 kV overhead line. The proposed 33 kV line route is shown on the map below. Transmission line routes, typically follow existing roads to facilitate line easements and construction access.

The maximum demand at Toowoomba Range PS is 13,083 kW. It is assumed that this can be supplied through a 33 kV overhead line from Postmans Ridge Substation.

From the Energex DAPR, the Postmans Ridge Substation currently has a capacity rating of 7.2 MVA and is loaded up to 7 MVA. It is noted that this rating is at the 11 kV side of the substation. The available capacity at the 33 kV side has not been evaluated, and has been assumed to be sufficient for this exercise. This should be evaluated and confirmed in subsequent phases of work.



2.6 Assumptions

The connection options proposed in this report are based on the current network map available on Energex website:

https://www.energex.com.au/about-us/company-information/company-policies-And-reports/distribution-annual-planning-report/dapr-map-2017

Each of the NuWater Pump Stations will be supplied by dedicated feeders from the nearest Energex Substation. The Energex tariff (NTC4000) selected for cost comparison is based on direct connections to the Energex substations.

Based on the Lowood and Heathwood substations, it is assumed that the substations for the remaining pump stations that have not been assessed are adequately rated and can supply the pumping station loads without any major augmentation at the substation or upstream supply feeders.

3. Power supply options

3.1 Power supply options

The following power supply options have been considered for this study:

- Supply of power from the grid
- Solar PV (photovoltaic) generation to offset grid purchases
- Wind generation to offset grid purchases
- Diesel generation to offset grid purchases
- Battery storage in combination with solar PV to increase renewable penetration

These options are discussed further in the following sections.

3.2 Wind and diesel generation

Wind and diesel generation have been considered and ruled out as viable options for this application. Each of these is discussed below.

3.2.1 Wind

Wind power is heavily dependent on the following favourable conditions:

- High wind speeds
- At larger scales, where large high-efficiency wind turbines (e.g. 3 MW+) can be implemented
- Where the variable nature of the power supply from the wind turbines is not an issue
- Available land in the high wind speed areas that are not restricted by land classification or other location-specific factors (e.g. nearby houses, state forests etc.)

The two pump station locations with large enough loads to justify behind-the-meter wind farms are Gatton and Toowoomba Range. The smaller nature of the remaining sites would likely make a wind project cost-prohibitive as the individual installation costs would be far higher than a typical large-scale wind farm.

A high level desktop assessment of the wind resource in the vicinity of the Gatton and Toowoomba Range pump stations indicates that wind power is not likely to be favourable in this area. A snapshot of wind speeds at 70 m above ground is provided in Figure 1 from MinesOnlineMaps[1] in the Gatton area. It can be seen that the wind resource between Gatton and the Toowoomba range is lower than surrounding areas and far lower than that required for an economical wind farm. It is noted that a detailed wind assessment has not been undertaken to confirm this.

For the above reasons, wind power has not been considered further in this study.

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[1] https://www.dews.qld.gov.au/electricity/renewables/tools/solar-maps

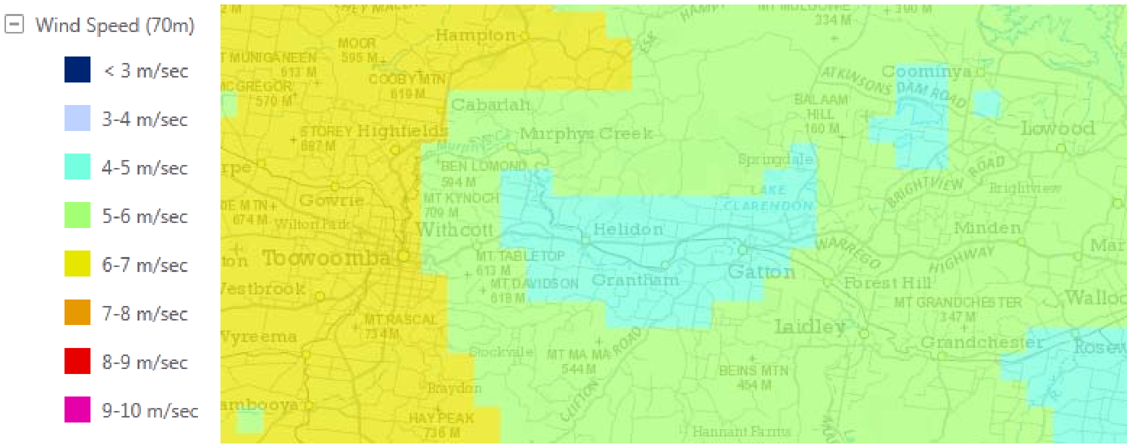

Figure 1 Wind speeds at 70 m above ground near Gatton

3.2.2 Diesel

Generation from diesel is typically more expensive than purchasing power from the grid. If connecting to the grid is not an option (e.g. for very remote sites) it may be preferred to install on-site diesel generation than to install transmission lines to become grid-connected. Diesel generation may also be preferred when a very high power reliability is required and the grid connection in the vicinity of the project is not reliable (again typically in remote areas).

As this project is going to be grid connected and is located within a strong network area, these motivating factors are not considered to apply. Accordingly, diesel generation has not been considered further in this study.

3.3 Cost of power supply from grid

The base case for power supply has been based on purchasing all electricity from Energex on their NTC4000 tariff. This tariff is described as "*Customers with a network coupling point at an 11 kV zone substation bus via a dedicated 11 kV feeder that is not shared with any customer.*"[2] It is understood that this tariff requires a customer to connect to the 11 kV substation at their own cost.

While there are some sites considered in this study that connect to 33 kV substations, the tariffs for 33 kV connections are determined on a case-by-case basis and are not published online. Energex has not been engaged as part of this study, and as such no specific 33 kV tariff is available for use. In lieu of this, the NTC4000 tariff has been used for all sites.

The details of the tariff are provided in Table 2.

Table 2 Energex NTC4000 tariff details

11 kV Bus NTC4000	Unit	Price
Demand Charge	$ per kVA per month	8.592
Off-Peak Usage (Weekdays 11pm – 7am, Weekends)	cents per kWh	18.4 c/kWh
Peak Usage (Weekdays 7am – 11pm)	cents per kWh	18.4 c/kWh
Daily Supply Charge	Confidential – price provided directly to the customer	

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[2] https://www.energex.com.au/home/our-services/pricing-And-tariffs/business-customers/large-business-tariffs-and-prices

It is noted that the electricity tariff is a key factor in the cost of operating a load as large as that being considered in this study. Large industrial power consumers are often able to negotiate better tariffs than a typical consumer, especially when the load is consistent or predictable, as is the case here. The following can be key factors in such a discussion:

- The size of the load
- The load profile – i.e. a constant 24/7 load may present a favourable customer to a retailer as it reduces risk to the retailer
- Flexibility of the load operator – if a load operator is able to reduce demand during peak (or other) times at the request of the retailer or network operator, it may provide an additional incentive for the retailer to provide a lower tariff.

Negotiation of tariffs must be addressed on a case-by-case basis with electricity retailers and the outcome cannot be predicted prior to these discussions. It is recommended that this is considered in future works for the project.

The cost of powering the pump stations purely from grid power is presented as the baseline comparison case option in the following section.

3.4 Comparison of power supply options

3.4.1 Overview of methodology

An assessment of power supply options has been carried out using HOMER microgrid modelling software. This software models the energy demand and various power supply options (e.g. solar PV, battery storage, grid power supply) in order to determine the lowest NPC (net present cost) option for a given set of project parameters.

The following options were included for the software to consider:

- Purchase of electricity from the grid at the tariff discussed in the preceding section
- Installation of solar PV ‘behind-the-meter’ at the pump station site
- Installation of lithium ion battery storage integrated with the behind-the-meter solar PV
- A wide range of combinations of the above, from 100% grid power (base case) to almost 100% renewable energy.

3.4.2 Consideration of revenue streams from generation

The modelling has been undertaken with the primary motive of offsetting grid-purchased electricity (i.e. generating and consuming power onsite to reduce power costs). There is also a potential opportunity to install an ‘oversized’ PV system to offset power costs and also feed electricity back into the network to generate revenue. The magnitude of the revenue that can be generated is heavily dependent upon two factors:

1. Negotiated feed-in tariff with a retailer (i.e. sale price for excess electricity generated)
2. The value of LGCs (Large-scale Generation Certificates) at the time of generation.

The feed-in tariff that may be negotiated is entirely dependent upon discussions with retailers. It may be negotiated as part of the tariff negotiations discussed in the preceding section, however it is noted that a large amount of on-site generation that feeds into the network may in fact reduce the negotiating power for a low electricity tariff as it destabilises the load that the retailer sees.

LGCs are a market-driven commodity that is a product of the Renewable Energy Target (RET). A LGC is generated for every MWh of renewable energy that is generated, whether it is consumed onsite in place of grid-purchased electricity or exported into the grid. The value of LGCs has been in the order of $40-90/MWh over the last 24 months, and typically above $70/MWh since the start of 2016.

Predicting the value of LGCs in the future cannot necessarily be done based on historic trends however, in particular as the requirements of the RET may be met early by the industry, resulting in the potential for a sharp decline sometime after 2020. GHD has not developed an expectation or estimate of when or how the LGC market will perform in the future. It is noted however that relying on revenue generated through LGCs could present a high risk to a project given the uncertainty of the future LGC market value.

To present the impact of these variables, two cases have been considered in the modelling:

1. 'No revenue case' – the potential revenue from excess power sold to the grid and for LGCs is not considered (i.e. the value of both is assumed to be zero)
2. Potential revenue case – an allowance of approximately $40/MWh for LGCs and a feed-in tariff rate of $40/MWh for electricity sold to the grid.

3.4.3 Key modelling assumptions

The key assumptions used in this analysis are presented in Table 3. These costs are based on GHD's understanding of the current market or based on HOMER software figures.

Table 3 Key modelling assumptions

Parameter	Unit	Value
Project life	Years	25
Discount rate	%	8%
PV tracking type	n/a	Single axis tracking
Capital cost of solar PV	$/MWe	$2 million
Operating cost of solar PV	$/kWe/yr	$21
Capital cost of Li-ion batteries	$/MWh	$400,000
Replacement cost of Li-ion batteries	$/MWh	$200,000
Li-ion battery life (by throughput)	MWh	3,200 MWh
Operating cost of Li-ion batteries	$/MWh/yr	$1,000
Capital cost of inverter	$/MW	$500,000

3.4.4 Results

The results from the modelling are presented in Table 4.

For each site, the following is provided:

- The configuration of solar farm that provides the lowest NPC across the project life
- The renewable penetration (i.e. the percent of consumed power that is provided from the solar system)
- Capital cost

- Operating cost (including cost of electricity required to meet shortfalls in solar production)
- Indicative connection capital costs based on an assumed connection requirement.

These results are provided for the baseline comparison case (i.e. grid power only), the ‘no revenue case’, and for a ‘potential revenue’ case based on the assumed feed-in and LGC prices.

The following observations can be made from these results:

- Battery storage was not selected by the software as the optimal configuration for any of the sites under any of the scenarios
- The renewable penetration of the selected configuration is generally consistent across all sites for the two scenarios – i.e. approximately 30% for the ‘no revenue’ case, and approximately 60% for the potential revenue case
- The amount of solar PV installed in the configurations selected by the optimisation software is as follows:
  - Approximately 150% of the maximum load for the ‘no revenue’ case
  - Approximately 450% of the maximum load for the ‘potential revenue’ case.

Table 4 Results of lowest NPC power supply options for all pump stations

Site	Load (assumed at this load 24/7	Operating hours/day	Avg daily kWh	Base line comparison case (grid only)	No revenue case					Allowance for revenue of ~40$/MWh LGC and $40/MWh grid sale price					Connection costs	
					Details of lowest NPC option	Renewable penetration %	NPC	Capital cost	Annual cost (grid cost plus O&M, minus REC value)	Details of lowest NPC option	Renewable penetration %	NPC	Capital cost	Annual cost (grid cost plus O&M, minus REC value)	Assumption	Connection cost
Heathwood PS	2000	24	48000	NPC: $45 million Annual cost: $3.4 million	3 MW solar PV No batteries	31%	$40 million	$6 million	$2.6 million	9.4 MW solar PV No batteries	62%	$33 million	$19 million	$1.1 million	2km * 11 kV UG cable 2 * 11kV RMU connection	$1,700,000
Lowood Booster PS	800	24	19200	NPC: $17.8 million Annual cost: $1.4 million	1.3 MW solar PV No batteries	32%	$16 million	$2.6 million	$1 million	3.6 MW solar PV No batteries	61%	$13 million	$7.3 million	$0.47 million	2km * 11 kV UG cable 2 * 11kV RMU connection	$1,700,000
Gatton Interim Booster PS	15100	24	362400	NPC: $337 million Annual cost: $26 million	24 MW solar PV No batteries	31%	$299 million	$48 million	$19.4 million	69 MW solar PV No batteries	61%	$251 million	$138 million	$8.8 million	7km * 33kV OH line 2 * 33kV connection cost	$2,250,000
Toowoomba Range PS	13083	24	313992	NPC: $292 million Annual cost: $22.6 million	21 MW solar PV No batteries	32%	$259 million	$42 million	$16.8 million	60 MW solar PV No batteries	62%	$218 million	$121 million	$7.5 million	7km * 33kV OH line 2 * 33kV connection cost	$2,250,000
Redcliffe STP Transfer PS	225	24	5400	NPC: $5 million Annual cost: $0.4 million	0.4 MW solar PV No batteries	34%	$4.5 million	$0.8 million	$0.3 million	1 MW solar PV No batteries	62%	$3.7 million	$2 million	$0.13 million	1km * 11 kV UG cable 2 * 11kV RMU connection	$1,000,000
Sandgate STP Transfer PS	350	24	8500	NPC: $8 million Annual cost: $0.6 million	0.5 MW solar PV No batteries	29%	$7 million	$1 million	$0.5 million	1.6 MW solar PV No batteries	61%	$6 million	$3 million	$0.2 million	1km * 11 kV UG cable 2 * 11kV RMU connection	$1,000,000
Luggage Point STP Transfer PS (aka Effluent Diversion PS)	360	24	8500	NPC: $8 million Annual cost: $0.6 million	0.5 MW solar PV No batteries	29%	$7 million	$1 million	$0.5 million	1.6 MW solar PV No batteries	61%	$6 million	$3 million	$0.2 million	1km * 11 kV UG cable 2 * 11kV RMU connection	$1,000,000
Bundamba Booster PS (Lockyer Valley)	1600	24	38400	NPC: $36 million Annual cost: $2.8 million	2.6 MW solar PV No batteries	32%	$32 million	$5.2 million	$2 million	7.3 MW solar PV No batteries	61%	$26.6 million	$15 million	$0.93 million	2km * 11 kV UG cable 2 * 11kV RMU connection	$1,700,000
Lowood Booster PS (Lockyer Valley)	390	24	9360	NPC: $8.7 million Annual cost: $0.7 million	0.7 MW solar PV No batteries	33%	$7.7 million	$1.3 million	$0.5 million	1.6 MW solar PV No batteries	58%	$6.5 million	$3.1 million	$0.26 million	2km * 11 kV UG cable 2 * 11kV RMU connection	$1,700,000
Gatton Booster PS (Lockyer Valley)	1050	24	25200	NPC: $23.4 million Annual cost: $1.8 million	1.6 MW solar PV No batteries	30%	$21 million	$3.1 million	$1.4 million	4.7 MW solar PV No batteries	61%	$17.5 million	$9.4 million	$0.6 million	7km * 33kV OH line 2 * 33kV connection cost	$2,250,000
Upper Tenthill PS (Lockyer Valley)	74	24	1776	NPC: $1.65 million Annual cost: $0.13 million	0.12 MW solar PV No batteries	31%	$1.5 million	$0.24 million	$0.095 million	0.34 MW solar PV No batteries	62%	$1.2 million	$0.68 million	$0.043 million	2km * 11 kV UG cable 2 * 11kV RMU connection	$1,700,000

3.4.5 Trade-off between CAPEX, OPEX, and NPC

The results in the previous section focus on identifying the lowest NPC option for a given load and set of modelling parameters. In these sorts of assessments, it is also critical to understand the trends and trade-offs that exist between the different financial drivers (e.g. CAPEX and OPEX).

To illustrate these trade-offs, a more detailed assessment is provided below for the 15.1 MW Gatton pump station. The model outputs used to produce the results from the preceding section have been broken down to provide the CAPEX, OPEX, and NPC for solar PV installations ranging from 0 to 75 MW in 3 MW increments. This has been done for the 'no revenue' case and for the potential revenue case. The results are shown in Figure 2 and Figure 3 respectively.

It can be seen from these two figures that the low-point of the NPC line (shown in green) is at 24 MW and 69 MW respectively (the turn-around point for the latter is difficult to read from the graph but is at 69 MW). These low points align with the preferred options presented for the 15.1 MW Gatton site in the results in Table 4, as would be expected.

The following observations can also be made from these results:

- In the 'no revenue' case, the drop in operating cost is most significant up to approx. 20 MW of installed PV, indicating a higher return on CAPEX for each additional MW installed at these sizes. As the overall size of the installation increases, the incremental drop in OPEX decreases.
- In the potential revenue case, the OPEX figures drop more linearly between 0 and 75 MW of installed solar PV. This is reflective of the linear revenue stream that is assumed for this scenario (i.e. each MWh of additional solar provides the same amount of revenue).
- Despite the lowest NPC option for the potential revenue case being at 69 MW installed PV, the NPC line is almost flat from approximately 30 MW onward. This indicates that the preference for spending or deferring capital cost could easily tilt the preferred option toward a lesser amount of installed PV.

For the purposes of the options assessment, the 'potential revenue' case was adopted.

Figure 2 CAPEX, OPEX, and NPC trade-off – Gatton – no revenue case

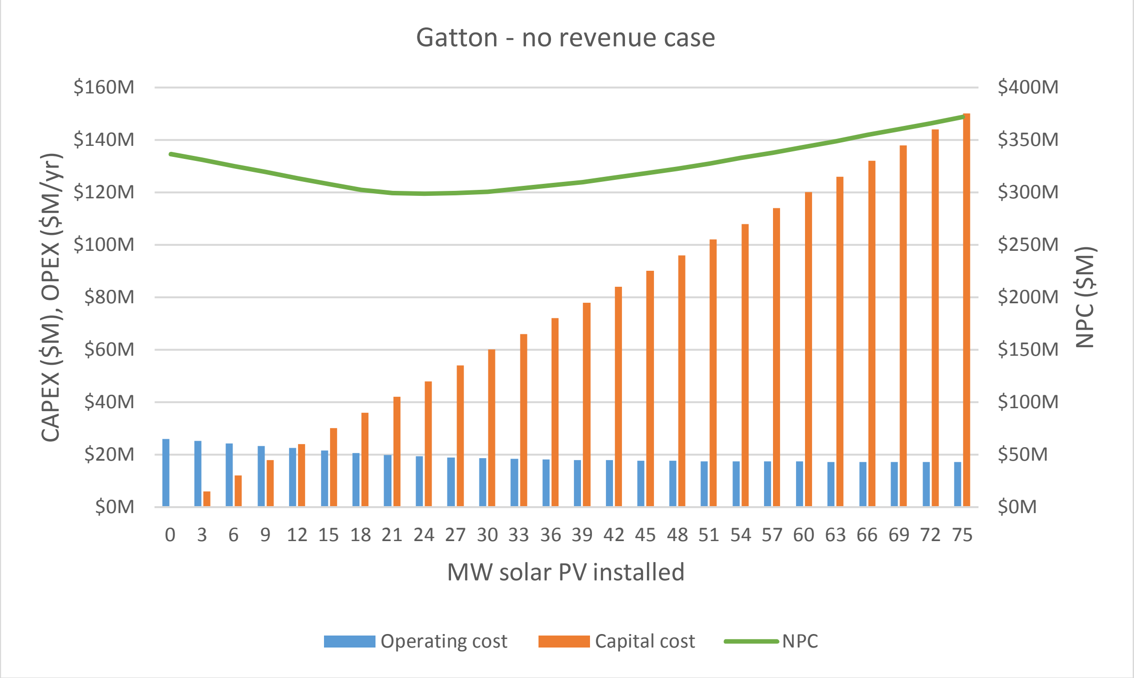
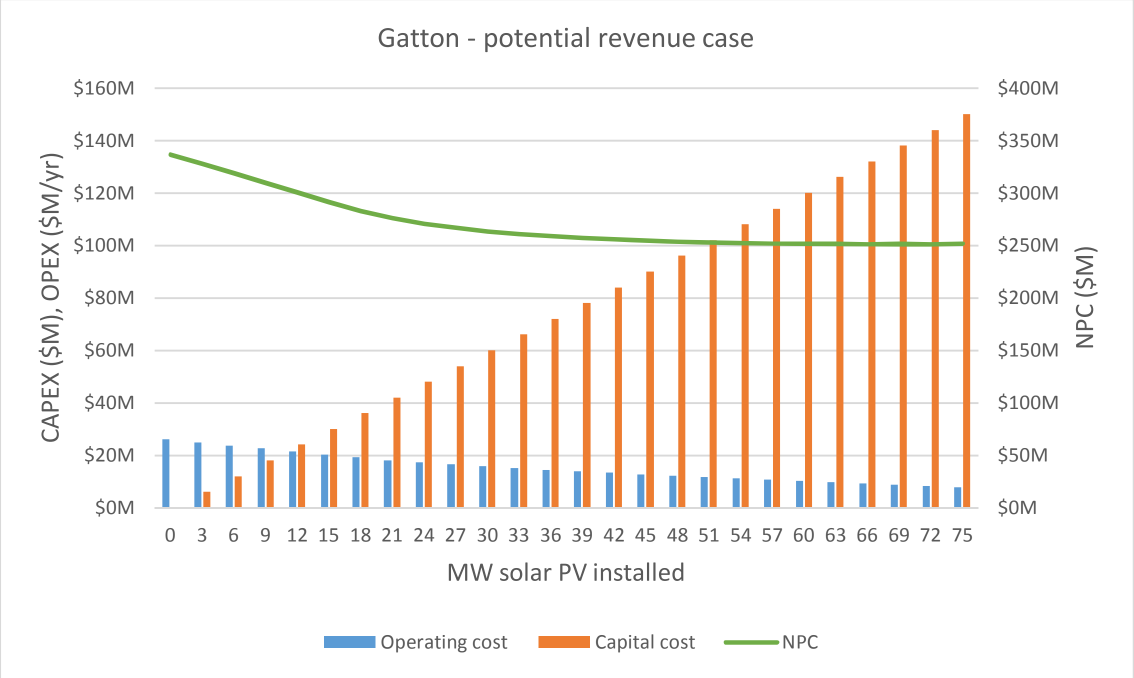


Figure 3 CAPEX, OPEX, and NPC trade-off – Gatton – potential revenue case



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0	D Baptie / A Gupta	P Wootton	P. Woott	W Traves		28/3/18

Appendix K – MCA report

1. MCA Report

1.1 Overview

A Multi Criteria Assessment (MCA) process has been developed to filter the short-listed options. The MCA tool facilitates the ranking of options that will be subject to more detailed feasibility assessment. It is important to note that the candidate options are of a pre-feasibility nature only and have been examined to compare the overall merits of the specific options in meeting project objectives.

MCA is a technique that is commonly used to evaluate options when the relative merit of those options is not solely measured by monetary units. Instead the performance of the options is assessed against multiple assessment criteria. MCA techniques attempt to measure the effectiveness and not the absolute worth of each option.

The form of the MCA used is known as the Goals Achievement Matrix (GAM) method. The primary focus of the GAM method is on the selected project outcomes as opposed to the effects of the project.

The following sections describe the short list of options in detail and reviews the ability of options to specifically address the key assessment criteria.

1.2 Short list options

Based on the outcomes of the short-listing process, the options that were progressed to more detailed assessment are described in Table 1-1.

Table 1-1 NuWater Project short-listed options

Option	Project Option	Sub-Option	Description	Quantity (ML/day)	Quantity (ML/annum)
A	PRW	1.2.2	WCRWS pipeline + construction of Heathwood Pump Station and upgrade of Gibson Island AWTP, including pipelines from Redcliffe STP to Sandgate STP and from Sandgate STP to Luggage Point STP	232	84,680
B	Class A+	2.2	WCRWS pipeline + construction of Heathwood Pump Station and upgrade of Gibson Island AWTP	232	84,680
C	Class B/C (as produced)	3.2	WCRWS pipeline + construction of Heathwood PS	232	84,680
D	PRW (LV) / Class B/C (DD)	6.1	WCRWS pipeline (current capacity)	116	42,340
		6.2	Pipeline from Bundamba AWTP to Lowood Booster Pump Station	84	30,660

An outcome of the selection process was that each of the three water product quality options are represented in the short listed options. Option D is a composite product delivering a water product suitable for end user requirements, i.e. higher quality water for the Lockyer Valley.

The remaining options were not progressed beyond this project stage on the basis of relative merit compared to the short-listed options.

A component summary is included in Table 1-2.

Table 1-2 NuWater Short-listed Options Components Summary

Option	WCRWS Pump Stations and pipelines	WCRWS Advanced Water Treatment Plant	Modification to Advanced Water Treatment Plants	Heathwood Pump Station	Luggage Point to Gibson Island Pump Station upgrade	Additional pipelines	Storage dams in Lockyer Valley	End-off-pipe Class A+ treatment facility
A	✓	✓ Luggage Point Gibson Island Bundamba	✓ Gibson Island upgrade to 100 ML	✓ Heathwood PS	✓ Luggage Point to Gibson Island (additional)	✓ Redcliffe to Sandgate (13.9Km) + Sandgate to Luggage Point (14km)	✘	✘
B	✓	✓ Luggage Point Gibson Island Bundamba	✓ A+ quality only Gibson Island upgrade to 82 ML	✓ Heathwood PS	✘	✘	✓ 4GL Lockyer Valley storages	✘
C	✓	✘	✓ (bypass)	✓ Heathwood PS	✘	✘	✓ 4GL Lockyer Valley storages	✓
D	✓	✓ Luggage Point Gibson Island	✓ (bypass Bundamba)	✘	✘	✓ Loowood Booster Pump Station to Lake Clarendon	✘	✘

1.3 Design of MCA Tool

The Nuwater short-listed options were evaluated using a Multi-Criteria Assessment (MCA) tool. The tool was developed to firstly filter and ultimately rank short-listed options by using both qualitative and quantitative information to achieve the best balance between:

- Economic/viability Goals
- Environmental Goals
- Social Goals

These primary goals provide the base on which the MCA tool has been developed. The approach used involved developing a series of nested selection criteria which measure how well an infrastructure option is likely to meet each of the required goals. Each goal is broken into a series of criteria and sub-criteria until a point is reached where the sub-criteria are easily evaluated for each project option. The final leaf on each branch of the tree represents an assessment criterion that will be used in the evaluation and ranking of specific options.

The resulting weight for each assessment criterion is developed by multiplying each of the weights that appear on the path from the assessment criteria back to the primary goal.

The evaluation of short-listed options was focused on comparative option elements, including:

- Scale to be able to increase the irrigated production (current WCRWS capacity 180 ML/d or increasing it)
- Total capital cost per megalitre of yield ($/ML) at the farm
- Total operating cost per megalitre of yield ($/ML) at the farm
- Improvement of water quality in Moreton Bay and water product being produced
- Utilisation of wastewater treatment plants STPs, including modifications to the AWTPs and existing WCRWS pump stations and pipelines.

Each of the short-listed options was scored using the criteria identified in Table 1-3 and provided a relative ranking. The scoring process is further defined in section 1.4.

Table 1-3 NuWater Project short-listing criteria

Primary Goals	Weight	Criteria	Weight	Sub-criteria 1	Weight	Measurable rating	Weight
Economic	50%	Project viability	40%	Project at a scale able to drive significant increase in irrigated agricultural production that is regionally significant	30%	Rank by system yield supporting farmland development <20,000ML, 20-50,000ML, 50-80,000ML, 80-100,000ML, >100,000ML	6.0%
				Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system (This will provide relativity between options and a coarse indication of the potential need for transparent subsidy)	35%	<$1,000/ML, $1-2,000/ML, $2-3,000/ML, $3-4,000/ML, >$4,000/ML	7.0%
				Operating cost (e.g. energy cost, treatment costs - relativity between options)	35%	<$500/ML, $500-1000/ML, $1-1,500/ML, $1,500-2,000/ML, >$2,000/ML	7.0%
		Project risks	40%	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk - capacity of beneficiaries to pay	35%	Complexity, Investor risks, multiple investors, asset ownership complexity etc.	7.0%
				Approvals pathway - ability to address planning requirements, organisational/govt support and social licence	20%	Relativity between options	4.0%
				Reliability of water supply (anticipated periods of interrupted supply), e.g. reduced period required for recommissioning	15%	Considered together with total yield	3.0%
				Quality of product water (eg. salt loads, public health, constraint to applicable crops, market access)	10%	Reflect factors such as quality (e.g. A+, C, etc.), salt loads, etc - Higher quality = higher score	2.0%

Primary Goals	Weight	Criteria	Weight	Sub-criteria 1	Weight	Measurable rating	Weight
				Compliance requirements for product water	10%	Reflect factors such as complexity re user agreements, mixed products, etc., compliance obligations	2.0%
				Construction risks (including geological, tunnel, infrastructure footprint, etc.)	10%	High to low (bigger and more complex footprint potentially will score lower)	2.0%
		Regional impact	20%	Offsetting chemical fertiliser needs (function of scale and treatment level)	25%	High to low	2.5%
				Impacts on regional infrastructure (e.g. roads, rail, power etc)	20%	High to low (relocate and additional needs etc)	2.0%
				Employment (direct operation including irrigation and related activities)	25%	<50, 50-100, 100-150, 150-200, >200 (additional employees resulting from development)	2.5%
				Increased utilisation of regional/community infrastructure (asset utilisation e.g. alignment with State Government Bulk Water Opportunities Statement)	30%	High to low (factor of scale and diversity of potential offerings - including Wellcamp airport etc.)	3.0%
Environmental	30%	Ecology	40%	Net biodiversity (based on biodiversity mapping) Rare and threatened ecosystems, habitats and taxa of high conservation value (based on RE database mapping) Protected Areas (conservation areas, wetlands, etc. mapping) Potential to change or improve existing seasonal flow pattern (changes to aquatic habitats)	100%	Low to high impact	13.5%
		Water values	55%	Opportunity to replace potable water sources, sustainable use of water resources	25%	Low to high impact (Largely a function of buffer to watercourses etc.)	4.1%

Primary Goals	Weight	Criteria	Weight	Sub-criteria 1	Weight	Measurable rating	Weight
				Improvements to water quality in Moreton Bay against relevant water quality objectives, reflecting the level of nutrient removal from discharges.	45%	Low to high impact	7.4%
				Potential to affect salinity levels	30%	Low to high impact (positive impacts on recharge in the Lockyer to negative by increasing salinity hazard)	5.0%
Social	20%	Community	100%	Potential employment opportunities and regional population growth	20%	Low to high impact	4.0%
				Community support	25%	High to low	5.0%
				Consistency with planning intents of other government authorities	10%	High to low	2.0%
				Health and safety risk (construction and operation)	5%	High to low	1.0%
				Community amenity	10%	High to low	2.0%
				Land requirements and private property impacts	15%	High to low	3.0%
				Cultural heritage impact	15%	High to low	3.0%

*It is noted that the quantum of the capital and operational cost estimates used to compare options does not include a number of key elements, including:

- Distribution infrastructure for product water
- Centralised and/or decentralised (on-farm) storage
- Power consumption and supply

These were viewed to be common option elements, and as such were defined and refined based on the short list options and outcomes of the demand survey and analysis.

1.4 Scoring

The evaluation of the options was undertaken using a five level ranking/scoring system as shown in Table 1-4. Scoring is on a 1-5 scale with a higher overall score indicative of a preferential outcome. The score of 1 indicates that the project/scenario contributes poorly to the criterion outcome while a score of 5 would indicate a significant contribution beyond that required to just meet the criterion outcome.

Table 1-4 MCA scoring system

A score of between 1 and 5 is allocated at the lowest level of the criteria tree indicating the level of success the proposed solution is expected to have in meeting the criterion	
1	Clearly does not meet the assessment criterion requirement
2	Unlikely to meet the assessment criterion requirement
3	Likely to meet the assessment criterion requirement
4	Likely to exceed the assessment criterion requirement
5	Likely to significantly exceed the assessment criterion requirement

The criteria and scoring method is normally considered suitable within the context of a strategic level study and preliminary level of accuracy inherent in this assessment.

The sum of individual option weighted scores provides an overall score for the option allowing it to be ranked against other development options.

1.5 Outcomes of MCA Analysis

The assessment criteria, criteria weightings and outcomes of the MCA are shown in Table 1-5 below.

Table 1-5 Summary of MCA Scoring

Primary Goals	Criteria	Sub-criteria 1	Option			
			A	B	C	D
Economic	Project viability	Project at a scale able to drive significant increase in irrigated agricultural production that is regionally significant	5	5	5	4
		Total capital cost per megalitre of yield ($/ML) at the farm. Factors in water distribution losses and cost of water storage and distribution system (This will provide relativity between options and a coarse indication of the potential need for transparent subsidy)	1	2	4	1

Primary Goals	Criteria	Sub-criteria 1	Option			
			A	B	C	D
		Operating cost (e.g. energy cost, treatment costs - relativity between options)	1	2	5	1
	Project risks	Commercial failure - capacity to attract commercial interest/investment (landholders, Seqwater (e.g.doesn't compromise planning for SEQ water supply), QUU, Gov etc), market risk - capacity of beneficiaries to pay	2	1	1	1
		Approvals pathway - ability to address planning requirements, organisational/govt support and social licence	2	3	2	2
		Reliability of water supply (anticipated periods of interrupted supply), e.g. reduced period required for recommissioning	2	1	1	1
		Quality of product water (eg. salt loads, public health, constraint to applicable crops, market access)	5	4	2	3
		Compliance requirements for product water	1	2	3	2
		Construction risks (including geological, tunnel, infrastructure footprint, etc.)	2	4	4	3
	Regional impact	Offsetting chemical fertiliser needs (function of scale and treatment level)	1	3	5	4
		Impacts on regional infrastructure (e.g. roads, rail, power etc)	1	2	2	1
		Employment (direct operation including irrigation and related activities)	5	4	3	4
		Increased utilisation of regional/community infrastructure (asset utilisation e.g. alignment with State Government Bulk Water Opportunities Statement)	5	5	4	4

Primary Goals	Criteria	Sub-criteria 1	Option			
			A	B	C	D
Environmental	Ecology	Net biodiversity (based on biodiversity mapping) Rare and threatened ecosystems, habitats and taxa of high conservation value (based on RE database mapping) Protected Areas (conservation areas, wetlands, etc. mapping) Potential to change or improve existing seasonal flow pattern (changes to aquatic habitats)	1	3	3	2
	Water values	Opportunity to replace potable water sources, sustainable use of water resources	5	5	5	4
		Improvements to water quality in Moreton Bay against relevant water quality objectives, reflecting the level of nutrient removal from discharges.	5	4	3	4
		Potential to affect salinity levels	5	4	2	3
Social	Community	Potential employment opportunities and regional population growth	4	4	4	3
		Community support	3	3	3	3
		Consistency with planning intents of other government authorities	4	4	4	4
		Health and safety risk (construction and operation)	3	4	3	2
		Community amenity	2	3	3	3
		Land requirements and private property impacts	2	3	3	3
		Cultural heritage impact	3	4	4	4
TOTAL SCORES			**2.77**	**3.17**	**3.27**	**2.72**

The following graphs show the total results from Table 1-5.

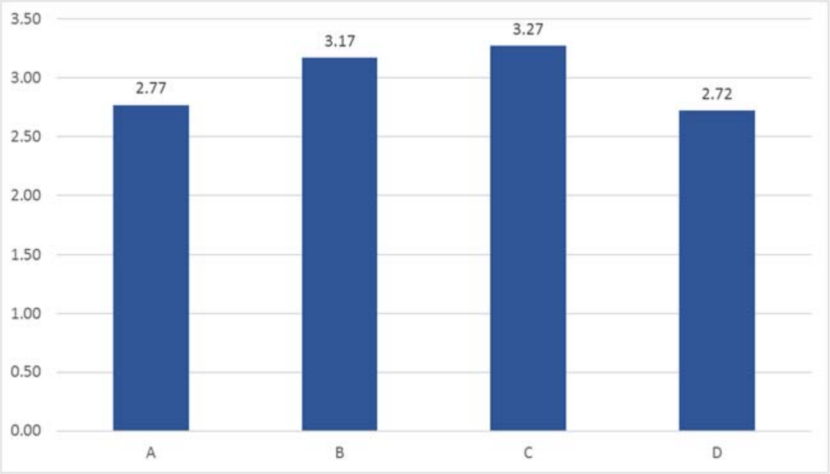

Figure 1-1 MCA Scoring summary

Observations from the MCA workshop are outlined below:

- Option A
  - Economic/Project viability – it has the highest CAPEX and is therefore scored the lowest
  - Economic/Regional impact – it maximises the use of WCRWS infrastructure so score highly as utilise the AWTPs plus WCWRS
  - Economic/ Regional impact – it has complex crossings in transferring source water from Redcliffe STP and Sandgate STP subject to significant approvals processes and technical feasibility; therefore score lowest
  - Enviromental/Ecology - It has pipelines through areas of high ecological significance in close proximity to Moreton Bay and tidal waterways and is therefore scored the lowest in ecology/enviromental.
  - Social/community - It has potential impact to Aboriginal Cultural Heritage
- Option B
  - Economic/Project viability – reduced CAPEX as avoids the need to increase source water capacity due to high recovery rate of Class A+ compared to PRW
  - Economic/Regional impact – Aiming to maximise use of WCRWS infrastructure so score highly as utilise the AWTPs plus WCWRS
- Option C
  - Economic/Project viability – it has the lowest CAPEX and is therefore scored the highest
  - Economic/Project viability – OPEX scored a 5 as it was substantially below the others (WCRWS operated using lower quality water requires lower operational and mantenaince cost)
- Option D
  - Economic/Project viability – it has limited capacity to WCRWS compared to others options, therefore score lowest
  - Economic/Regional risks – it has new road crossings and water crossing therefore score lowest
- Common to all the Options

– Most of the social/community impacts for all the options are consistent across all options, due to not being major differences between the options

To see the significance of each criteria the following figures have been created. It shows the scoring based one of the three criteria and its weightings.

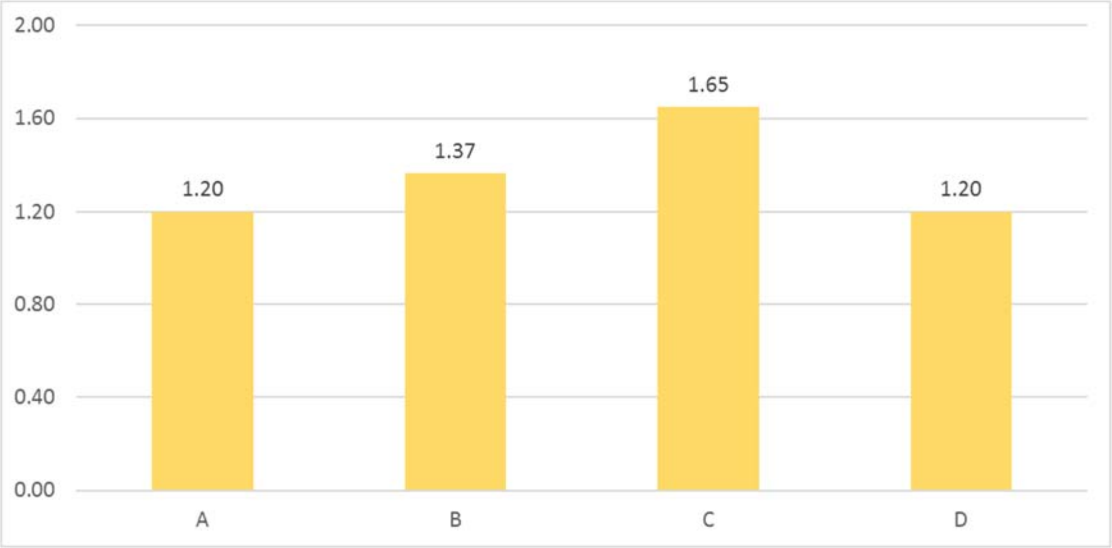

Figure 1-2 MCA Economic Goal (50%)

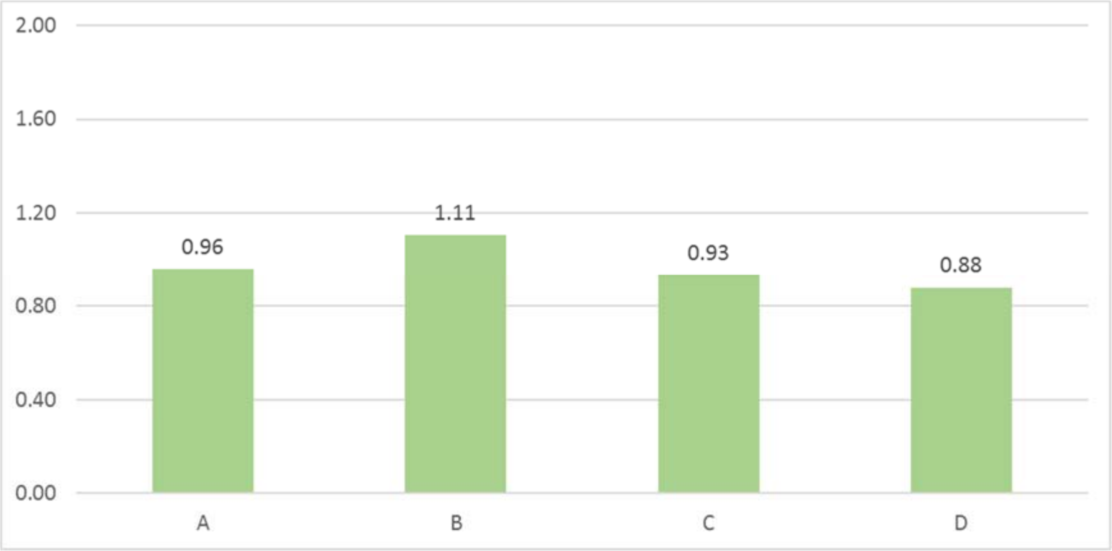

Figure 1-3 MCA Environment Goal (30%)

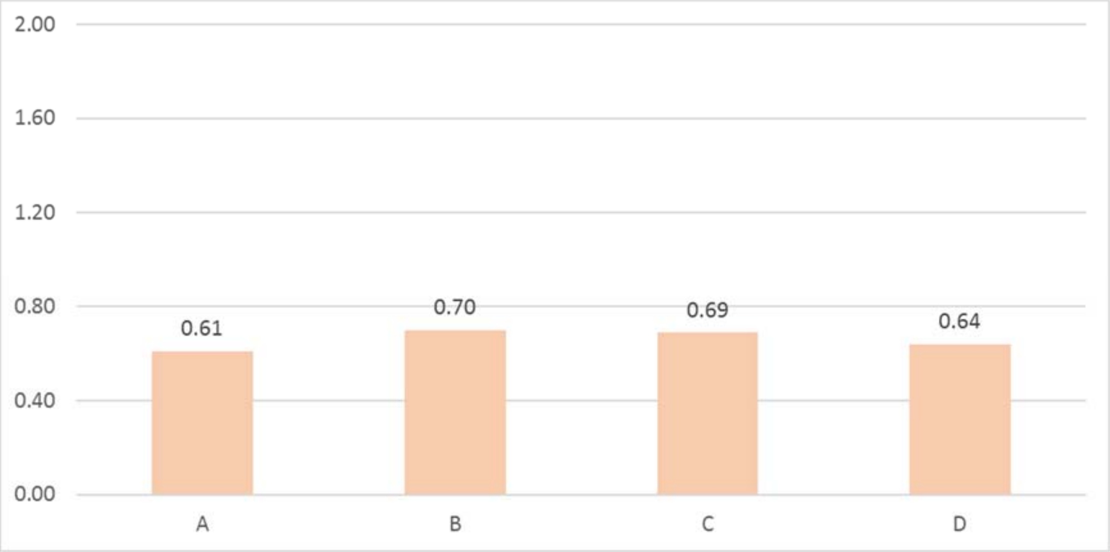

Figure 1-4 MCA Social Goal (20%)

These findings show that:

- On the basis of economic criteria, Option C is preferred followed by Option B. This is largely due to the reduced CAPEX and OPEX related to the reduced treatment requirement for these water products. Option A is impacted by infrastructure required to add source water and operational costs of producing PRW. Option D comprises some duplicate delivery pipeline sections (between Bundamba and Grantham) and incurs OPEX associated with delivering a significant quality of PRW.
- On the basis of environmental criteria, Option B is preferred. Option A is impacted by the additional waterway crossings for source water pipelines and associated high ecological significance areas. This is countered to a degree by the fact that this option utilises the highest quantity of source water, thereby creating the greatest benefit to Moreton Bay. Option C scoring is impacted by a low score in terms of potential to exacerbate salinity impacts. Option D scoring is impacted by additional pipelines along with higher resource consumption.
- On the basis of social criteria, all options scored very similar, with some minor reductions assigned to those options with a greater infrastructure footprint.

Appendix L – Assumptions Register

Project **NuWater Project Feasibility Study**
Job No. 4130968
Client Queensland Farmers' Federation Ltd

Document Owner: Project Manager
Last Updated: 08-Feb-18

Assumptions Register - Feasibility Study / Preliminary Business Case

Qualifications Description						Validation			Status
Ref	**Date Recorded**	**Entry By**	**Title/ Qualifications**	**Reason**	**Date Client Notified**	**Method of Validation**	**Date Rec'd**	**Comment**	**Action/ Closed**
1.00	28-Jul-17	JAS	No site investigations have been conducted. This study was purely of a desktop nature using the available information and stakeholder inputs	Out of scope.	31-Jul-17	Reference available information for other infrastructure.	Various	2/10 - Available information (DNRM, utility data, etc) has being obtained on basis of Short List Options.	2/10 - Some additional data is being sought for specific elements such as Energex supply information.
2.00	28-Jul-17	JAS	The size, capacity and suitability of existing infrastructure, including QUU sewage treatment plants, Seqwater advanced water treatment plants, the WCRWS, etc. have not been validated by the respective infrastructure owners at this stage of the project. Therefore the production and delivery quantities indicated in this report are indicative only and will be subject to further investigation	Information not as yet provided by relevant organisations.	31-Jul-17	Consult with relevant asset owners (QUU, Seqwater) re use of assets and existing agreements. Consult with DEWS on acceptability of transporting lesser quality product water in WCRWS.	31-Aug-17	2/10 - Partial information received to date. Additional information sought from Seqwater relating to specific Short List Option details, ongoing actions.	2/10 - New RFI to Seqwater being prepared. To occur between Nov 17 and Feb 18: Consult with DEWS on acceptability of transporting lesser quality product water in WCRWS.
3.00	28-Jul-17	JAS	It is assumed that Seqwater's advanced water treatment plants can be modified to produce alternative water quality products. This will be the subject of further investigation at future project phases	Part of forthcoming project phases.	31-Jul-17	Complete preliminary investigations into potential arrangements and identify feasible options. Seek data from Seqwater in accordance with outstanding information request.	31-Aug-17	2/10 - Partial information received to date. Additional information sought from Seqwater relating to specific Short List Option details, ongoing actions.	2/10 - New RFI to Seqwater being prepared. Workshop to occur 16 Oct 17.
4.00	28-Jul-17	JAS	The size/scale of water supply (and/or treatment) options will ultimately be tailored to site conditions and a wide range of other factors. These and other aspects may be the subject of further studies	Out of scope - part of subsequent project phases (beyond FS/Prelim Bus Case).	31-Jul-17	None. Assumptions to be stated and future studies identified as part of Preliminary Business Case.			2/10 - Closed.
5.00	28-Jul-17	JAS	It has been assumed that Lockyer Valley growers are unlikely to be able to accept low quality (e.g. Class B, C) recycled water due to limitations upon appropriate uses for such application. This has not been formally verified and will be the subject of further investigation and consultation with relevant stakeholders and regulatory bodies	Part of forthcoming project phases.	31-Jul-17	Seek LV grower feedback as part of demand assessment. Seek response from organic certification organisation. Seek feedback from Cardno, who were intending to contact Coles/Woolworths re grower agreements and any limitations. Consult with relevant agencies (DEWS, DEHP).	13-Sep-17	2/10 - Validated through the Demand Study (draft provided 13/9/17 by Synergies Economic Consulting).	2/10 - Further consultation proposed with agencies beteween Nov 17 and Feb 18.
6.00	28-Jul-17	JAS	It has been assumed that release of lower quality water products (Class B, C, etc.) to watercourses may not be environmentally acceptable given the substantial increase in waterway volumes this is likely to represent. Conversely it has been assumed that the release of higher quality water products (PRW, Class A+) to watercourse will be suitable. Both assumptions will be subject to further investigation and consultation with relevant stakeholders and regulatory bodies	Part of forthcoming project phases.	31-Jul-17	Consult with relevant agencies (DEWS, DEHP).			2/10 - Further consultation proposed with agencies beteween Nov 17 and Feb 18.
7.00	28-Jul-17	JAS	Potential areas able to be served with recycled water have not been defined beyond broad areas at this stage and would be subject to further investigations.	Part of forthcoming project phases.	31-Jul-17	Seek LV and DD grower feedback as part of demand assessment.	13-Sep-17	2/10 - Validated through the Demand Study (draft provided 13/9/17 by Synergies Economic Consulting). Further exploration of demand locations is anticipated in future project phases (beyond Preliminary Business Case).	
8.00	31-Jul-17	JAS	It is asssumed Tarong Power's agreement (to take up to 80ML/d from WCRWS) does not require fulfilling. This has not been verified.	Part of forthcoming project phases.	31-Jul-17	Seek Seqwater, Tarong Power response on current arrangement.			2/10 - To be discussed at workshop to occur 16 Oct 17. 8/2 - As per assumption.
9.00	31-Jul-17	JAS	It is assumed a range of current recycled water agreements will not impact the supply to WCRWS. This includes (6-10 ML/d) for Visy and Incitic (PRW water from Luggage Pt AWTP. Other agreements include Wynnum, Luggage Pt STP (recycled water), Fairfield, etc.	Part of forthcoming project phases.	31-Jul-17	Seek QUU, Seqwater confirmation of the current agreements.			2/10 - To be discussed at workshop to occur 16 Oct 17. 8/2 - As per assumption.
10.00	08-Nov-17	JAS	Power supply - revenue from excess power generation assumed to be 4c/kWh grid price, 4c/kWh for Large-scale renewable generation certificates (LGC)	To capture some form of revenue associated with excess power generation, recognition of the significant scale of the facility and the ability to negotiate a suitable revenue stream with energy retailers.	08-Nov-17	Not applicable.			To be revisited/reviewed at the next phase of the Business Case
11.00	08-Nov-17	JAS	Base demand in Lockyer Valley assumed to be 7,500 ML/a based on identified demand and current groundwater arrangements.	Noted that the water produced by the scheme needs to be taken or else QUU/Bay benefits are unable to be realised (24 hr/d, 365 days/yr scheme)	08-Nov-17	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
12.00	08-Nov-17	JAS	Base demand in Darling Downs assumed to be in excess of 65,500 ML/a based on assumed demand identified in the crop model.	Noted that the water produced by the scheme needs to be taken or else QUU/Bay benefits are unable to be realised (24 hr/d, 365 days/yr scheme)	08-Nov-17	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
13.00	08-Nov-17	JAS	Assumed that land can be found in reasonable proximity to new delivery pump station sites to locate a solar farm facility.	Part of forthcoming project phases.	08-Nov-17	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
14.00	08-Nov-17	JAS	Increased usage of the WCRWS and associated unavailability of the water was assumed to follow Seqwater's climate change predictions (no climate change 19%; 2030 climate change 32%, 2050 climate change 44%).	As provided by Seqwater on 16 October 2017. Advised by Seqwater that this was the basis of their own WCRWS utilisation predictions.	08-Nov-17	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
15.00	08-Nov-17	JAS	Increased usage of the WCRWS and associated unavailability of the water was assumed to be based on an increase of the current commencement trigger of 40% (as per WSP) to 70%.	As provided by Seqwater on 16 October 2017. Advised by Seqwater that this was the basis of their own WCRWS utilisation predictions.	08-Nov-17	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
16.00	28-Nov-17	HL	The electrical connection options proposed are based on the current network map available on Energex website	Typical assumption for feasibility level power supply study.	08-Nov-17	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
17.00	28-Nov-17	HL	Each of the Nuwater Pump Stations will be supplied by dedicated feeders from the nearest Energex Substation.	As provided by Seqwater on 16 October 2017. Advised by Seqwater that this was the basis of their own WCRWS utilisation predictions.	09-Nov-17	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
18.00	28-Nov-17	HL	The Energex tariff (NTC4000) selected for cost comparison between grid connected and solar powered sites	Typical assumption for feasibility level power supply study.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
19.00	28-Nov-17	HL	It is assumed that the substations are adequately rated and can supply the pumping station loads without any major augmentation at the substation or upstream supply feeders	Typical assumption for feasibility level power supply study.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.

Qualifications Description						Validation			Status
Ref	Date Recorded	Entry By	Title/ Qualifications	Reason	Date Client Notified	Method of Validation	Date Rec'd	Comment	Action/ Closed
20.00	28-Nov-17	HL	Diesel and battery options were considered but are higher cost per kWh compared to grid power so are not included in the optimised solution	Based on GHD estimates/prev studies.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
21.00	28-Nov-17	HL	Restart and Operational forecast costings were based on figures provided by Seqwater for WCRWS in 2017 dollars for a 1st July 2018 restart	Assumption provided by Seqwater.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
22.00	28-Nov-17	HL	Opex costs for WCRWS is based on $1125/ML on PRW whilst operational costs for other water quality are based on 62% of PRW for A+, 10% of PRW for B/C water	Based on GHD estimates/prev studies. Typical for this level of feasibiltiy study.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
23.00	28-Nov-17	HL	Opex costs for pump stations ares based on $0.23/kWh consumed by the pumps operating on a 24hr basis continuously.	Typical assumption for feasibility level power supply study.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
24.00	28-Nov-17	HL	Opex costs for pipelines are based on 0.25% of the capex	Assumption provided by Seqwater.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
25.00	28-Nov-17	HL	ROC treatment cost were based on a GHD Estimate at $9.75M for 22MLD ROC theoretical treatment plant and pro-rated for other sites at their relevant treatment capacities	Based on GHD estimates/prev studies.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
26.00	28-Nov-17	HL	STPs data such as flows, TDS were based on those provided by QUU	Based on QUU data.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
27.00	28-Nov-17	HL	Recovery rate for PRW is based on 82% whilst Class A+ is based on 96.5%	Based on GHD estimates/prev studies.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
28.00	28-Nov-17	HL	Estimates assume that the scheme source water will be made available from QUU at no cost.	Developed in discussion with QUU.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
29.00	28-Nov-17	HL	Capex costs are based on historical data escalated to 2017 at 3%pa	Based on GHD estimates/prev studies.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
30.00	28-Nov-17	HL	From Gibson Is to Toowoomba, the pipeline route will follow existing corridors providing an unconstrained environment for maximum productivity	Based on review of possible routes, identification of most efficient solution.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
31.00	28-Nov-17	HL	In the highly constrained urban areas from Sandgate to Gibson Is a reduced rate for production and modified method of construction has been adopted	Based on review of possible routes, identification of most efficient solution/relevant assumption.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
32.00	28-Nov-17	HL	Groundwater and rock is expected to be encountered during excavation in certain areas and the implications have been factored in	Based on review of possible routes, identification of most efficient solution/relevant assumption.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
33.00	28-Nov-17	HL	Pipeline rates include allowance for 1 scour valve and 1 air valve assembly per km	Based on GHD estimates/prev studies. Typical for this level of feasibiltiy study.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
34.00	28-Nov-17	HL	Budget estimates for pipe and pumps have been sourced from relevant suppliers and adopted into our estimate	Typical assumption for feasibility level study.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
35.00	28-Nov-17	HL	A 42% contingency allowance has been included for unmeasurable and unidentified scope required to provide a complete and working system.	Typical assumption for feasibility level study.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.
36.00	28-Nov-17	HL	Footprint sizes for pump station buildings with undefined limits have been factored from known constants	Based on GHD estimates/prev studies.	08-Feb-18	Not applicable.			Closed. To be revisited/reviewed in subsequent project phase.

Exclusions Register - Feasibility Study / Preliminary Business Case

Qualifications Description						Validation			Status
Ref	Date Recorded	Entry By	Title/ Qualifications	Reason	Date Client Notified	Method of Validation	Date Rec'd	Comment	Action/ Closed
1.00	28-Nov-17	HL	Planning and approval fees						
2.00	29-Nov-17	HL	Land purchase fees						
3.00	30-Nov-17	HL	Removal of spoil						
4.00	01-Dec-17	HL	Council and Authority Fees, if required						
5.00	02-Dec-17	HL	Latent ground conditions and works associated with the remediation of contaminated ground						
6.00	03-Dec-17	HL	Diversion of existing services						
7.00	04-Dec-17	HL	Escalation costs beyond the estimate date						
8.00	05-Dec-17	HL	Finance costs and holding charges						
9.00	06-Dec-17	HL	GST						

Appendix M – NuWater Project Risk Register

Queensland Farmers' Federation
NuWater Project Preliminary Business Case

16th October, 2017
GHD Offices, Brisbane
Attendees:

Name	Role
Abel Immeraj	QUU
Shane Tyrell	QUU
Ross Muir	Seqwater
Joseph Tam	Seqwater
Kate Lanskey	Seqwater
Mark Cullinan (apology)	Seqwater
Tom Vanderbyl	Badu Advisory
Kim Bremner	
Project Team	
Warren Traves	GHD, Project Director
James Skene	GHD, Project Manager
Murray Smith	GHD, Business Case Lead
Dan Culpitt	Synergies Economic Consulting, Economics Lead
Russell Mills	Risk Lead

Objectives (Problem Statement):
The Project aims to examine the potential for synergistic solutions arising from the nexus of two separate problems:

- Costs of managing environmental impacts associated with treating South-East Queensland’s wastewater and disposing the effluent to sea are expected to continue to increase driven by growing SEQ population and increasingly more stringent environmental standards that are in response to the communities’ expectations for a maintaining the environmental health of Moreton Bay; and
- Growth in agricultural and industrial production and associated regional economic benefits (particularly as measured in regional jobs) in the Lockyer Valley and the Darling Downs is being significantly constrained by the lack of opportunities and access to traditional water source supplies and need to develop alternate supplies for the region.

KEY SUCCESS FACTORS:
1. A broad stakeholder acceptance of the preliminary business case outcomes

			Risk & Opportunity Register (Project Project Preliminary Business Case Development)											
						Initial Risk Rating				Residual Risk Rating (with additional treatments / mitigations)				
Ref #	**Class of Risk / Opportunity**	**Phase where Risk/Opportunity is Material**	**Risk/Opportunity Description**	**Cause**	**Impact to Project Objectives**	**Consequence Severity**	**Likelihood**	**Risk**	**Risk Mitigations/Opportunity enhancement**	**Consequence Severity**	**Likelihood**	**Risk**	**Risk Owner**	**Comments**
2	Strategic		Options not able to be progressed due to poor upstream stakeholder alignment.	1. Key stakeholders such as Seqwater, QUU etc. may have existing expectations with regard to the availability and use of treated wastewater (e.g. Water Security Plan). 2. Review of assets owned/operated by others leads to non-acceptance of potential technical solutions offered.	Options relying on accessing key assets are ruled out, potentially making an option non-viable or significantly affecting cost of scheme			#N/A	1. The stakeholder engagement plan to identify stakeholders and issues early on in the process such that tailoring can occur to optimise stakeholder alignment with project objectives. 2. Quantify environmental benefits - Flag alignment with Resilient Rivers , Healthy Land and Water and Catchment Action Plans 4. Establish environmental offset value 5. Shared understanding of SEQ Water Security imperatives, costs and options 6. Develop understanding of indicative capital and opperating cost offsets 7. Understanding of whole of life costing to all potential benefitting stakeholders 8. Alignment with QLD Bulk Water Opportunities Statement (infrastructure efficiency and regional development) 9. Opportunity for Commonwealth investment			#N/A		
2	Strategic		Demand take-up	1. Poor alignment with review timing of Water Plans (Central Lockyer aquifer) 2. WQ not-fit-for purpose 3. Other alternatives being pursued by stakeholders (e.g. pipeline from Wivenhoe Dam) 4. Interruptable supply nature makes the water product of limited value to the farm business 5. Indicative price of water product too high to be attractive 6. Landholder consultation fatigue	1. Likely to be a key point of focus from State and Federal Government entities 2. Project may be assessed as not feasible due to low demand (at indicative price)			#N/A	1. Ensure demand estimates are underpinned by robust, farm-level assessments of the return to irrigation water use, providing relevant govt authorities with the necessary confidence regarding the robustness of the water demand assessments. 2. Focus group sessions held with producers; based on the outcomes from the focus groups, key inputs and assumptions were identified to the inform the modelling of financial returns to additional irrigation water. 3. Water product is made fit-for-purpose 4. Optimal utilisation of on-farm water storage 4. Indicative irrigation water price is sustainable			#N/A		
2	Strategic		Policy constraints arising from the current regulatory framework	1. Qld govt may reserve the right to use water from the WCWRSS to supplement potable water supply in the future. 2. Should a lower quality product be selected, release constraints associated with water tranfer and on-farm use may impact the viability of option/s being considered.	1. Quality of water used in WCRWS supply to users may be affected 2. Reduced reliability of supply 3. Value that potential users place on water may be reduced 4. Options selected may encounter future regulatory constraints affecting project viability.			#N/A	1. Clear definition of options with stakeholder inputs 2. Understanding of capital and operating costs 3. Liaise with regulators to identify potential acceptable on-farm management arrangements for use of treated wastewater			#N/A		
	Financial		Developing a cost-effective solution	1. The relatively dispersed nature poses significant challenges for providing affordable water to irrigators in the region. 2. The topography and dispersed nature of points of water demand drives high operating costs (energy requirements)	Project may not provide a financially viable water price.			#N/A	1. Create a range of options that provide alternative delivery arrangements to address scale of scheme and avoiding/downsizing signficant CAPEX/OPEX elements - minimise energy needs/identify cost effective energy solutions. 2. Quantify environmental benefits 3. Flag alignment with Resilient Rivers , Healthy Land and Water and Catchment Action Plans 4. Establish environmental offset value 5. Shared understanding of SEQ Water Security imperatives, costs and options 6. Indicative capital and operating cost offsets 7. Explain whole of life costing to all benefitting stakeholders 8. Opportunity for Commonwealth investment / multiple programs			#N/A		
	Public Safety		Algal bloom in Wivenhoe attributed to use of WCP for non-PRW transfer in the past (Option B,C)	Accidental transfer of Class A$^+$, B/C water to Lowood to Wivenhoe Dam pipeline during operation in either Option B or C	Project reputation tarnished	Minor	Possible	Medium	1. Undertake Hazid followed by Hazop and implement safeguards to avoid risk 2. Establish strict operating procedures, monitor and compliance	Minor	Unlikely	Low		
	Public Safety		Inadvertent release in drinking water catchment	Accidental transfer of Class A$^+$, B/C water to Lowood to Wivenhoe Dam pipeline which feeds Mt Crosby WTP during operation in either Option B or C	same as above	Minor	Possible	Medium	1. Undertake Hazid followed by Hazop and implement safeguards to avoid risk 2. Establish strict operating procedures, monitor and compliance 3. Engage stakeholder such as Mt Crosby operations in the process	Minor	Unlikely	Low		
	Public Safety		Conversion of pipeline back to IPR use (Option B,C)	Water Security Plan wanting to bring WCRWS back on line following Key Bulk Water Storage level reaches 60% with production trigger at 40%	Supply reliability affected	Moderate	Likely	High	1. Advance notification from Water Security Plan about intention 2. Develop specific operating procedure to undertake conversion from non PRW to PRW	Moderate	Possible	Medium		
	Public Safety		Public health issue with recommissioning WCRWS after Class A+ or B/C water in pipeline (Option B,C)	Once the WCRWS had been distributing in non PRW water under option (B or C), there is a risk of not being able to reinstate back to full PRW standard despite superchlorination and slime removal in pipelines.	Project reputation Operational cost increase	Major	Possible	High	1. Develop a periodic water monitoring programme to sample, test and assess slime buildup in pipelines 2. Undertake routine slime stripping campaign by maximising flow/velocity through pipelines 3. Conduct after test to assess effectiveness	Moderate	Unlikely	Medium		
	Public Safety		Unable to properly/adequately clean pipeline after use (Option B,C)	Insufficient facility for pipeline isolation, superchlorination, flushing and receival of discharge water. Excessive volume of "non PRW" water to be safely cleaned.	Inability to restore WCRWS initial operation	Major	Possible	High	1. Undertake full investigation on superchlorination methodology and implementation 2. Identify sections of assets for trial and water testing for efficacy proofing	Major	Unlikely	Medium		

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	Public Safety		Pfas effect etc. Oakey etc. - perception among non-irrigators	Non irrigators may not be familiar about the source of Project and may be confusing with ground water extraction which has been contaminated with PFAS around Oakey .	Water quality affected Project reputation	Major	Unlikely	Medium	1. Community consultation to inform non irrigators about the exact source of Project 2. Develop a communication plan to educate non irrigators and public	Moderate	Unlikely	Medium		
	Public Safety		Five years of effluent data desirable before source can be used for PRW (Option A)	WCRWS has been operating almost 3 years since commissioning, therefore its long term PRW production track record is minimal	Project viability may be affected due to insufficient data	Moderate	Possible	Medium	Tighter operational control and monitoring at AWTP's to ensure continuity of performance due to insufficient track record in order to maintain a reliable source	Minor	Possible	Medium		
	Public Safety		Long lead time (5 years) for source water monitoring for use as PRW	same as above	same as above	Moderate	Possible	Medium	as above	Minor	Possible	Medium		
	Public Safety		Release of PRW to environment, creating IPR	1. Operational hiccups 2. Insufficient safeguards	Project reputation tarnished	Moderate	Possible	Medium	1. Undertake Hazid followed by Hazop and implement safeguards to avoid risk of release to the environment 2. Establish strict operating procedures, monitor and compliance	Moderate	Unlikely	Medium		
	Public Safety		Control over how recycled water is used - supplier has responsibility (Option C,D)	Inadequate or insufficient recycled water management protocols/agreement in place with end users Insufficient distribution control mechanism	Commercial nuisance Potential revenue loss	Minor	Possible	Medium	1. Establish robust agreeement 2. Propose bulk metering	Minor	Unlikely	Low		
	Public Safety		If some long-term effect, who bears responsibility, financially and legally?	Subject to individual recycle water management agreement	Commercial nuisance Potential revenue loss	Moderate	Possible	Medium	1. Establish clearly defined responsibilty matrix in the agreement 2. Put in place risk management practices to avoid litigation	Moderate	Unlikely	Medium		
	Public Safety		WQ regulator does not accept use of assets for PRW after alternative WQ use (i.e. PRW)	Risk of water quality decrease as a result of delivering class A+ , B/C water	Potential Liabilities	Major	Possible	High	Demonstrate to WQ regulator of feasibility of reusing pipe for PRW after being used for non PRW	Major	Unlikely	Medium		
	Public Safety		Qld Health do not allow use of WCP for delivering of non-PRW	Risk of water quality decrease as a result of delivering class A+ , B/C water	Project viability jeapordised for Options B, C	Major	Possible	High	Demonstrate to Qld Health of feasibility of reusing pipe for PRW after being used for non PRW	Major	Unlikely	Medium		
	Delivery		Reliability, including extended period with no supply	Overall performance in all options in the AWTP's, pump stations, pipelines and personnel	Project economic viability questionable	Moderate	Unlikely	Medium	set KPI's for plant and pump station/pipeline performance	Minor	Unlikely	Low		
	Delivery		Probability and duration of interruptions (all options)	Frequency of shutdowns or planned maintenance on the WCRWS assets	Supply reliability affected	Moderate	Likely	High	set KPI's for plant and pump station/pipeline preventive maintenance	Moderate	Possible	Medium		
	Delivery		Interruptibility - uncertainty regarding frequency and timing of when supply will be available	as above	same as above	Moderate	Likely	High	set KPI's for plant and pump station/pipeline preventive maintenance	Moderate	Possible	Medium		
	Delivery		Degree of interruption means product not of interest to growers	as above	as above	Moderate	Likely	High	set KPI's for plant and pump station/pipeline preventive maintenance	Moderate	Possible	Medium		
	Delivery		Change in habits/demand etc. leading to reduced sewage flows	Water restrictions catchment population decline, sewerage flow diversion, increased use of recycled water	as above	Minor	Unlikely	Low	Flow trends analysis for early identification of changes	Minor	Rare	Low		
	Delivery		Insufficient source water	Option A: 3 existing AWTP's non performance and insufficient source water from Sandgate and Redcliffe Option B: 3 existing AWTP's partial performance Option C: performance issued associated with exsiting STP's Option D: combination of above	as above	Moderate	Possible	Medium	1. Early detection of flow reduction via flow trending 2. Investigate additional storage volume at end user 3. Early notification of potential water (all sources) shortage to end users	Moderate	Unlikely	Medium		
	Delivery		Is there enough water to maintain demand? (all options)	same as above	as above	Minor	Unlikely	Low	as above	Minor	Rare	Low		
	Delivery		Supply sources not adequately secured/contracted, leading to supply shortage	Inadequate or insufficient recycled water management protocols/agreement in place with end users	as above	Moderate	Possible	Medium	Develop more robust agreement to avoid source water shortage	Moderate	Unlikely	Medium		

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	Delivery		Volume of water able to be supplied due to interruptibility is not viable	same as above water volume issues	as above	Moderate	Possible	Medium	1. Early detection of flow reduction via flow trending 2. Investigate additional storage volume at end user 3. Early notification of potential water supply interruption to end users	Moderate	Unlikely	Medium		
	Delivery		Frequency of need for WCP for Seqwater water security needs means water not available for irrigation	PRW demand fluctuation caused by drought	as above	Moderate	Possible	Medium	1. Early detection of flow reduction via flow trending 2. Investigate additional storage volume at end user 3. Early notification of potential need for WCP to be used by Seqwater for water security purposes to end users	Moderate	Unlikely	Medium		
	Delivery		Is there enough source water from Oxley/Wacol/Goodna/Bundamba to meet DD demand? (Option D)	Performance issues at Oxley, Wacol, Goodna and Bundamba STP	as above	Moderate	Likely	High	1. Early detection of flow reduction via flow trending 2. Investigate additional storage volume at end user 3. Early notification of potential B/C water shortage to end users	Moderate	Possible	Medium		
	Delivery		Can Redcliffe and Sandgate add sufficient volume of source water ADWF? (Option A)	Performance issues at Redclife and Sandgate STP	as above	Minor	Possible	Medium	Flow trends analysis for early identification of changes at both STPs	Minor	Unlikely	Low		
	Delivery		No viable renewable power source available	lack of land available nearby Complexity of becoming an energy consumer via grid and producer from PV energy supplier in terms of commercial arrangement	Project may not provide a financially viable electricty revenue to offset grid power	Minor	Possible	Medium	Investigate possibility of installing an "oversized PV system to offset power costs and also feed electricity back into the network to generate revenue.	Moderate	Possible	Medium		
	Delivery		No viable power supply available from Grid/power link	Existing nearby substations have insufficient capacity Inability to provide more power from nearby grid	Project economic viability questionable	Major	Possible	High	Early assessment with electricity authorities about potential substations upgrade (in particular to Gatton and Lower Toowoomba area)	Major	Unlikely	Medium		
	Delivery		Ability to supply other users of water from scheme (Option B,C)	Pipeline sized to 232 ML/d	May help the project viability	Moderate	Possible	Medium	Demand identification to be expanded in an effort to augment number of end users	Moderate	Likely	High		
	Delivery		Flexibility in varying volumes between LV and DD (Option D)	as above	as above	Minor	Possible	Medium	Only additional distributions can be installed at a later stage to cater new demand zones	Minor	Likely	Medium		
	Delivery		Cannot achieve balance of water use for agriculture and water security purposes (all options)	Conflicting demand and poorly defined water supply strategy Climate change uncertainty	Water supply affected Project reputation	Moderate	Possible	Medium	Demand identification to be expanded and quantified.	Moderate	Unlikely	Medium		
	Delivery		Dealing with uncertainty over demand in LV	LV end users insufficient binding contracts	Project economic viability questionable	Moderate	Likely	High	Demand identification to be expanded in an effort to augment number of Lockyer Valley end users	Moderate	Possible	Medium		
	Delivery		Ability to modify/ add N/P treatment at LP and GI (esp. GI as the site is constrained)	Improve water quality for options B, C and D	Increase Project viability	Minor	Unlikely	Low	Undertake process review of existing to assess augmentation options to improve water quality	Minor	Possible	Medium		
	Delivery		Convert pipeline LP --> Bundamba to source water - avoids re-purposing pipeline	Capex minimisation by reusing WCRWS pipes	Increase Project viability	Moderate	Likely	High	Review WCRWS exisitng assest and undertake options analysis	Moderate	Possible	Medium		
	Delivery		Salt turns out to be a bigger issue or salt levels increase over time, leading to reduced demand (Option B,C,D)	Poor performance of existing STP's	Potential revenue loss for Project Supply reliability affected	Moderate	Possible	Medium	1. Identify cause of salts level increases 2. Revisit water quality performance at relevant STP/AWTPS 3. Implement remedial actions	Moderate	Unlikely	Medium		
	Delivery		Deterioration of source water quality makes water unfit for use (Option C,D)	Performance reduction at source water AWTPs	same as above	Moderate	Possible	Medium	1. Identify cause of source water deterioration 2. Revisit water quality performance at relevant AWTPS 3. Implement remedial actions	Moderate	Unlikely	Medium		
	Delivery		Sea levels rise, increasing salt ingress, which creates water too saline for irrigation	Climate change	same as above	Moderate	Possible	Medium	1. Confirm cause of salts level increases 2. Revisit water quality performance at relevant STPs 3. Implement remedial actions	Moderate	Unlikely	Medium		
	Delivery		New "higher and best use" over time (all options)	PRW or any reclyced water too expensive	Inability to implement project	Major	Unlikely	Medium	Undertake rigorous cost benefit analysis	Moderate	Possible	Medium		

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	Delivery		Seqwater elect to make WCRWS part of standard operating regime	Water Security Plan increases the availablity of water by raising Key Bulk Water Storage level to higher level.	Potential revenue loss for Project Supply reliability affected	Moderate	Possible	Medium	Seqwater to consider alternative sources than WCRWS, eg: northern desal	Minor	Possible	Medium		
	Delivery		Operating strategy (i.e. triggers to restart) are revised, change interruptibility	same as above	same as above	Moderate	Possible	Medium	1. Early warning from Seqwater about changes 2. Communication to End users and encouragement to store more water on site	Minor	Possible	Medium		
	Delivery		Existing commitments for PRW supply cannot be met due to Project use e.g. power station or industry demand	shift in water usage to other priority	same as above	Moderate	Possible	Medium	End users to revert back to their previous water supply scheme	Moderate	Unlikely	Medium		
	Delivery		PRW is not available for drinking water when required	Option A operation prioritised over WCRWS ability to resume its operation during drought	Potential revenue loss for Project Supply reliability affected	Moderate	Possible	Medium	Interruptibility clause to be included in agreement with end users	Moderate	Unlikely	Medium		
	Social/Community		Percentage of IPR by 'stealth' (Option A)	Penetration of PRW into public use	Project reputation tarnished	Minor	Possible	Medium	Reinvigorate IPR communications plan by Seqwater to gain public support	Minor	Unlikely	Low		
	Social/Community		Public acceptance (or lack thereof) of return of assets for drinking water purposes after PRW quality uses	WCRWS assets have been "soiled" after use for class A^{+}, B/C irrigation	Water quality affected Project reputation	Moderate	Possible	Medium	Gain Qld Health support to advertise safe return of assets after use with non PRW water Public communications	Minor	Possible	Medium		
	Social/Community		WCRWS not reinstated in time for security	Unrealistic time frame set by Water Security Plan following 60% trigger	Inability to restore WCRWS initial operation	Major	Possible	High	Early communications in the event of a trigger Establish and trial a rigorous reinstatement plan of WCRWS	Moderate	Possible	Medium		
	Social/Community		Social acceptability of "turning off" irrigation once commenced	Seqwater wanting to resume WCRWS scheme original operation	Potential revenue loss for Project Supply reliability affected	Minor	Possible	Medium	Gain Qld Health support to advertise safe return of assets after use with non PRW water Public communications	Minor	Possible	Medium		
	Social/Community		Use of WCP for PRW irrigation when out of drought expected by community	Full utilisation of assets (not just for drought periods)	Increase Project project viability	Moderate	Possible	Medium	Community to be pushing for environmental benefit of using WCRWS on PRW to benefit Moreton Bay.	Major	Possible	High		
	Social/Community		Future value of water leads to community objection to use of water for agriculture	Excessive treatment and delivery costs for Project	Project financial viability questionable	Moderate	Possible	Medium	Project to review their viable price for water	Minor	Possible	Medium		
	Social/Community		IPR not accepted by community (all options)	Public perception of health issues related to IPR	Project viability questionable	Moderate	Possible	Medium	Reinvigorate IPR communications plan by Seqwater to gain public support	Minor	Unlikely	Low		
	Social/Community		Community backlash at use of WCRWS for water less than PRW quality	same as above	Water quality affected Project reputation	Moderate	Possible	Medium	1. Gain Qld Health support to advertise safe return of assets after use with non PRW water 2. Public communications	Minor	Possible	Medium		
	Social/Community		Community says "no" to PRW in drinking water	same as above	Water quality affected Project reputation	Moderate	Possible	Medium	Reinvigorate IPR communications plan by Seqwater to gain public support	Minor	Unlikely	Low		
	Social/Community		Acceptance of PRW in water supply	Increased level of perception by public for PRW	Increase Project viability	Moderate	Possible	Medium	1. Reinvigorate IPR communications plan by Seqwater to gain public support 2. Gain Qld Health support to advertise safe use of IPR with PRW water in water supply	Minor	Possible	Medium		
	Social/Community		Community says "yes" to PRW and takes ownership of WCRWS	same as above	Increase Project viability	Moderate	Possible	Medium	Encourage Seqwater to maximise use of AWTPs' for PRW production	Major	Possible	High		
	Social/Community		Lack of guaranteed supply of water for irrigation	Performance reduction at source water STPs	Supply reliability affected	Moderate	Possible	Medium	1. Early detection of flow reduction via flow trending 2. Investigate additional storage volume at end user 3. Early notification of potential water supply interruption to end users	Moderate	Unlikely	Medium		

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	Social/Community		Irrigators demand supply maintained during drought (i.e. "forget" interruptibility)	Continuity of supply required by end users	Inability to restore WCRWS initial operation	Minor	Possible	Medium	Seqwater to consider alternative sources than WCRWS, eg: northern desal	Minor	Possible	Medium		
	Social/Community		Quality of water not suitable for irrigation e.g. trade waste import (Options B,C,D)	Insufficient level of treatment of wastewater Performance issues at all source water STP's and AWTP's	Water quality affected Project reputation	Minor	Possible	Medium	Improve treatment capacity to achieve min water quality target for Options (B,C or D)	Minor	Unlikely	Low		
	Social/Community		Economic growth due to supporting agriculture	Success of Project	Increase Project viability	Moderate	Likely	High	Communicate success story to other potential users to gain more PR	Moderate	Likely	High		
	Social/Community		Collapse of irrigation in LV attributed to failure to use WCP appropriately	Demand assessment and forecast inadequate	Project economic viability questionable	Major	Possible	High	Ensure demand surveys in LV area are monitored and increase communications with farmers about their continuous need for water	Moderate	Likely	High		
	Environment		High energy use, high greenhouse gas emissions, noise, due to delivery up the hill not good for the environment	High pumping cost associated with sending water over the Toowoomba range	Project economic viability questionable	Major	Possible	High	Consider alternative renewable energies such as solar to offset power consumption	Major	Likely	High		
	Environment		QUU nutrient abatement	Reduced load to Moreton Bay	1. Increase Project viability 2. Avoidance of costs associated with nutrients removal prior to discharge to the bay	Moderate	Possible	Medium	QUU to undertake a comprehensive nutrient abatement costs quantification to improve project economic viability (current figures used in BC are $23,000/t for Nitrogen and $18,400/t for Phosphorus removal)	Major	Likely	High		
	Environment		Unable to release end of pipe by-products in Lockyer	ROC treatment for PRW scheme at Lockyer faces environmental discharge approval	Project reputation Operational cost increase	Moderate	Possible	Medium	Undertake feasibility of alternative ROC treatment/discharge/ttransportation options	Moderate	Unlikely	Medium		
	Environment		Accidental release from storages in Lockyer Valley/Darling Downs	1. Operational hiccups 2. Insufficient safeguards	Project reputation tarnished Environmental fines	Major	Possible	High	1. Undertake Hazid followed by Hazop and implement safeguards to avoid risk of release to the environment 2. Establish strict operating procedures, monitor and compliance	Moderate	Unlikely	Medium		
	Environment		AWTPs cannot be retrofit with nutrient removal due to site constraints, therefore the environmental objective cannot be met	Insufficient footprint to allow expansion	Project economic viability questionable	Major	Possible	High	1. Review current AWTP's performance and upgrade if possible 2. Investigate alternative sites or treatment of nutrients	Moderate	Possible	Medium		
	Environment		Nutrient not permanently diverted from waterway, undermining enviro leadership i.e. ROC reject	1. Treament Performance issues 2. ROC Treatment not meeting licensed discharge levels	Project reputation License not granted Operational cost increase	Moderate	Possible	Medium	1. Review current AWTP's performance and upgrade if possible 2. Investigate alternative sites or treatment of ROC	Moderate	Unlikely	Medium		
	Environment		ROC discharge causes concentration-related impacts on Bay	Insufficient or unreliable ROC treatment process for Options A and D only	Potential additional treatment required Cost implications to Project	Moderate	Possible	Medium	1. Investigate alternative sites or treatment of ROC	Moderate	Unlikely	Medium		
	Environment		Unintended salination of irrigated land (Options B,C,D)	Options B, C, D viability was based on volume, capex and opex only, no assessment to effects caused by variant water quality	Project reputation	Minor	Possible	Medium	Undertake salinity studies and implement options to reduce discharge to end user land	Minor	Unlikely	Low		
	Financial		Opex - cost of power increases	dependent on Electricity retailer tariff	Commercial nuisance Potential revenue loss	Moderate	Possible	Medium	1. Investigate cause of power cost increase 2.Consider alternative renewable energies such as solar to offset power consumption	Moderate	Unlikely	Medium		
	Financial		High operating cost due to delivery of water (and perhaps agricultural products too) up the hill	High pumping cost associated with sending water over the Toowoomba range	Project economic viability questionable	Major	Possible	High	1. Investigate cause of pumping cost increase 2. Review electricity tariffs 2.Consider alternative renewable energies such as solar to offset power consumption	Moderate	Unlikely	Medium		
	Financial		Cost of energy for pumping exorbitant	same as above	Project economic viability questionable	Major	Possible	High	1. Investigate cause of pumping cost increase 2. Review electricity tariffs 2.Consider alternative renewable energies such as solar to offset power consumption	Moderate	Unlikely	Medium		
	Financial		Power costs increase in future and make cost of water unattractive to users	Electricicity cost keeps rising	Commercial nuisance Potential revenue loss	Moderate	Possible	Medium	1. Review electricity tariffs 2.Consider alternative renewable energies such as solar to offset power consumption	Moderate	Unlikely	Medium		

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	Financial		Compliance costs for use of class B & C (Options C,D)	Qld Health regulatory requirements for crop irrigation	Commercial nuisance Potential revenue loss	Moderate	Possible	Medium	review compliance testing regimes, work ith regulator to alleviate compliance requirements, or lower limits within allowable	Moderate	Unlikely	Medium		
	Financial		Underestimation of time and costs required to return WCRWS to PRW - this has not been done before	Seqwater operational unit rates based on three year operation only	May delay the Project implementation May impact on Water Security Plan ability to restart once Project scheme is in place	Moderate	Possible	Medium	1. Revisit timeframes and undertake trials to return WCRWS to PRW 2. Firm up on minimal timeframes	Moderate	Unlikely	Medium		
	Financial		Cost to return to standard required for Seqwater security is not funded i.e. users unwilling to pay reinstatement costs when supply is interrupted (e.g. security deposit?)	Water Security Plan can still dictate PRW production of WCRWS	Commercial nuisance Potential revenue loss	Moderate	Possible	Medium	Such cost to be included in the decision process before interrruption	Minor	Possible	Medium		
	Financial		(Excessive) cost of recommissioning pipeline	Seqwater operational unit rates based on three year operation only and only did one commissioning	Project economic viability questionable	Moderate	Possible	Medium	1. Increase contingency for recommissioning budget 2. Firm up commissioning procedures and consumables	Moderate	Unlikely	Medium		
	Financial		Capital cost blowouts	Oversizing, inefficient pipe route selection, water quality too excessive	Project economic viability questionable	Major	Possible	High	1. Optimisation of asset sizing, best route selection, use best practices construction techniques and effective project management and cost controls, including critical path management	Major	Unlikely	Medium		
	Financial		Cost of wide distribution throughout DD	Distribution too widespread	Project economic viability questionable	Minor	Possible	Medium	Optimistation of demand zones and group distribution at LV	Minor	Unlikely	Low		
	Financial		Recognition/value of environmental offset	1. Economic benefit to rural end users 2. Reduction of loading to Moreton Bay 3. Re use of WCRWS assets	Increase Project viability	Moderate	Possible	Medium	Communicate success story to other potential users to gain more PR	Moderate	Likely	High		
	Financial		Demand forecasts are overly optimistic	1. Unrealistic expectations from consulted end-users 2. Insufficient widespread consultation with end users	Project economic viability questionable	Minor	Possible	Medium	Revisit demand forecast by contacting participant and new end users.	Minor	Unlikely	Low		
	Financial		Insufficient government capital funding support	Potentially an unsubstantiated business case	Project viability questionable	Major	Possible	High	Seek alternative capital funding say increase contribution from irrigators, Seqwater contribution, (offsetting maintenace costs), QUU contribution (if discharge limits were to be raised) or seek Dept of Enviroment and Heritage Protection support via otbiaing nutrient pollution credits to reduce/eliminate nutrients discharge to Moreton Bay	Major	Unlikely	Medium		
	Financial		Federal government funding not available for power supply	Inability for project to attract solar subsidies	Project viability questionable	Major	Possible	High	Seek alternative capital funding say private sector , from irrigators, or introduce another "green energy" generating options to consumers ,	Major	Unlikely	Medium		
	Financial		More cost effective sources become available, reducing demand for 'Project'	High cost of water per ML forces endusers to seek alternative source	Commercial nuisance Potential revenue loss	Major	Possible	High	Careful implementation to minimise project cost overruns to maintain competitiveness	Major	Unlikely	Medium		
	Financial		Cost equity for pumping water over range	Financial return over investment into Project scheme	Project economic viability questionable	Major	Likely	High	Careful assessment of pumping assets via designing fit for purpose assets and monitor project cost overruns to maintain efficient opex costs	Major	Possible	High		
	Financial		Increasing costs from producers not able to be passed on, "smearing" required inequality	Production cost still high despite additional volume of water able to be supplied by Project	Project economic viability questionable	Moderate	Likely	High	1. Review and Optimise irrigation water pricing 2. Irrigators to optimie their operations and attempt to reduce their opex	Moderate	Possible	Medium		
	Financial		Avoided costs to QUU to dispose of effluent from inland STPs i.e. irrigation schemes	Project can displace 232MLD potentially away from the bay	Increase Project viability	Moderate	Likely	High	Measure and quantify avoided costs to QUU and identify additional ways and costs to reduce effluents	Moderate	Possible	Medium		
	Financial		Once operational, owners of scheme won't/can't bear cost of return to PRW	PRW operating costs is greater than Class A$^+$, B/C water	Commercial impacts Potential revenue loss	Moderate	Likely	High	1. Minimise operation on PRW mode 2. if scheme owners have to operate on PRW mode, then investigate energy reduction measures or new technnologies in the PRW treatment process	Moderate	Possible	Medium		
	Financial		Access NWIDF funds for CAPEX of recycling (like SA)	1. To increase financial viability of project 2. Justification favoured by environmental benefit	Increase Project viability	Moderate	Possible	Medium	Develop a robust justification for NWIDF funding, following earlier finding for this Business Case	Moderate	Likely	High		

			Risk & Opportunity Register (Project Project Preliminary Business Case Development)											
Ref #	Class of Risk / Opportunity	Phase where Risk/Opportunity is Material				Initial Risk Rating				Residual Risk Rating (with additional treatments / mitigations)				
			Risk/Opportunity Description	Cause	Impact to Project Objectives	Consequence Severity	Likelihood	Risk	Risk Mitigations/Opportunity enhancement	Consequence Severity	Likelihood	Risk	Risk Owner	Comments
	Financial		Opex beyond affordable	excessive cost of treament and pumping over the range	Project economic viability questionable	Major	Possible	High	1. Minimise operation on selected Option/mode 2. Investigate energy reduction measures or new technnologies in the treatment process	Major	Unlikely	Medium		
	Financial		Customers cannot afford scheme OPEX	same as above	Project economic viability questionable	Major	Possible	High	1. Minimise operation on selected Option/mode 2. Investigate energy reduction measures or new technnologies in the treatment process 3. Consider differing return on investment targets to help irrigators/customers	Major	Unlikely	Medium		
	Financial		Irrigators' capacity to pay	high cost per ML	Project economic viability questionable	Major	Possible	High	1. Minimise operation on selected Option/mode 2. Investigate energy reduction measures or new technnologies in the treatment process 3. Consider differing return on investment targets to help irrigators/customers	Major	Unlikely	Medium		
	Financial		Irrigators not willing/able to pay	Cost per ML too excessive to start with Initial water demand/crop yield too conservative	Project economic viability questionable	Major	Possible	High	Ensure robust agreements are in place to avoid unwillingness to pay	Major	Unlikely	Medium		
	Financial		Beneficiaries unwilling to contribute i.e. QUU - avoided cost, State Govt - economic	Capex and cost of water per ML too excessive	Project economic viability questionable	Major	Possible	High	Commence early negotiations with relevant entities	Major	Possible	High		
	Financial		Gap between costs and revenue from irrigators	Pricing inaccurate Project Cost escalation	Project economic viability questionable	Major	Possible	High	Increase accuracies of cost estimate, better define project scope and tighter cost control on project to avoid cost overruns	Major	Unlikely	Medium		
	Financial		Costs to produce 'Project' increase, making water too expensive for growers	Initial Seqwater operational unit rates too conservative Financial and economic evaluation inaccurate	Project economic viability questionable	Major	Possible	High	1. Revisit unit rates accuracies and calculations 2. Refine cost quantities and assumptions	Major	Unlikely	Medium		
	Financial		Capacity to 'lock' end users into contracts. Potential to influence cost recovery	Demand assessment and forecast imprecise	May help the project viability	Minor	Likely	Medium	Comprehensive agreement with end users	Minor	Possible	Medium		
	Strategic		Change to WCRWS trigger (>60%)	Water Security Plan decreases the availablity of water by raising Key Bulk Water Storage to higher levels.	Commercial impacts Potential revenue loss	Minor	Possible	Medium	1. Farmers to increase on site storage 2. Seqwater to consider alternative source of potable water eg: desal	Minor	Unlikely	Low		
	Strategic		Change to WCRWS trigger (<60%)	Water Security Plan increases the availablity of water by raising Key Bulk Water Storage to lower levels.	Commercial impacts Potential revenue gain	Minor	Possible	Medium	1. Farmers reassured of reduced interruptions of water supply 2. Seqwater pressure to produce and distributre water is soften and can concentrate on improving plant reliabilities	Minor	Likely	Medium		
	Strategic		Time needed for source monitoring and to seek regulatory approval in the use of new source for source water (e.g. Sandgate STP)	1. Sandgate effluent quantities and suitable quality as additional source to be verified 2. New transfer pipeline requires a number of approvals	May delay the Project implementation (for option A only)	Moderate	Possible	Medium	Early stakeholder engagement to reduce approval timeframes	Moderate	Unlikely	Medium		
	Strategic		Time availability of WCRWS for irrigation uses will reduce in the long run. May require another option in addition to WCRWS for supply of irrigation use	1. Climate change, drought 2. Water Security Plan raises trigger point to reinstate WCRWS PRW operation 3. Qld govt may reserve the right to use water from the WCRWS to supplement potable water	Potential revenue loss for Project Supply reliability affected	Moderate	Possible	Medium	1. Keep Farmers informed 2. Start investigating additional source water, eg : from Logan or Beenleigh STPs or elsewhere to anticipate flow redcutions	Moderate	Unlikely	Medium		
	Strategic		Users reluctant to interrupt supply when required	User perception that Seqwater may revise their priorities	Supply reliability affected	Minor	Possible	Medium	Establish clear and frequent communication plan to inform farmers	Minor	Likely	Medium		
	Strategic		Future planning changes distribution of source water i.e. sea level rise impacts Luggage Point	1. Climate change 2. Availabilty of source water to feed WCRWS	Potential revenue loss for Project Supply reliability affected	Moderate	Possible	Medium	1. Keep Farmers informed 2. Start investigating additional source water, eg : from Logan or Beenleigh STPs or elsewhere to anticipate flow redcutions	Moderate	Unlikely	Medium		
	Strategic		Hurdle of direct discharge to water course (Options A,D)	ROC treatment for PRW scheme faces regulatory hurdle	Project viability jeapordised for Options A and D	Major	Possible	High	Work with Department of Environment and Heritage Protection to highlight the benefit of the project	Moderate	Possible	Medium		
	Strategic		DEWS says no to lesser quality water in WCWRS	Risk of water quality decrease as a result of delivering class A^+ , B/C water	Project viability jeapordised for Options B, C	Major	Possible	High	1. Develop a periodic water monitoring programme to sample, test and assess slime buildup in pipelines when delivering class A^+, B/C water 2. Undertake routine slime stripping campaign by maximising flow/velocity through pipelines 3. Conduct after test to assess effectiveness 4. Demonstrate to relevant authorities that no lesser water quality is encountered on WCRWS pipelines (when switched back to PRW)	Major	Unlikely	Medium		

Risk & Opportunity Register (Project Project Preliminary Business Case Development)

						Initial Risk Rating				Residual Risk Rating (with additional treatments / mitigations)				
Ref #	Class of Risk / Opportunity	Phase where Risk/Opportunity is Material	Risk/Opportunity Description	Cause	Impact to Project Objectives	Consequence Severity	Likelihood	Risk	Risk Mitigations/Opportunity enhancement	Consequence Severity	Likelihood	Risk	Risk Owner	Comments
	Strategic		Qld Health says no to lesser quality water in WCWRS	same as above	Project viability jeapordised for Options B, C	Major	Possible	High	1. Develop a periodic water monitoring programme to sample, test and assess slime buildup in pipelines when delivering class A^+, B/C water 2. Undertake routine slime stripping campaign by maximising flow/velocity through pipelines 3. Conduct after test to assess effectiveness 4. Demonstrate to relevant authorities that no lesser water quality is encountered on WCRWS pipelines (when switched back to PRW)	Major	Unlikely	Medium		
	Strategic		Seqwater says no to lesser quality water in WCWRS	same as above	Project viability jeapordised for Options B, C	Major	Possible	High	1. Develop a periodic water monitoring programme to sample, test and assess slime buildup in pipelines when delivering class A^+, B/C water 2. Undertake routine slime stripping campaign by maximising flow/velocity through pipelines 3. Conduct after test to assess effectiveness 4. Demonstrate to relevant authorities that no lesser water quality is encountered on WCRWS pipelines (when switched back to PRW)	Major	Unlikely	Medium		

Risk Criteria (Building Queensland Preliminary Business Case)

					CONSEQUENCE		
			INSIGNIFICANT	MINOR	MODERATE	MAJOR	SEVERE
Consequence Type	Financial	Capital cost of infrastructure solution	May require some slight modifications to proposed infrastructure	Changes required to proposed infrastructure with a cost impact of $1m	Changes required to proposed infrastructure with a cost impact of $10m	Changes required to proposed infrastructure with a cost impact of $100m	Proposed infrastructure solution cannot be implemented
		Operating cost of infrastructure solution	<5% increase in operating costs	5-10% increase in operating costs	10-20% increase in operating costs	20-50% increase in operating costs	>50% increase in operating costs
	Strategic	Regulatory changes or inability to effect regulatory change	Might cause some issues but not prevent the project.	Might add cost or time but not prevent the project.	Adds significant cost or time but not prevent the project.	Prevents several elements of the project proceeding.	Precludes the project from proceeding.
	Environment	Quantity of nutrients diverted from Moreton Bay	>50% of expected nutrient diversion	25-50% of expected nutrient diversion	15-25% of expected nutrient diversion	5-15% of expected nutrient diversion	<5% of expected nutrient diversion
		General environmental duty of care	Minor transient environmental harm	Limited impact which is fully recoverable	Significant release of pollutants with mid-term recovery (<1yr)	Significant environmental harm (1-5yrs) and costly restoration	Long-term (5-10yrs) environmetal harm
	Delivery	Volume of water available for irrigation	>50% of volume available	25-50% of volume available	15-25% of volume available	5-15% of volume available	<5% of expected volume available
		Volume of water that can be used for irrigation	>50% of volume to be used	25-50% of volume to be used	15-25% of volume to be used	5-15% of volume to be used	<5% of expected volume to be used
		Project Delivery	Delay in delivery <2 months	Delay in delivery 2-6 months	Delay in delivery 6-12 months	Delay in delivery 12-24 months	Delay in delivery >24 months
	Social / Community		Local small scale impact of social characteristics or values, and community acceptance of project. Negative local media attention	Short term recoverable changes to social characteristics or values, and community acceptance of project. Local media attention with short term reputational damage to Seqwater/QUU/SPV	Medium term recoverable changes to social characteristics or values, and community acceptance of project. Adverse local media coverage with medium term reputational damage to Seqwater/QUU/SPV	Long term recoverable changes to social characteristics or values, and community acceptance of project. Adverse state and local media coverage with long term reputational damage to Seqwater/QUU/SPV	Irrecoverable changes to social characteristics or values, and community acceptance of project. State intervention in response to adverse media coverage, Seqwater/QUU/SPV dismissed.
	Public Safety	Public Health associated with recycled water use	Minor injury - first aid treatment	Minor injury - medical treatment	Individual major injury requiring hospital attendance	Extensive serious or permanent inuries or disabilities, single fatality	Multiple fatalities

	Description	Rating	RISK RATING				
Likelihood	The event is expected to occur in most circumstances	**Almost certain**	Medium	Medium	High	High	High
	The event will probably occur in most circumstances	**Likely**	Low	Medium	High	High	High
	The event should occur at some time	**Moderate**	Low	Medium	Medium	High	High
	The event could occur at some time	**Unlikely**	Low	Low	Medium	Medium	Medium
	The event may occur only in exceptional circumstances	**Rare**	Low	Low	Low	Medium	Medium

Appendix N – Regional Economic Impacts

Regional economic impacts

A regional economic impact analysis was conducted by applying the input-output method, utilising a multi-regional model with non-linear properties. The purpose of regional economic impact analysis is to estimate the impact of the project on the level of economic activity in the region during both the construction and operational phase. This is achieved through an analysis of the inter-industry relationships within the regional economy.

Defining the region

There are some difficulties in determining the appropriate region(s) for modelling economic activity in the Lockyer Valley and on the Darling Downs. The Lockyer Valley is situated in the West Moreton region, which is normally included in the larger Brisbane-Moreton region of the Queensland Non-Linear Model (QNLM), whilst the Darling Downs is assigned to the Darling Downs economic model (within the QNLM). However, spatial divisions are often ad hoc and do not necessarily reflect economic linkages. As a result, it was considered that the true economic linkages in the region would be more accurately reflected by modelling both regions through the Darling Downs region within the QNLM.

Modelling approach

The Darling Downs regional economic model is one of a series of regional models that split the Queensland economy into six regions, plus a 'rest of Australia' region. Regional Gross State Product (GSP) data for the construction of this model was originally supplied by the Queensland Government Statistician's Office (QGSO) and updated from 2010/11 through projection and the injection of superior data which is used to constrain the model to reflect recognised aggregates. Available regional data are used where possible and the model is then adjusted through a balancing algorithm.[1]

The model achieves non-linear properties by the use of the IO-8 (originally) and IO-9 software developed by Guy West from the Centre of Economic Policy Modelling (CEPM) at the University of Queensland.[2] The current Darling Downs model was updated in 2015 to reflect latest Australian Bureau of Statistics (ABS) Census employment data and,

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[1] See, "Experimental estimates of Gross Regional Product" http://www.qgso.qld.gov.au/products/reports/experimental-estimates-grp/. It should be noted that more recent data are not available and statistical projection methods had to be used to achieve more current estimates.

[2] Some assumptions had to be made concerning elasticity coefficients for some industries. Where exact data was not known, the Rest of Australia (minus NSW) estimates were used.

more recently, supplemented by labour force data supplied by the ABS. Finally, it has been revamped in 2015 to take into account new estimates of output, income and employment elasticities made available at the University of Queensland.[3] In an essentially static model, the way in which non-linearities can be included is by the interaction of estimated elasticity coefficients upon the multipliers, particularly the employment and factor income multipliers.

It is important to note that economic impact analysis differs from cost-benefit analysis. Whilst the purpose of the latter is to determine whether a project will have a net economic benefit for society, the objective of economic impact analysis is to estimate the impact the project will have on the amount and type of economic activity in the region. Whilst the outputs from the economic impact analysis are not considered in assessing the economic viability of the project, it provides important information on regional economic impacts that are to be considered in the assessment.

Economic impacts assessed

The impacts assessed in the regional economic impact analysis are as follows:

- gross output (regional turnover) – the gross value of increased production from additional economic activity. This provides an indicator of the level of turnover in the economic and its capacity to accommodate increased economic activity;[4]
- value added (Gross State Product) – the additional or net output attributable to the project. This metric measures the added value placed on intermediate products from the productive process and typically includes margins, wages, profits and transfers. It is normally preferred to gross output when assessing the regional economic impact of a project;
- factor income – the share of value added and gross output that is directly paid to individuals or businesses in the form of wages and/or profits;[5] and
- employment – the amount of labour, in Full Time Equivalents (FTEs) required for the level of production.

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[3] As a result of this reason there are now some minor differences between sectoral results obtained within the current version and those obtained for the Darling Downs region in earlier studies.

[4] Gross output includes the value of raw materials that, in most cases, have already been counted as part of gross output from earlier production processes. Therefore, there is a tendency for gross output figures to include some double counting (hence more weighting is typically place on incremental measures such as ‘value added’).

[5] This measure is a proportion of value added.

Construction period impacts

This section summarises the regional economic impacts during the construction phase of the shortlisted options. The capital expenditure profile developed by GHD was applied to the Construction sector of the Darling Downs regional model. The data were averaged over a four year period and used to estimate average annual impacts for each year of the construction period. Taken over the four-year period, the total periodic impact would be approximately four times the average annual estimates.[6]

Table 1 sets out the annual estimates for the regional economic impacts derived for the construction phase of the four shortlisted options.

Table 1 Annual economic impacts during construction phase

Impact	Final demand	Industry effects	Consumption effects	Total impacts	Flow-on impacts
Option A					
Gross output/turnover	$550 million	$145 million	$383 million	$1,078 million	$528 million
Gross State Product	$276 million	$67 million	$315 million	$658 million	$382 million
Factor income	$141 million	$30 million	$237 million	$408 million	$267 million
Employment supported	776 FTEs	506 FTEs	1431 FTEs	2713 FTEs	1937 FTEs
Option B					
Gross output/turnover	$420 million	$111 million	$292 million	$823 million	$403 million
Gross State Product	$211 million	$51 million	$240 million	$502 million	$291 million
Factor income	$108 million	$23 million	$181 million	$312 million	$204 million
Employment supported	592 FTEs	386 FTEs	1166 FTEs	2144 FTEs	1552 FTEs
Option C					
Gross output/turnover	$384 million	$102 million	$268 million	$754 million	$370 million
Gross State Product	$194 million	$47 million	$220 million	$461 million	$267 million
Factor income	$99 million	$21 million	$169 million	$289 million	$190 million
Employment supported	543 FTEs	344 FTEs	1142 FTEs	2029 FTEs	1486 FTEs
Option D					
Gross output/turnover	$447 million	$118 million	$312 million	$877 million	$430 million
Gross State Product	$225 million	$55 million	$256 million	$536 million	$311 million
Factor income	$115 million	$25 million	$193 million	$333 million	$218 million
Employment supported	632 FTEs	412 FTEs	1154 FTEs	2198 FTEs	1566 FTEs

Source: Impacts derived from QNLM (2016) Darling Downs Table.

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[6] With some variations due to non-linear effects.

Whilst the estimated economic impacts reported in the above table are significant, it is important to note that this is a result of the significant capital expenditure and relatively short construction periods (given the amount of capital expenditure) under each of the shortlisted options. However, projects of this magnitude often play an important role in terms of maintaining a viable local construction industry.

Option A results in the largest economic impacts due to the higher direct investment under this option relative to the other shortlisted options.

Operational period impacts

In accordance with the outcomes of the water demand assessment, the operational impacts of the shortlisted options have been assessed based on increased production of the following crops:

- in the Lockyer Valley, lettuces, broccoli, cauliflower, cabbages, carrots and onions
- on the Darling Downs, cotton, maize, chickpeas and wheat.

As discussed in Section 3.2, cotton is the key crop produced on the Darling Downs, accounting for the most significant proportion of both irrigation water use and value of crop production in the region. This has been reflected in the economic impact analysis by estimating the economic impacts of increased cotton production separately to the increases in the production of other crops[7] (i.e. a stand alone cotton sector has been added to the Darling Downs regional model).[8] Whilst it would also be possible to create separate sectors for the other crops, this would place considerable strain on the integrity of the model due to the large amount of additional data required.[9]

It is important to note that non-linear input-output models are not designed to be applied for the estimation of long-term economic impacts. These models are most effective over five to seven-year periods as over longer periods structural changes in the economy have the capacity to require the model to be re-balanced and re-estimated to

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[7] As an alternative to modelling the economic impacts in accordance with the normal ANZSIC classifications in the 'Agriculture, Forestry and Fishing' sector.

[8] Note that this is not achieved without making some simplifying assumptions. In particular, the inter-sectoral flows between the newly created cotton sector and the rest of the Darling Downs economy as well as the extent of leakage (particularly exports) needed to be estimated. These were done based on average coefficients for Queensland as a whole. Therefore, the results obtained, although based on the best data available, should be treated as indicative.

[9] Furthermore, the large amount of additional data required and the relatively small amount of additional production of these crops (relative to current levels of production in the region) make this option problematic.

produce robust estimates. There is also the potential for significant changes in the estimated value of output over the long term.

Table 2 presents a long time series of revenue associated with the increased agricultural production under the shortlisted options.[10] These estimates are based on the outcomes of consultation conducted with growers and are based on the estimated volumes to be supplied under the shortlisted options.

Table 2 Average annual revenue from increased crop production

Crop category	2021-27	2028-35	2036-42[a]
Vegetable production – Lockyer Valley	$57.7 million	$48.5 million	$32.6 million
Cotton production – Darling Downs	$36.7 million	$32.9 million	$30.8 million
Wheat, maize and chickpea production – Darling Downs	$11.3 million	$10.1 million	$9.5 million

a Longer periods were not considered as they would be well beyond the scope of a static model.

Source: Synergies modelling.

The average annual revenues for the 2021-27 period have been used to model the regional economic impacts for the operational phase. In the absence of detailed production cost data, revenue data has been applied to estimate impacts with default assumptions concerning operating surplus and profits.

The estimated impacts associated with the increase in vegetable crop production in the Lockyer Valley are set out in Table 3.

Table 3 Annual economic impacts – increased agricultural production in the Lockyer Valley

Impact	Final demand	Industry effects	Consumption effects	Total impacts	Flow-on impacts
Gross output/turnover	$57.7 million	$19.1 million	$32.8 million	$109.6 million	$51.9 million
Gross State Product	$26.8 million	$9.7 million	$18.8 million	$55.2 million	$28.4 million
Factor income	$13.4 million	$4.4 million	$11.8 million	$29.6 million	$16.2 million
Employment supported	627 FTEs	175 FTEs	230 FTEs	1,032 FTEs	405 FTEs

Note: Estimated impacts are based on projected average annual revenue for the period 2021-27.

Source: Synergies modelling.

The above results indicate that the increase in vegetable crop production in the Lockyer Valley under the shortlisted options leads to an output multiplier of 1.90, a value added multiplier of 2.06, an income multiplier of 2.21, and an employment multiplier of 1.64. These estimates are consistent with a number of other studies that have assessed the wider economic impacts of agricultural production, as shown in the table below. It is

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[10] Note that the operational impacts have been modelled based on the additional crop production to be achieved by the water to be made available under shortlisted options A, B and C.

noted that the multipliers estimated in this study are conservative relative to these estimates.

Table 4 Multiplier estimates from past economic impact studies in the agriculture, forestry and fishing sector

Study	Year	Multiplier estimates
NSW Department of Transport and Industry – 'The Contribution of Primary Industries to the New South Wales Economy'	2004	2A output multiplier for forestry and logging of 2.45; 2A output multiplier for agriculture of 2.17
Grane, G. – 'Employment Multipliers in the Forestry and Wood-based Industries in the Australian Economy, a CGE Analysis'	1998	2A employment multiplier of 1.8
Murty, A. & Cubbage, F. – 'An update on the economic contributions of the forest-based industries in the South'	2004	2A output multiplier of 1.88; 2A value added multiplier of 2.25; 2A income multiplier of 2.13; 2A employment multiplier of 1.61
Schmid, J. – 'Assessment of the Employment and Economic Consequences of a Change in Access to Tasmania's publicly owned native forests'	2012	2A output multipliers of 1.6-2.1 (State) and 2.2-2.9 (National); 2A income multipliers of 1.4-2.2 (State) and 2.6-3.0 (National); 2A employment multipliers of 1.5-2.3 (State) and 2.5-2.7 (National)

Note: It should be noted that non-linear models by design tend to produce lower employment impacts than standard input-output models.

Source: Various.

Table 5 presents the estimated annual impacts associated with the increase in cotton production on the Darling Downs. As previously stated, the impacts of the project during the operational phase have been modelled separately for cotton production and the production of other broadacre crops on the Darling Downs.

Table 5 Annual economic impacts – increased cotton production on the Darling Downs

Impact	Final demand	Industry effects	Consumption effects	Total impacts	Flow-on impacts
Gross output/turnover	$36.7 million	$12.2 million	$35.7 million	$84.6 million	$47.9 million
Gross State Product	$19.9 million	$6.2 million	$23.1 million	$49.2 million	$29.4 million
Factor income	$9.6 million	$3.1 million	$17.4 million	$30.0 million	$20.5 million
Employment supported	362 FTEs	64 FTEs	265 FTEs	691 FTEs	329 FTEs

Note: Estimated impacts are based on projected average annual revenue for the period 2021-27.

Source: Synergies modelling.

Expenditure on cotton results in greater regional economic impacts relative to other broadacre crops produced on the Darling Downs. Based on the estimated impacts produced by the model, cotton production in the region has an output multiplier of 2.3, a value added multiplier of 2.47, an income multiplier of 3.14, and an employment multiplier of 1.91. These are significantly higher than the multipliers that apply to the production of other broadacre crops in the region.

Table 6 presents the estimated annual impacts associated with the increase in production of other broadacre crops on the Darling Downs.

Table 6 Annual economic impacts – increased broadacre crop production on the Darling Downs

Impact	Final demand	Industry effects	Consumption effects	Total impacts	Flow-on impacts
Gross output/turnover	$11.3 million	$3.7 million	$5.9 million	$20.9 million	$9.6 million
Gross State Product	$5.3 million	$1.9 million	$3.5 million	$10.6 million	$5.4 million
Factor income	$2.6 million	$0.9 million	$2.7 million	$6.2 million	$4.0 million
Employment supported	122 FTEs	36 FTEs	53 FTEs	211 FTEs	89 FTEs

Note: Estimated impacts are based on projected average annual revenue for the period 2021-27.

Source: Synergies modelling.

Summary of regional economic impacts

The key findings from the regional economic impact analysis of the shortlisted options are as follows:

- during the construction phase of the project, the shortlisted options will generate annual increases in total gross output ranging from $1,332 million to $1,646 million and additional value added (i.e. Gross State Product) ranging from $814 million to $1,006 million;
- operational impacts of the shortlisted options were modelled based on the volume of water to be made available for agricultural use (and the associated demand profiles) under Options A, B and C. This resulted in the following annual impacts being estimated:
  - an increase in total gross output of $109.6 million in the Lockyer Valley, $84.6 million from increased cotton production on the Darling Downs, and $20.9 million from the production of other broadacre crops on the Darling Downs;
  - an increase in value added of $55.2 million in the Lockyer Valley, $49.2 million from increased cotton production on the Darling Downs, and $10.6 million from the production of other broadacre crops on the Darling Downs; and
- the project has a significant impact on employment, particularly during the construction phase, with modelling estimating the shortlisted options will generate employment ranging from 3,584 FTEs to 4,142 FTEs. In the operating phase, employment generated is estimated at 1,934 FTEs across both regions (under Options A, B and C).

Attachment – Non-linear input-output models

The Non-Linear Input-Output Model seeks to remove one of the major limitations of standard input-output analysis by removing the assumption of linear coefficients for the household sector and allowing marginal income coefficients adjustment.[11] This is because, as is widely known, the household sector is the dominant component of multiplier effects in an input-output table. As a result, using marginal income coefficients for the household sector will provide a more accurate, and empirically more valid, estimate of the multiplier effects, which in turn, provides results closer to those of a computable general equilibrium (CGE) model. The transactions flows in the input-output table can be expressed in matrix equation form as:

$$\mathbf{T}(\hat{\mathbf{X}}^{-1})\mathbf{X} + \mathbf{Y} = \mathbf{X}$$

That is, for each industry, total industry sales equal intermediate sales to other industries for further processing plus sales to final users, where T is the matrix of intermediate transactions, X is the column vector of sector total outputs and Y is the column vector of aggregate final demands. This can be rewritten as:

$$\mathbf{AX} + \mathbf{Y} = \mathbf{X}$$

Where A is the matrix of direct coefficients which represents the amounts of inputs requires from sector *i* per unit of output of sector *j*. Thus, for a given direct coefficient matrix, it is possible to solve the set of simultaneous equations to find the new sector production levels X which will be required to satisfy a potential or actual change in the levels of sector final demands Y. By rearranging and converting to differences, this equation can be rewritten as:

$$\Delta\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\Delta\mathbf{Y}$$

Where $(\mathbf{I} - \mathbf{A})^{-1}$ is termed the total requirements table, Leontief inverse matrix or general solution, and represent the direct and indirect change in the output of each sector in response to a change in the final demand of each sector. ΔY can incorporate any element of final demand expenditure, including household expenditure, government expenditure and capital expenditure.

This model is a linear model in which the A matrix represents a (constant) matrix of average input propensities. Normally, the A matrix endogenises[12] the household sector so that household consumption induced effects can be measured. This is referred to as the Type II model; the alternative Type I model is where households are treated as

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[11] The description of the Non-Linear model properties is taken from CEPM model descriptions (West, 2003).

[12] That is, household income varies with the level of intersectoral activity.

exogenous to local economic activity. Generally speaking, the consumption-induced effects are the largest component of the total multipliers. This is because consumer driven consumption (and income) to a large extent dominates local economic activity.

Total inputs are equal to intermediate inputs plus primary inputs (labour and capital). In the conventional input-output model, the inputs purchased by each sector are a function only of the level of output of that sector. The input function is assumed linear and homogeneous of degree one, which implies constant returns to scale and no substitution between inputs. A more reasonable assumption is to allow substitution between primary factors. If there is an expansion in economic activity, say due to a development project, employers will attempt to increase output without corresponding proportional increases in employment numbers, particularly in the short term, e.g. construction projects, where there are economies of scale in getting the existing workforce to work longer hours rather than employ additional persons. This occurs for two reasons.

First, there is evidence in Australia that labour productivity (output per employee) is increasing over time. Secondly, as companies strive to reduce costs and satisfy the micro-economic reform processes imposed on all states by the National Competition Policy, there is evidence of a shift in primary factor use from labour to capital. This implies that the conventional input-output model has a tendency to overestimate impacts, in particular the income and employment impacts. Therefore, a more realistic approach to modelling impacts is to replace the average expenditure propensities for labour income by employers with marginal input propensities. In other words, the household income row in the A matrix, which are average input coefficients, should be replaced by income elasticities of demand. Note that, as in the CGE model, the linear coefficients assumption between intermediate inputs, and also total primary inputs, and total inputs is retained.

One problem associated with this approach is that the solution procedure is now more complex. Now the income impacts will be a function of ΔX but the income coefficients are included in the A matrix which determines ΔX. Therefore, the equation set becomes recursive; ΔX depends on A and A depends on ΔX. Solving the input-output equation therefore requires an iterative procedure, a common method being the Gauss-Seidel method.

The income and employment flow-ons from the initial impact also need to be modified. In the conventional input-output model, income and employment flow-ons are calculated as linear functions of the output flow-ons, but in the revised model the parameters relating income to output are no longer constant. The impact on household income needs to be calculated as the difference between the base (i.e. before impact) income levels and the post impact income levels. It can be shown that this is equivalent to using the matrix equation:

$$\mathbf{\Delta Inc} = \mathbf{\hat{X}_0^{-1}}(\Delta\mathbf{\hat{X}})\mathbf{\hat{L}U_0}$$

Where U is a vector of household income flows and L is a vector of sectoral household income elasticities of demand. The zero subscript denotes the base level values and the hat denotes a diagonal matrix formed from the elements of the corresponding vector. This equation simply states that, for each sector, the change in household income payments equals the proportional change in output times the base level income payments multiplied by the income elasticity of demand. These income elasticities of demand can be shown to be equal to:

$$I_j = \eta_{WX} + \eta_{EX}$$

Where ηWX is the elasticity of wage rate with respect to output, and ηEX is the elasticity of labour demand with respect to output; that is, they are made up of two components, the wage price component and the labour productivity component.

Similarly, the change in sectoral employment can be calculated as the change in the sectoral wage bill times the wage rate:

$$\mathbf{\Delta Emp = \hat{H}_0^{-1}\hat{P}_0^{-1}\Delta Inc}$$

Where H is a vector of average household income coefficients and P is a vector of coefficients representing average output per employee.

There are several implications arising from the use of this model, compared to the conventional input-output model. Firstly, while the output multipliers and impacts should not be significantly different between the two models, we would expect the income and employment impacts to be smaller in the marginal coefficient model. This is because many industries, especially those which are more capital intensive and can implement further productivity gains, can increase output, particularly in the short run,[13] without corresponding proportional increases in employment and hence income payments.

Secondly, unlike the conventional input-output model in which the multiplier value is the same for all multiples of the initial shock, the multiplier values from the marginal coefficient model vary with the size of the initial impact. Thus, larger changes in final

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[13] The term 'short run' here does not refer to any specific time period; rather it will vary from industry to industry. It is used here in the conventional economic sense to mean that the full adjustment from any shock has not had time to occur, i.e. the system has not yet returned to full, long run, equilibrium.

demand will tend to be associated with smaller multipliers than small changes in final demand. Therefore, the differential impacts of the marginal coefficient model are not additive, unlike the conventional (linear) Leontief model and CGE model. Overall, within the confines of a static model, the major improvements brought by the non-linear model are to improve the overall accuracy of the factor income and employment impact projections.

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