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Final report to the Queensland Farmers' Federation

Water demand assessment for the NuWater Project feasibility study

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Executive Summary

Purpose and approach

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

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

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

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

Water supply-demand balance

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

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

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

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

Consultation with water users

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

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

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

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

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

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

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

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

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

Returns to water use

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

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

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

water supplied to growers in the Lockyer Valley would be applied to expand (or maintain) areas under crop production.

Lockyer Valley demand

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

Summary of modelling results for the Lockyer Valley

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

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

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

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

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

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

Darling Downs demand

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

Summary of modelling results for the Darling Downs

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

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

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

Breakdown of water use for crop production on the Darling Downs

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

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

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

Other sources of demand

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

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

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Figures and Tables

1 Introduction

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

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

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

The report is set out as follows:

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

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

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

2 Background and approach

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

2.1 Project overview

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

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

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

The key features of the NuWater project are as follows:

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

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

2.2 Previous reports

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

The 2003 business case was conducted on the following project:

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

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

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

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

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

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

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

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

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

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

2.3 Current status

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

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

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

- increase in urban wastewater volumes available for beneficial reuse;

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

2.4 Approach to demand assessment

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

2.4.1 Approach to assessing agricultural water demand

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

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

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

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

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

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

The aim of this consultation was to identify:

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

2.4.2 Approach to assessing industrial water demand

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

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

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

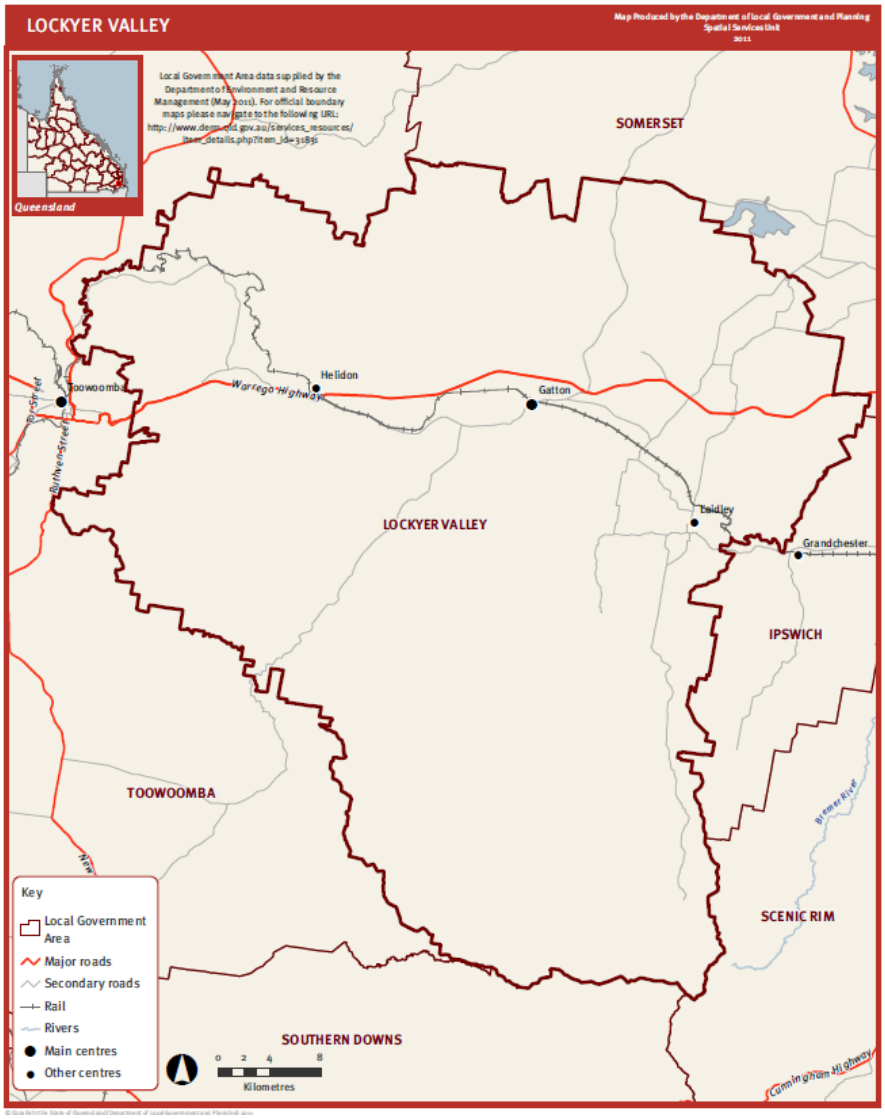
3 Regional economic overview

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

3.1 Lockyer Valley

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

Figure 1 Map of the Lockyer Valley region



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

3.1.1 Agricultural production

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

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

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

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

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

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

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

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

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

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

3.1.2 Industrial activity

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

3.2 Darling Downs

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

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

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

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

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

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

Figure 2 Map of the Darling Downs Region

3.2.1 Agricultural production

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

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

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

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

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

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

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

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

The key observations from the above table are as follows:

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

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

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

3.2.2 Industrial activity

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

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

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

[11] TIQ Darling Downs regional profile.

[12] TIQ Darling Downs regional profile.

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

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

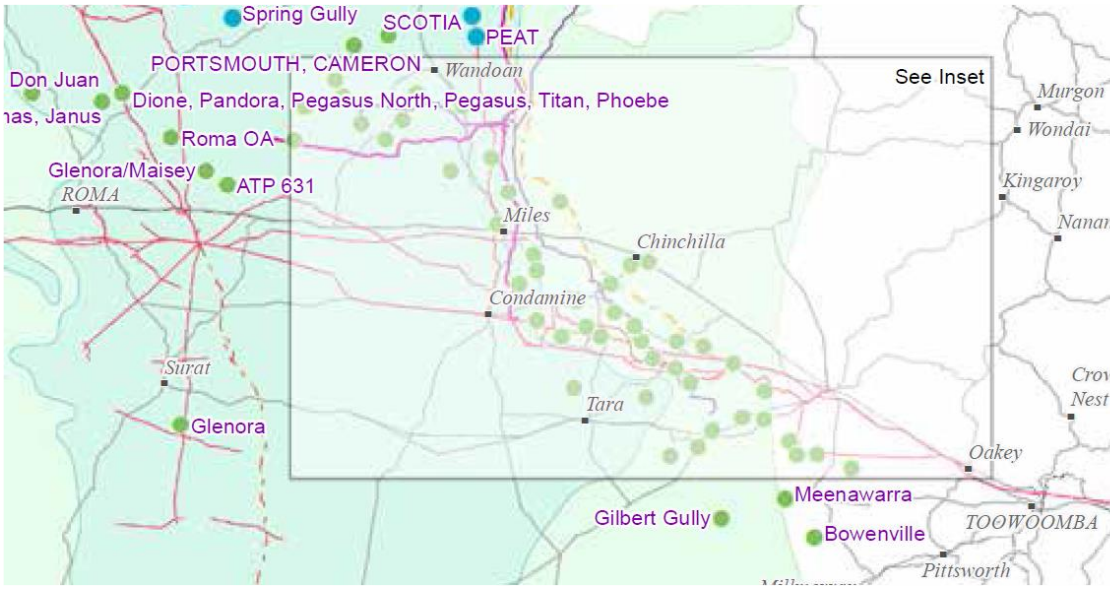
The South West region has become a major energy hub over the past decade, with the region containing several major power stations a large number of significant coal mining and CSG projects. There are several coal and gas power stations located in the Darling Downs, including the Condamine Power Station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

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

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

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

Figure 3 Location of CSG projects in the project area



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

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

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

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

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

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

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

4 Current water supply and demand

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

4.1 Lockyer Valley

4.1.1 Water supply

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

Groundwater

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

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

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

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

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

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

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

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

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

Surface water

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

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

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

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

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

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

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

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

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

4.1.2 Water demand

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

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

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

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

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

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

Table 3 Irrigation water use on crops in the Lockyer Valley

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

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

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

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

4.2 Darling Downs

4.2.1 Water supply

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

[27] Queensland Agricultural Land Audit.

[28] Based on consultation with growers.

Groundwater

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

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

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

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

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

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

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

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

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

Surface water

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

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

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

4.2.2 Water demand

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

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

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

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

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

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

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

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

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

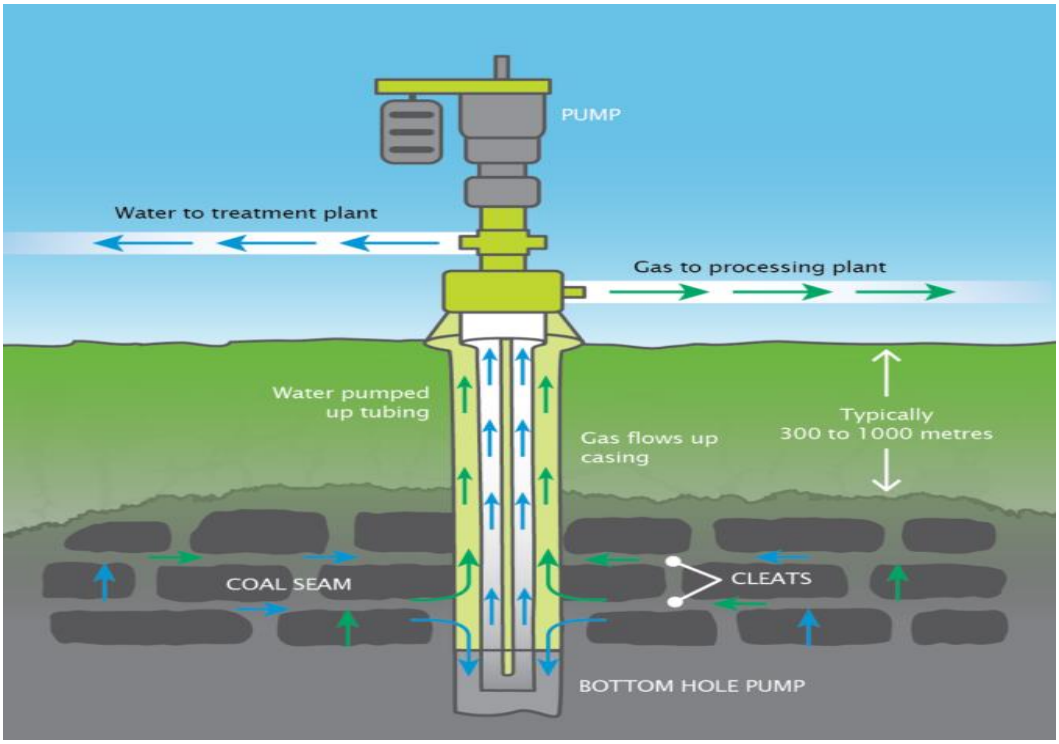
Source: Psi Delta (2010). Healthy Headwaters. Coal Seam Gas Water Feasibility Study. South West Queensland Water Demand Analysis. Non-Urban Demand, August 2010, p. 5.

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

In terms of future industrial water demand in the region, the 'make good' requirements of CSG producers are likely to represent the most likely source of potential demand. CSG production requires water to be pumped from the target coal seam to the surface in order

to release gases from coal particulars. The ratio of gas to water gradually increases over the duration of the life of the gas well due to the decreasing pressure resulting from the pumping of water. This extraction process is demonstrated in the figure below.

Figure 4 Schematic diagram of a standard CSG extraction process



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

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

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

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

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

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

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

4.3 Summary

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

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

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

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

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

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

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

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

5 Water market analysis

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

5.1 Lockyer Valley

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

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

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

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

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

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

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

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

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

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

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

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

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

5.2 Darling Downs

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

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

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

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

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

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

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

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

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

The above table shows that water trading activity is far greater in the Upper Condamine WSS than the other WSS in the region relevant to the project. In 2015/16 and 2016/17, over 4,300 ML of supplemented surface water allocations and over 5,000 ML of

unsupplemented surface water allocations were traded in the Upper Condamine WSS. In addition, the average price of some trades exceeded $3,000 per ML for supplemented allocations and $2,000 per ML for unsupplemented allocations. There is also significant trading activity in the temporary water market in the Upper Condamine WSS, as demonstrated in Table 11.

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

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

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

5.3 Conclusions

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

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

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

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

6 Consultation with agricultural water users

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

6.1 Engagement process

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

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

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

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

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

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

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

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

6.2 Irrigator survey

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

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

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

6.2.1 Lockyer Valley survey responses

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

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

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

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

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

6.2.2 Darling Downs survey responses

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

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

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

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

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

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

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

Source: Responses to irrigator survey.

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

6.3 Grower consultation days

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

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

The purpose of the grower consultation days was to:

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

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

6.3.1 Lockyer Valley

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

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

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

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

6.3.2 Darling Downs

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

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

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

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

6.4 Key findings

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

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

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

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

7 Modelling the on-farm returns from irrigation water

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

7.1 Crops modelled

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

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

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

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

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

7.2 Data and information sources

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

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

7.3 Beneficial uses of irrigation water

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

7.3.1 Application to existing cropped area

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

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

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

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

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

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

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

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

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

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

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

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

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

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

7.3.2 Expansion of area under crop production

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

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

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

Availability of suitable land

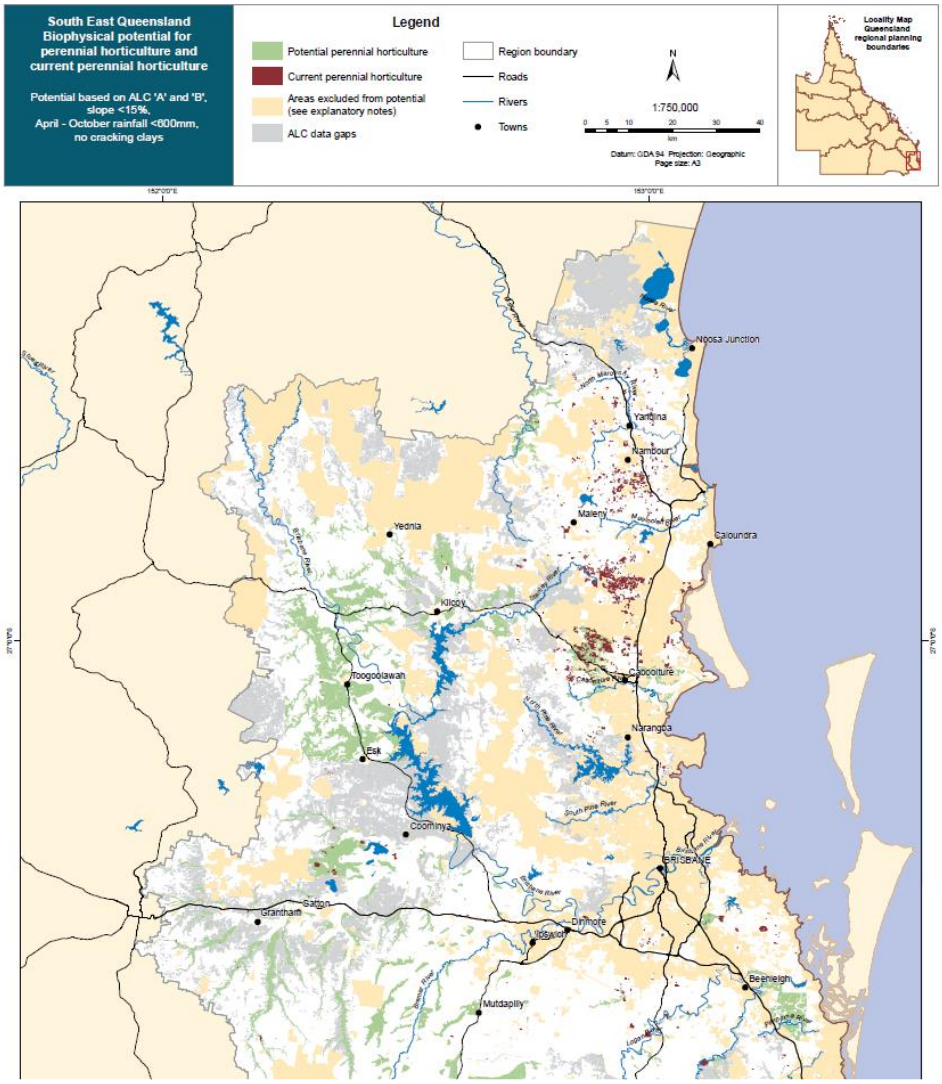
The Queensland Government periodically undertakes audits of agricultural land in different regions of Queensland. The purpose of these audits is to document current agricultural land uses and also to assess the potential for the expansion of agricultural production into new areas.

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

Lockyer Valley

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

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



Source: Queensland Agricultural Land Audit.

Darling Downs

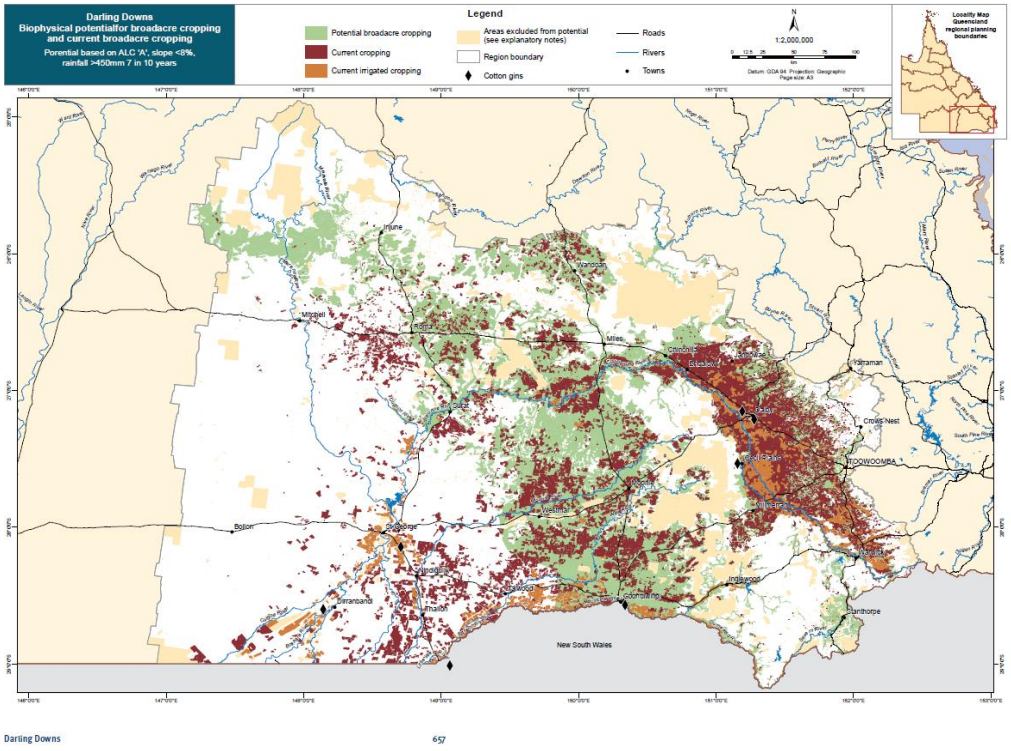
The outcomes of the audit for the Darling Downs region demonstrated that whilst broadacre cropping accounts for a significant proportion of total land use in the region, a significant proportion of 'potential' cropping land is currently used for grazing. The 2006 Queensland Land Use Mapping Program has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

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

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

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

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



Data source: Queensland Agricultural Land Audit.

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

An increase in the value of crops produced using additional irrigation water could occur as a result of growers shifting from lower value to higher value crops. For example, a grower on the Darling Downs could move from growing dryland lucerne to irrigated cotton were they to have access to additional irrigation water. Whilst this would be

modelled as an expansion in area of crop production, it would also be necessary to take into account the loss of value derived from the production of the lower value crop – it would only be the difference that would constitute the gain in value as a result of the application of irrigation water.

Market demand

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

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

Fixed costs of expansion

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

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

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

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

Overview of potential for expansion of crop production

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

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

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

Opportunity cost of expanding crop production

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

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

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

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

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

8 Modelling results

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

8.1 Lockyer Valley crops

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

8.1.1 Lettuce

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

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

[50] Australian Bureau of Statistics (2008).

[51] Australian Bureau of Statistics (2012).

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

[53] AusVeg market snapshots.

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

Table 14 Parameters for lettuce production

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

a Cartons have a capacity of 62L.

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

Source: Various.

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

8.1.2 Broccoli

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

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

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

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

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

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

Table 15 Parameters for broccoli production

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

a Cartons contain an average of 8 kilograms.

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

Source: Various.

[56] Australian Horticultural Update – August 2017.

[57] AusVeg market snapshots.

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

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

8.1.3 Onions

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

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

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

Table 16 Parameters for onion production

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

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

[59] AEC (2013).

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

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

[62] AusVeg market snapshots.

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

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

Source: Various.

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

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

8.1.4 Carrots

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

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

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

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

[65] AusVeg market snapshots.

Table 17 Parameters for carrot production

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

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

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

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

8.1.5 Cabbage

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

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

[67] Australian Bureau of Statistics (2008).

[68] AusVeg market snapshots.

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

Table 18 Parameters for cabbage production

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

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

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

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

8.1.6 Cauliflower

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

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

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

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

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

Table 19 Parameters for cauliflower production

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

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

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

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

8.1.7 Summary of returns in the Lockyer Valley

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

[71] AusVeg.

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

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

8.2 Darling Downs crops

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

8.2.1 Cotton

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

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

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

[73] Australian Bureau of Statistics (2012).

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

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

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

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

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

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

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

Source: Various.

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

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

Application to established crops

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

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

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

Expansion of crop production

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

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

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

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

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

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

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

8.2.2 Maize

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

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

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

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

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

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

[79] Australian Bureau of Statistics (2012).

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

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

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

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

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

Source: Various.

Application to established crops

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

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

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

Expansion of crop production

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

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

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

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

8.2.3 Chickpeas

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

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

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

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

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

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

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

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

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

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

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

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

Source: Various.

Application to established crops

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

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

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

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

Expansion of crop production

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

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

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

8.2.4 Sorghum

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

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

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

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

[89] Australian Bureau of Statistics (2012).

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

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

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

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

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

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

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

Source: Various.

Application to established crops

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

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

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

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

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

Expansion of crop production

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

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

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

8.2.5 Wheat

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

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

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

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

[93] Australian Bureau of Statistics (2012).

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

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

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

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

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

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

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

Source: Various.

Application to established crops

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

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

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

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

Expansion of crop production

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

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

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

8.2.6 Summary of returns from water use on the Darling Downs

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

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

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

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

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

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

Source: Synergies modelling.

9 Water demand for other uses

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

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

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

9.1 Intensive animal producers

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

Table 26 Summary of outcomes of consultation with intensive animal producers

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

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

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

In summary:

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

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

9.2 'Make good' requirements for CSG producers

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

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

9.3 Implications for the NuWater project

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

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

10 Key findings and implications

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

10.1 Crop production

10.1.1 Lockyer Valley

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

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

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

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

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

per annum, this would represent an increase in water use (and hence agricultural production) of between 8 and 17 per cent.[98]

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

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

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

10.1.2 Darling Downs

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

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

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

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

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

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

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

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

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

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

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

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

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

10.2 Intensive animal production

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

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

10.3 Industrial water demand

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

10.4 Overall demand and findings

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

- for the Darling Downs, survey respondents identified total demand of 46,050 ML. Given the preliminary stage of this feasibility study, the relatively small proportion of growers on the central Darling Downs that responded to the irrigator survey, and

the results of the crop modelling, it is concluded that actual demand on the Darling Downs is significantly greater than 46,050 ML; and

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

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

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

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

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

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

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

In terms of industrial demand, the only potential industrial water user identified as a potential customer for the NuWater project were CSG producers on the Darling Downs. Whilst there is the potential for water to be supplied to CSG producers to meet their

'make good' requirements, the uncertainty over the timing and magnitude of these requirements means that CSG producers have not been included in the demand profile for the project.

A Grower questionnaire

Preamble

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

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

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

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

QUESTIONNAIRE

Property details

Property Owner/manager: _____

Property Address: _____

Land Availability

Total area of property: _____ ha

Total area suitable for cropping: _____ ha

Total area suitable for irrigation: _____ ha

Land Use

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

Irrigated cropping:

Crop 1 _____ Area[1]: _____ha

Crop 2 _____ Area[1]: _____ha

Crop 3 _____ Area[1]: _____ha

Crop 4 _____ Area[1]: _____ha

Crop 5 _____ Area[1]: _____ha

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

Water supply

Current water resources

Groundwater nominal allocation: _____ Ml, licence conditions, etc

Groundwater announced allocation: _____ Ml, percent current period

Supplemented nominal allocation: _____ Ml

Supplemented announced allocation: _____ Ml, percent current period

Unsupplemented allocation: _____ Ml, harvesting conditions, etc

On-farm water storage capacity

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

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

Recent water purchases

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

_____
_____
_____
_____
_____

Water Use and irrigation method

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

Crop 1 _____Ml Applic. rate: _____ Ml/ha Method:_____

Crop 2 _____Ml Applic. rate: _____ Ml/ ha Method:_____

Crop 3 _____Ml Applic. rate: _____ Ml/ ha Method:_____

Crop 4 _____Ml Applic. rate: _____ Ml/ ha Method:_____

Crop 5 _____Ml Applic. rate: _____ Ml/ ha Method:_____

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

Estimated total water use: _____ Ml/annum

Future water supply, demand and Use

Future Water Supplies

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

YES/NO

_____
_____
_____
_____
_____

Future Water Use

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

YES/NO

_____
_____
_____
_____
_____

Demand for recycled Water

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

YES/NO

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

_____ Ml

Use of recycled water

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

For use on existing cropped areas: _____ %

For use on new cropping areas: _____ %

Application to existing crops

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

Crop _____

Application Rate _____ Ml/ha

Additional revenue from this crop _____ %

Crop _____

Application Rate _____ Ml/ha

Additional revenue from this crop _____ %

Crop _____

Application Rate _____ Ml/ha

Additional revenue from this crop _____ %

Expansion of cropping area

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

Crop 1 _____

Area irrigated: _____ ha

Application Rate: _____ Ml/ha

Crop 2 _____

Area irrigated: _____ ha

Application Rate: _____ Ml/ha

Crop 3 _____

Area irrigated: _____ ha

Application Rate: _____ Ml/ha

Level of reliability and timing requirements

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

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

_____

_____

_____

_____

Timing of Supply

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

_____

_____

_____

_____

_____

Water quality and nutrient composition

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

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

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

_____
_____
_____
_____

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

_____
_____
_____

Willingness to pay for water

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

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

800	_____ Ml
1000	_____ Ml
1200	_____ Ml