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Final report to the Queensland Farmers' Federation

Economic and financial assessment of the NuWater project

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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]

[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,

[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

[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;

[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.

[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.

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]

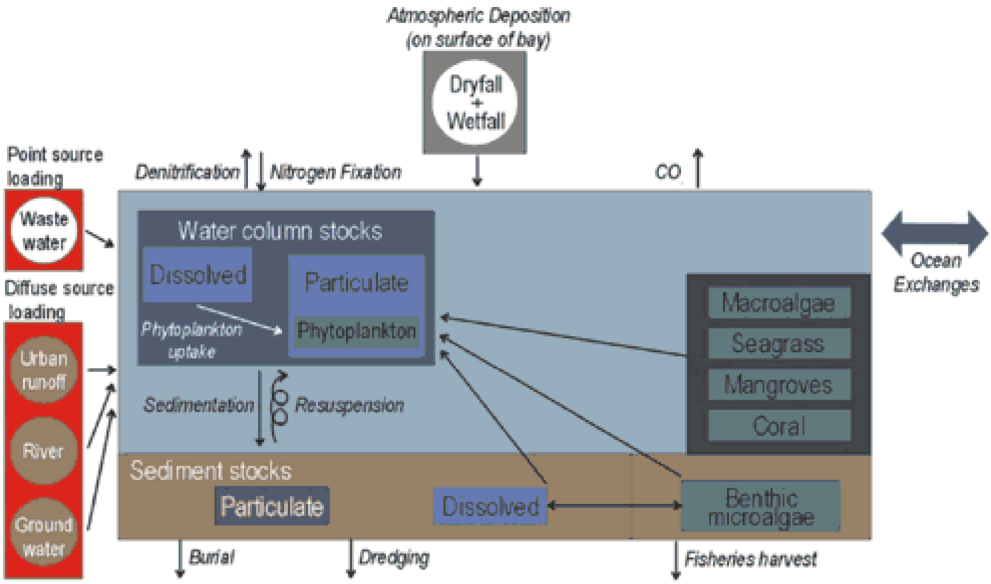
32 'Moreton Bay Region – Tourism visitor summary'; Moreton Bay Region Industry and Tourism; See: http://economy.id.com.au/moreton-bay/tourism-visitor-summary; DOA: 25 October 2017.

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.

[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

[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

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

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.

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

[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

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

[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

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

[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

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.

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.

[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

[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]

[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

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

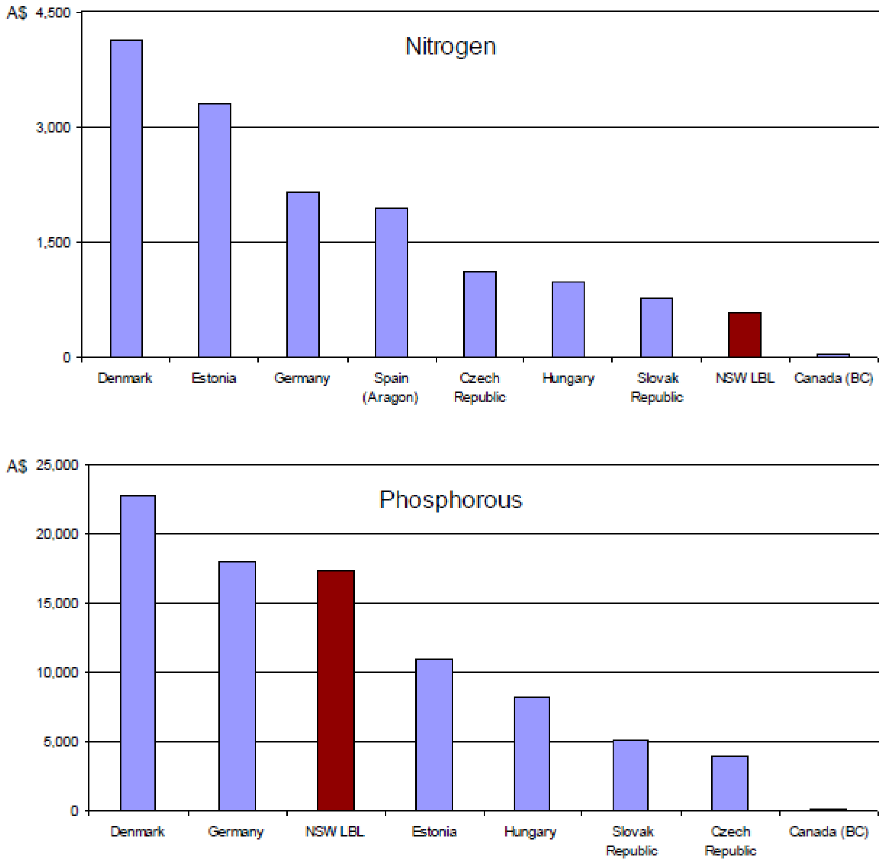
72 NSW EPA (2016). NSW EPA’s Load-based Licensing Scheme. Overview of facts about load-based licensing, October 2016, p. 1.

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.