Pre-feasibility

Water for agriculture productivity and sustainability

3606-15

Prepared for

Lockyer Valley Regional Council

28 February 2018

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Executive Summary

Introduction

Lockyer Valley Regional Council (LVRC) has obtained funding under the National Water Infrastructure Development Fund (NWIDF) to undertake a pre-feasibility study to identify supply options for securing water for the agricultural sector.

The objective of the study is to identify a long list of potential water supply options and screen these options against criteria including availability, reliability, costs to supply (fixed and variable), environmental impacts, social impacts and regulatory constraints, in order to generate a short list of options that will be progressed to the full feasibility study. Cardno, in association with Marsden Jacob Associates, has been commissioned to undertake this study.

This pre-feasibility study does not include:

> A detailed assessment of the demand for, or willingness of end users to pay for, water from the various supply options

> A cost benefit analysis of pursuing any of the identified supply options.

It is the objective of this pre-feasibility study to inform a later demand assessment and detailed business case. This pre-feasibility study therefore establishes a baseline of information relating to the supply options available and conduct a technical and financial assessment of these options to enable the detailed business case to be focused on a small number of viable options.

Methodology

The following activities have been undertaken to complete this pre-feasibility study:

> Literature review of previous studies. An overview of previous studies and their relevance to this pre-feasibility study is included in Appendix B

> Engagement with the community and stakeholders. Community engagement was led by Lockyer Valley Regional Council. Details of the engagement undertaken and the findings are included in Appendix C

> Based on the literature review, stakeholder engagement and further research and analysis, a long list of potential water security options was generated. The long list of options is included in Appendix D

> The long list of options have been assessed against the project objectives to arrive at a short list of options

> Conclusions on the feasibility of the shortlisted options to meet the project objectives have been made and recommendations for future work have been made.

The need for water security in the Lockyer Valley

The following is evidence that water security is a current and future constraint to agricultural productivity and sustainability in the Lockyer Valley:

> *High quality land not in use* – around 35% (15,000ha) of the high quality agricultural land in the Lockyer Valley is currently not in use. There is an opportunity to increase agricultural output by bringing this land into production. However, this will require additional water to be supplied

> *More productive use of existing land* – there is a move to more intensive irrigated agriculture in the Lockyer Valley in large scale greenhouses. Greenhouses generally use more water and produce more for the same area under production. They also require more reliable supplies to support year round production. Increased intensive animal husbandry has a similar requirement for increased volumes of more reliable water. Across the region, the production of vegetables for human consumption has increased by 24% in the five years between 2010/11 and 2015/16 (Australian Bureau of Statistics, 2012) (Australian Bureau of Statistics, 2017). This suggests that the region has intrinsic locational advantages and improving productivity which could support further growth in this sector should water availability be improved.

> *Potential for value adding* – there is currently limited processing of agricultural produce in the Lockyer Valley. Processing would benefit the regional economy but generally requires reliable water supply.

> *Climate change* – climate change is anticipated to more likely impact the Lockyer Valley than competing regions. Anticipated impacts include declining average annual rainfall and reduce groundwater reliability. Both of these impacts challenge future water security for agriculture.

> *Performance of existing water sources* – the alluvial groundwater aquifers in the Lockyer Valley experience stress in times of low rainfall although they can be recharged relatively quickly following sustained rainfall. The two regulated supply schemes do not provide reliable water. The Lower Lockyer Valley WSS has had an announced allocation of 100% in only five out of the last twelve years. The combined median releases from the three large storages in the Lockyer Valley since 1995 represent less than 10% of estimated average annual usage.

> *Proposed changes to groundwater management* – The Queensland Government is considering new water-resource management arrangements for groundwater areas benefited by operation of the Central Lockyer Water Supply Scheme. The new arrangements which are yet to be defined are intended to specify entitlements and provide equitable access to groundwater. To the extent that these new arrangements reduce the availability of groundwater in some instances production of agricultural products may be reduced.

> *Increased global demand for food and fibre* – the Queensland and Commonwealth governments both recognise the opportunity for agricultural production in Australia to supply growing global demand for food and fibre and accordingly have policies to support growth in agricultural exports.

> *Environmental benefits* - Environmental benefits may be realised from increased water security in the Lockyer Valley were groundwater extraction to be reduced. This would lead to higher groundwater levels and higher flows in surface watercourses. However, investment in riparian rehabilitation is anticipated to be required to reduce sediment loading and realise the associated benefits. Environmental benefits may also be realised where recycled water is used and reduces nutrient loading into watercourses and Moreton Bay.

There is no existing plan for securing water for the Lockyer Valley to meet these challenges and capitalise on the opportunities.

Option long list

Based on literature review, stakeholder engagement and further research and analysis, a long list of potential supply options to improve water security was generated. This list is summarised below.

Options long list

Category	Option	Description
Surface water	Water from Wivenhoe/Somerset dam	A new large diameter trunk main supplying raw water to Atkinsons Dam, Lake Clarendon and Lake Dyer
Surface water	Water from other area in south east Queensland	As above but with water sourced from a source other than Wivenhoe/Somerset
Groundwater	Recharge of aquifers with surface water	There are nine existing recharge weirs in the Lockyer Valley. Increase the volume of water going to groundwater through more weirs, increasing the effectiveness of existing weirs (potentially through desilting) or other infrastructure such as injection wells. Possibly discharge directly to creeks
Groundwater / recycled water	Recharge aquifers with recycled water	Recharge of groundwater aquifers with recycled water from either the WCRWS or local treatment plants. Possibly discharge directly to creeks
Groundwater	Treatment of saline groundwater	There are some saline groundwater resources in the Lockyer Valley that could be treated for use
Groundwater	Water from coal seam gas extraction	When coal seam gas is extracted, water is a by-product. There are coal seam reserves nearby to Lockyer Valley (not currently being accessed) and further away in the Surat Basin
Recycled water	Recycled water from local wastewater treatment plants	QUU owns and operates five wastewater treatment plants in the Lockyer Valley from which recycled water may be sourced.

Category	Option	Description
Recycled water	Western Corridor Recycled Water Scheme (WCRWS) – Higher class water	The WCRWS (although currently in care and maintenance mode) can be operated to supply high quality (Class A or A+) via an offtake from the existing pipeline. If the WCRWS is discharging to Lake Wivenhoe, water could be taken from there. Recycled water could then be transferred to the Lockyer Valley using new infrastructure or discharged into waterways.
Recycled water	Western Corridor Recycled Water Scheme (WCRW) – Lower class water	WCRWS is operated to supply low class (Class B or C) water directly to the Lockyer Valley through an offtake from the existing transfer pipeline
Recycled water	Greywater reuse	Centralised or decentralised greywater (typically water from laundry, taps and showers) capture, treatment and reuse
Water trading	Trading of permanent and seasonal water	Trading of permanent and seasonal water from other supply schemes in the Water Plan area
Efficiency	Improve on-farm irrigation efficiency	Enable irrigators to use higher efficiency irrigation equipment and/or farming techniques

Option assessment

This long list of options has been filtered through testing how each option meets the project objective measures of:

> Supply of water in the very long term (*sustainability*) – agriculture should be a sustainable land use far beyond traditional planning horizons (20-50 years). Sustainability means water supply and agricultural production in perpetuity.

> Supply of sufficient volume of water to meet demand (*yield*) – while demand cannot be accurately assessed without a demand study and with reference to the various water products able to be supplied and the likely cost of supply of these products, the potential magnitude of demand can be estimated. The analysis in Section 2.11 suggests that there is potential for additional demand of greater than 15 GL/year from bringing existing high quality land into production. Additional demand may also result from more intensive cropping, switching to higher water use (and higher value) crops and substitution away from groundwater. For the analysis that follows in this study, a low case of 20GL/year and a medium case of 40GL/year of additional demand are considered. This is not to preclude lower yielding solutions that may benefit end users locally.

> Supply option cost (*cost*) – levelised cost has been determined for options based on the particular parameters of the option or with reference to levelised costs reported in literature. At this stage, only options with an obviously high cost or higher cost than a close alternative have been excluded. An assessment of the financial and economic viability of options is outside the scope of this study.

The table below details the outcomes of filtering the long list of options.

Outcomes of option filter

Option	Description	Progress?
Water from Wivenhoe/Somerset Dam	Water from Lake Wivenhoe could be transferred to the Lockyer Valley through a new pipeline or reusing the existing Lake Wivenhoe to Cressbrook Dam pipeline in part. A distribution system would likely include the existing storages along with distribution pipelines to customers. This option requires that a water resource is available.	Yes. Although there are uncertainties over water availability for this option, this is a relatively low cost option compared with the other considered.
Water from other area in south east Queensland	Lake Wivenhoe is the largest storage in south east Queensland and also in close proximity to the Lockyer Valley. As detailed in Section 5.2 there are general and strategic reserves available in other areas in south east Queensland. However, the general reserve volumes are relatively small. The Mary River strategic reserve is relatively large. However, use of this strategic reserve is at the discretion of the State	No. This is a higher cost option than the preceding, comparable option.

<table>
<tr><th>Option</th><th>Description</th><th>Progress?</th></tr>
<tr><td></td><td>Government. For this pre-feasibility study, the reference option for surface water will be from Lake Wivenhoe as this is closer than the Mary River and conceptually, there is potential for the Mary River strategic reserve to be used for urban water security for south east Queensland which could be offset by allocation from Lake Wivenhoe. Note that while this is conceptually possible this has not been considered in Seqwater's Water Security strategy so would require significant investigation.</td><td></td></tr>
<tr><td>Recharge of aquifers with surface water</td><td>There are concerns over the performance of the existing recharge weirs. Improving the efficiency of recharge weirs would potentially increase the amount of water going to groundwater but would then also reduce surface water flows. However, this option does not generate any 'new' water – all available water is currently subject to planning arrangements. This option would therefore only potentially improve water security locally. Further, while the aquifer provides storage, it has limitations as a distribution system with inconsistent transmission and accessibility.</td><td>No. This option does not provide 'new water' and is a relatively high cost option</td></tr>
<tr><td>Recharge aquifers with recycled water</td><td>Recharge of groundwater aquifers with recycled water (injection) faces the following obstacles:
1. Prior to recycled water being introduced to the aquifers, an environmental monitoring program would need to be undertaken to understand the capability of the aquifer to take on recycled water and the quality of recycled water required to not adversely impact the aquifer. This monitoring program would likely to be in the order of five to ten years (Natural Resource Management Ministerial Council, Environment Protection and Heritage Council and National Health and Medical Research Council, 2009).
2. A means for transparently and equitably sharing and paying for the recycled water introduced into the aquifer would need to be established. This would require extractions to be metered and a recycled water purchasing and cost sharing mechanism agreed between users. The recycled water injected into the aquifer would need to be purchased (for example from the WCRWS) whereas natural recharge of the aquifer has no cost associated with it.
Providing large volumes of recycled water into the aquifers would require a transfer pipeline from the WCRWS. It therefore has much in common with providing recycled water piped to users – for this option the aquifer can be thought of as a storage and distribution system. However, groundwater injection has its own costs for injection wells and other infrastructure and as noted above, the aquifer does not perform well as a distribution system due to inconsistent transmission and access. Recycled water injection of aquifers is not considered further because of the relatively high cost. Further discussion of this option is included in UWSRA Technical Report No. 103 (Wolf, 2013). However, lower aquifers may be recharged with recycled water through lower cost alternatives such as discharge of recycled water into creeks which also has the benefit of providing environmental flows. This option should be considered further.</td><td>No – for aquifer recharge as this is a relatively high cost option
Yes - for lower cost options such as discharge of recycled water to waterways which may also recharge aquifers</td></tr>
<tr><td>Treatment of saline groundwater</td><td>Consultation with DNRM identified that there are some small volumes of saline groundwater available in the Lockyer Valley. However desalination of small volumes of groundwater is costly compared with other alternatives.</td><td>No. This is a relatively high cost option</td></tr>
</table>

Option	Description	Progress?
Water from coal seam gas extraction	Water produced as a by-product of coal seam gas extraction could be transferred to the Lockyer Valley for beneficial reuse. Coal seam gas extraction currently occurs on a large scale in the Surat Basin over 100km from the Lockyer Valley. While there are coal seam gas reserves closer to the Lockyer Valley, these are currently not in production and there are no proposals to develop these reserves.	No. This option is not sustainable in the long term and relatively high cost.
Recycled water from local wastewater treatment plants	QUU's long term planning to 2046 suggests that effluent production from the local treatment plants will be around 1.5 GL/year. At the upper limit of long term and total population of 61,000 people, an upper bound for local recycled water production is around 4.4 GL/year. Note also that around 0.5 GL/year of effluent from local treatment plants is currently reused.	Yes. While the yield available will only benefit some end users locally this is a relatively low cost option.
Western Corridor Recycled Water Scheme (WCRWS)	Recycled water may be supplied to the Lockyer Valley in large volumes from the WCRWS when this scheme is not required to meet urban demand. Recycled water could be supplied through a direct offtake from the existing scheme (e.g. from the Lowood recycled water balancing tank) or from Lake Wivenhoe as a shandy of raw water and recycled water. The demand for recycled water of different levels of quality needs to be ascertained by a robust demand assessment that considers the willingness to pay for these varying products.	Yes. Cost of supply of recycled water potentially cost prohibitive if A+. However, potential that lower class water can be provided cost effectively.
Greywater reuse	Greywater reuse has the same upper limit of production of local recycled water production – around 4.4 GL/year and therefore may only provide water in local areas, it is not a regional solution. Greywater reuse has very high costs to install, operate and maintain – with levelised costs an order of magnitude greater than recycled water. Recycled water produced centrally at treatment plants is therefore taken forward in this analysis due to its cost advantages over decentralised greywater reuse.	No. This a very high cost option.
Trading of permanent and seasonal water	DNRME is actively considering this option through stakeholder consultation, modelling and considering regulatory amendments.	Yes – although outside the scope of this study as being progressed by DNRME
Improve on-farm irrigation efficiency	On-farm efficiency can lead to savings in water use of up to 30% based on Queensland Government programs. The viability of this option will vary from farm to farm.	Yes

Following the filtering of options in the preceding section, the following options remain for further consideration:

> Water from Lake Wivenhoe
> Recycled water from local wastewater treatment plants
> Recycled water from the Western Corridor Recycled Water Scheme
> Trading of permanent and seasonal water
> Improved on-farm efficiency.

Water trading is being actively progressed by DNRME through stakeholder consultation, modelling and consideration of regulatory amendments. This option is therefore not discussed further in this study.

This report has identified the need for a robust demand assessment to confirm the need for water for agricultural productivity and sustainability in the Lockyer Valley. This would also inform a financial and economic assessment. For each of the short-listed options, further technical investigations required to confirm their feasibility have been identified and these are summarised in the table below.

Further technical investigations for shortlisted options

Option	Further technical investigations

Option	Further technical investigations
Water from Lake Wivenhoe	▪ Identify availability of surface water ▪ Determine cost to access water if available ▪ Determine if there it is more cost effective to use part of the existing Lake Wivenhoe to Cressbrook pipeline to transfer water to the Lockyer Valley or if a dedicated pipeline is preferable. ▪ Based on demand assessment, optimal transfer and distribution infrastructure to meet location and magnitude of demand
Recycled water from local wastewater treatment plants	▪ As this option is already available, the investigation to confirm feasibility are generally based on the end user's own circumstances in consultation with Queensland Urban Utilities
Recycled water from the Western Corridor Recycled Water Scheme	▪ Confirm potential for WCRWS to supply different classes of water (A+ and A generally required for current production mix in the Lockyer Valley). This needs to consider existing and alternative technologies, water quality management requirements and operating protocols. ▪ Confirm lifecycle costs to supply varying water classes ▪ Confirm reliability (interruption to supply) of WCRWS for agriculture given primary purpose of securing urban water supplies ▪ Confirm whether it is preferable for recycled water to be taken from the existing pipeline or from Lake Wivenhoe (shandied with surface water) ▪ Determine if there it is more cost effective to use part of the existing Lake Wivenhoe to Cressbrook pipeline to transfer water to the Lockyer Valley or if a dedicated pipeline is preferable. ▪ Based on demand assessment, optimal transfer and distribution infrastructure to meet location and magnitude of demand ▪ Investigation of cost and benefits of recycled water discharge to creeks and potential to recharge aquifers
Improved on-farm efficiency	▪ Confirm need for on-farm efficiency programs outside existing programs

Recommendations

The following two recommendations are made as outcomes of this pre-feasibility study:

1. The demand for and perceived value of potential water security options depends on whether volumetric entitlements are in place for groundwater abstraction or not. This is because groundwater when available is a substitute to potential water security options. Therefore, the proposed amendments to the Moreton Water Plan should be resolved as soon as possible to reduce the uncertainty over water security in the Lockyer Valley.

2. Based on the identified need to secure water supply for existing agriculture in the Lockyer Valley and the existence of potential supply options identified in this pre-feasibility study, it is recommended that:

   A. The service need (demand) across the region be defined in detail

   B. The identified shortlisted water supply options be further progressed

   C. The above, (A) and (B), be progressed utilising the Business Queensland Preliminary Business Case and Detailed Business Case frameworks.

   Further investigation needs to address the further technical investigations required for each shortlisted option.

   It may be preferable to complete a standalone demand assessment before progressing further with the Business Case so that the service need is clear.

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Figures

1 Introduction

1.1 Background

Lockyer Valley Regional Council (LVRC) has obtained funding under the National Water Infrastructure Development Fund (NWIDF) to undertake a pre-feasibility study to identify supply options for securing water for agricultural.

The objective of the study is to identify a long list of potential water supply options to improve agricultural productivity and sustainability and screen these options against criteria including availability, reliability, costs to supply (fixed and variable), environmental impacts, social impacts and regulatory constraints, in order to generate a short list of options. It is envisaged that the shortlisted options will be progressed to a full feasibility study. The Terms of Reference for the study are included in Appendix A. Cardno, in association with Marsden Jacob Associates, has been commissioned to undertake this study.

This study is supported by funding from the Australian Government's NWIDF, an initiative of the Northern Australian and Agricultural Competitiveness White Papers.

1.2 National Water Infrastructure Development Fund

The NWIDF implements the Australian Government's commitment to start the detailed planning necessary to build or augment existing water infrastructure including dams, pipelines or managed aquifer recharge. The objective of the Fund is to help secure the nation's water supplies and deliver regional economic development benefits for Australia, while also protecting the environment.

The Fund will initially support feasibility studies to help governments and industry make decisions based on evidence about the best sites for new water infrastructure, and accelerate the completion of thorough business cases. Feasibility assessments will confirm sufficient demand from users and their capacity to meet the ongoing costs of additional or more secure water supplies. For example, the cost of ongoing operational and maintenance activities will be assessed to determine if they can be funded over the longer term.

Funding for this study is administered by the State of Queensland. LVRC has entered into a Grant Deed with the State of Queensland to govern the study. The Grant Deed includes the expected outcomes and dates for important milestones.

1.3 Objective and scope of this study

The objective of this pre-feasibility study is to evaluate water supply options that will increase the security of supply of water to the Lockyer Valley for agricultural use.

The scope of the study is to:

> Include a literature review, collect data and undertake research to establish the existing knowledge base
> Identify concept options
> Prepare a pre-feasibility analysis of concept options and detailed planning
> Undertake stakeholder engagement.

This pre-feasibility study does not include:

> A detailed assessment of the demand for, or willingness of end users to pay for, water from the various supply options
> A cost benefit analysis of pursuing any of the identified supply options.

It is envisaged that this pre-feasibility study will inform a later demand assessment and detailed business case. This pre-feasibility study therefore establishes a baseline of information relating to the supply options available and conducts technical and financial assessment of these options to enable the detailed business case to be focused on a small number of viable options.

1.4 Methodology

The following activities have been undertaken to complete this pre-feasibility study:

> Literature review of previous studies. An overview of previous studies and their relevance to this pre-feasibility study is included in Appendix B
> Engagement with the community and stakeholders. Community engagement was led by Lockyer Valley Regional Council. Details of the engagement undertaken and the findings are included in Appendix C
> Based on the literature review, stakeholder engagement and further research and analysis, a long list of potential water security options was generated. The long list of options is included in Appendix D
> The long list of options have been assessed against the project objectives to arrive at a short list of options
> Conclusions on the feasibility of the shortlisted options to meet the project objectives and recommendations for future work have been made.

2 Need statement

2.1 Agricultural production in the Lockyer Valley

The Lockyer Valley is one of the most productive agricultural regions in Australia, producing fruit, vegetables and other produce with a value of over $670 million per year (WSP, 2017). Two thirds of the value of agricultural production in the Lockyer Valley is contributed by crops and one third by livestock production. Of the total estimated annual production, the largest category of production is vegetables for human consumption which contributes $355.8 million or 53% of the total. The second largest category is livestock slaughtered and other disposals which contributes $200.8 million (30% of the total).

Figure 2-1 provides a breakdown of agricultural production based on the 2015/16 Agricultural Census undertaken by the Australian Bureau of Statistics.

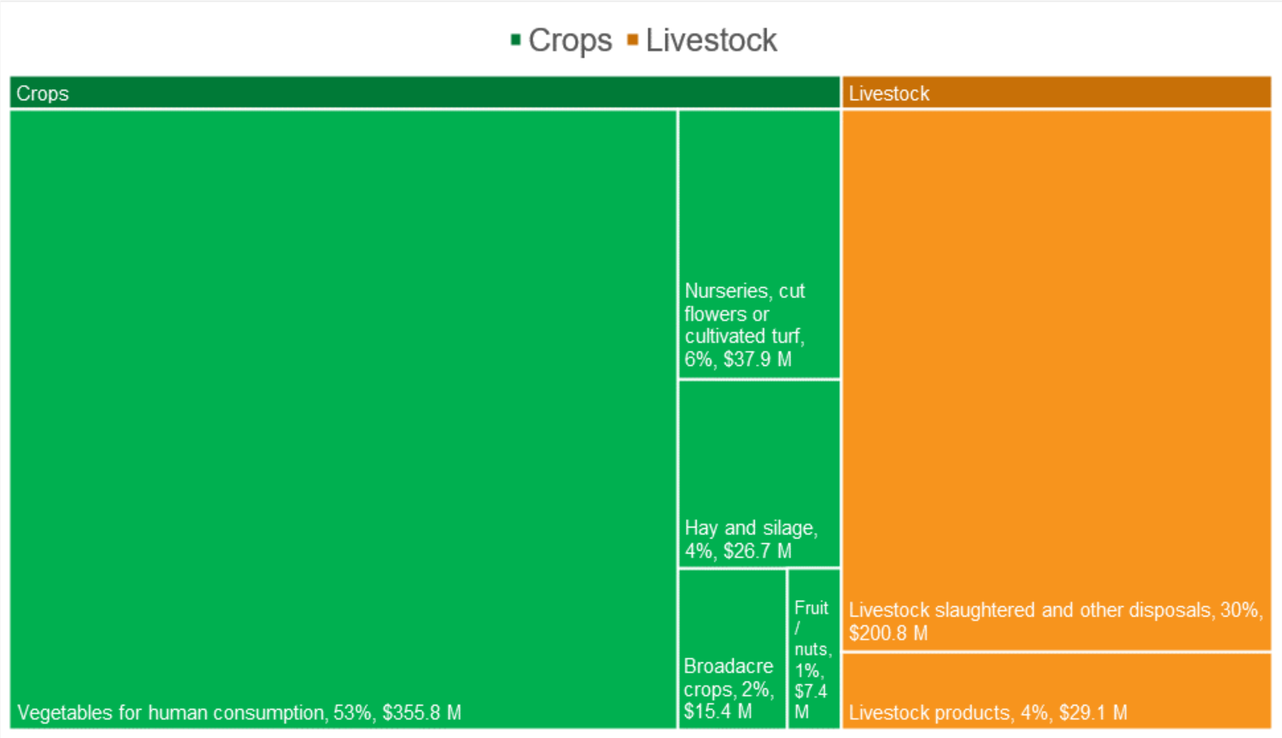

Figure 2-1 Value of agricultural production

Current agricultural production in the Lockyer Valley is shown in Figure 2-2. The major feature of agricultural production is the extent of irrigated seasonal horticulture which is generally undertaken on the alluvial plains and colluvial footslopes under intensive irrigation. The steeper slopes have been cleared for grazing.

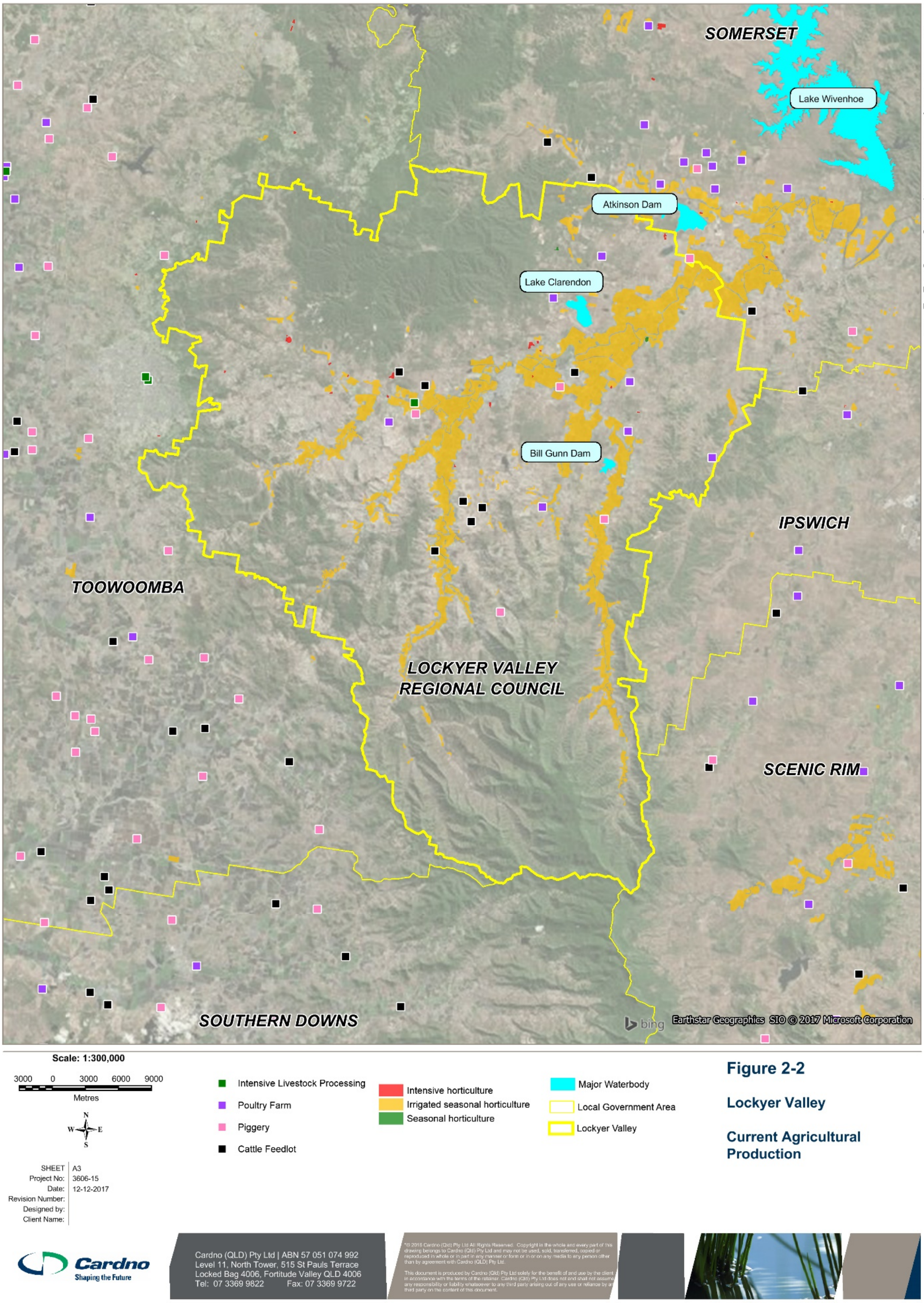

Figure 2-2 Map of current agricultural production in the Lockyer Valley

2.2 Overview of the need for change

A number of factors exist which are either limiting current agricultural productivity across the Lockyer Valley or may inhibit future productivity and sustainability of the agricultural sector and therefore create the need for change. Figure 2-3 shows these factors. Each factor is explored in further detail in Sections 2.3 to 2.10.

Figure 2-3 Drivers for the need for water for agriculture productivity and sustainability

2.3 High quality land not in use

The 2012 land use survey undertaken under the Queensland Land Use Mapping Program identified 28,361 ha of land in use for irrigated agriculture in the Lockyer Valley (Remote Sensing Centre, Science Division, 2014). A 2002 study of the soil and land suitability of the Lockyer Valley identified that 43,748 ha of the alluvial plains in the Lockyer Valley are likely to be suitable for irrigated agriculture (Powell et al, 2002). This suggests that around 35% of land suitable for irrigated agriculture was not in production at the time of the 2012 land use survey. The 2012 land use study reports an almost identical level of land used for irrigated agriculture in 1999 and 2012 suggesting that suitable land not being in production has persisted for at least this period.

The potential locations of high quality land currently not in use can be inferred as land identified as Strategic Cropping Land through the Queensland Government’s Agricultural Land Audit which is currently not in use for irrigated agriculture. Strategic Cropping Land corresponds to “Class A” agricultural land under the Queensland Agricultural Land Class system. Class A land is land that is suitable for a wide range of current and potential crops with nil to moderate limitations to production. Note that the Strategic Cropping Areas and Class A land include some areas that are not suitable for agriculture such as waterways. Figure 2-5 shows Strategic Cropping Areas (Class A land) that are currently not in use for agriculture. This figure should be taken as indicative only and needs to be confirmed through further investigation but identifies locations which could potentially contribute to increased production from the Lockyer Valley.

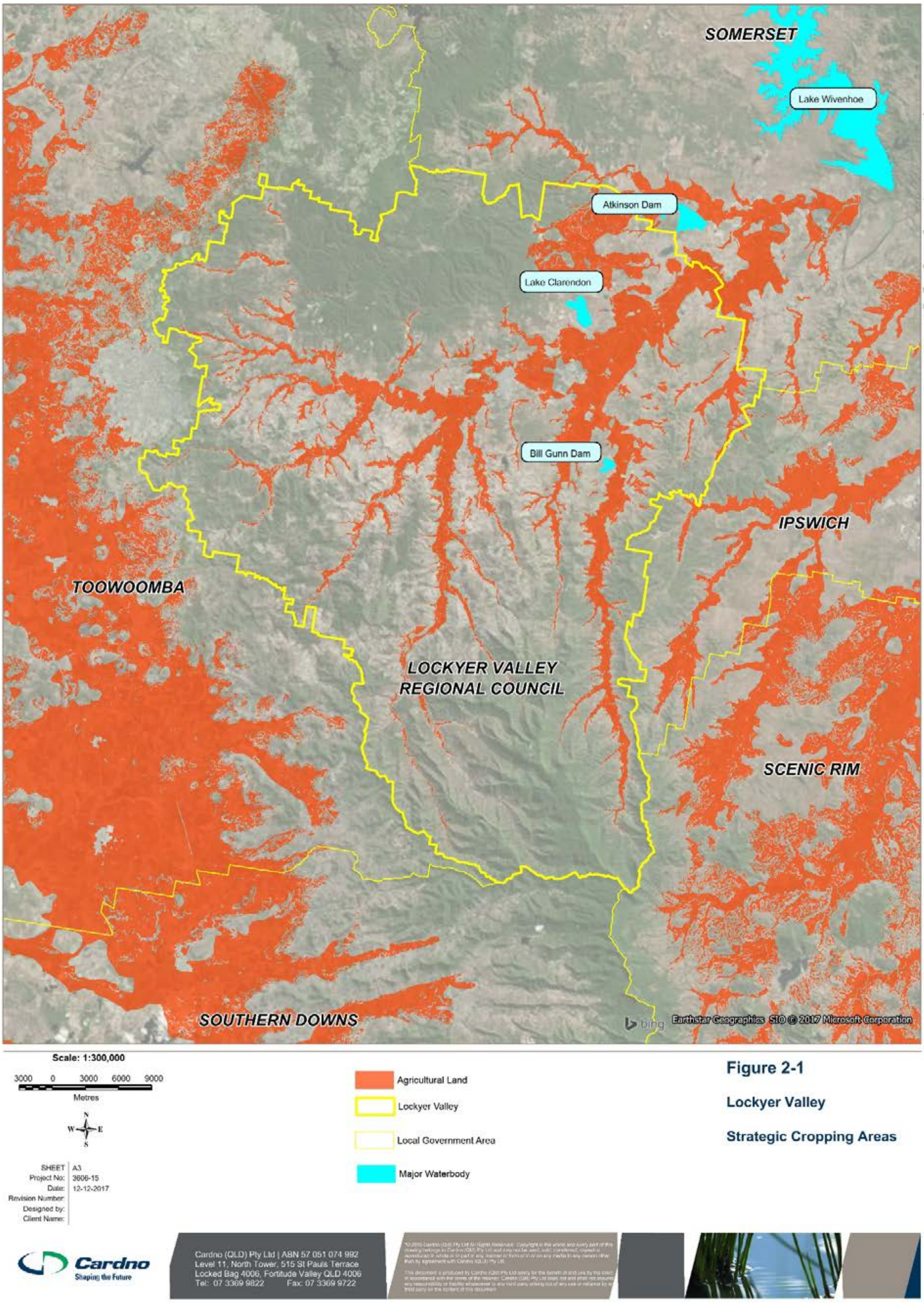

Figure 2-4 Strategic Cropping Areas

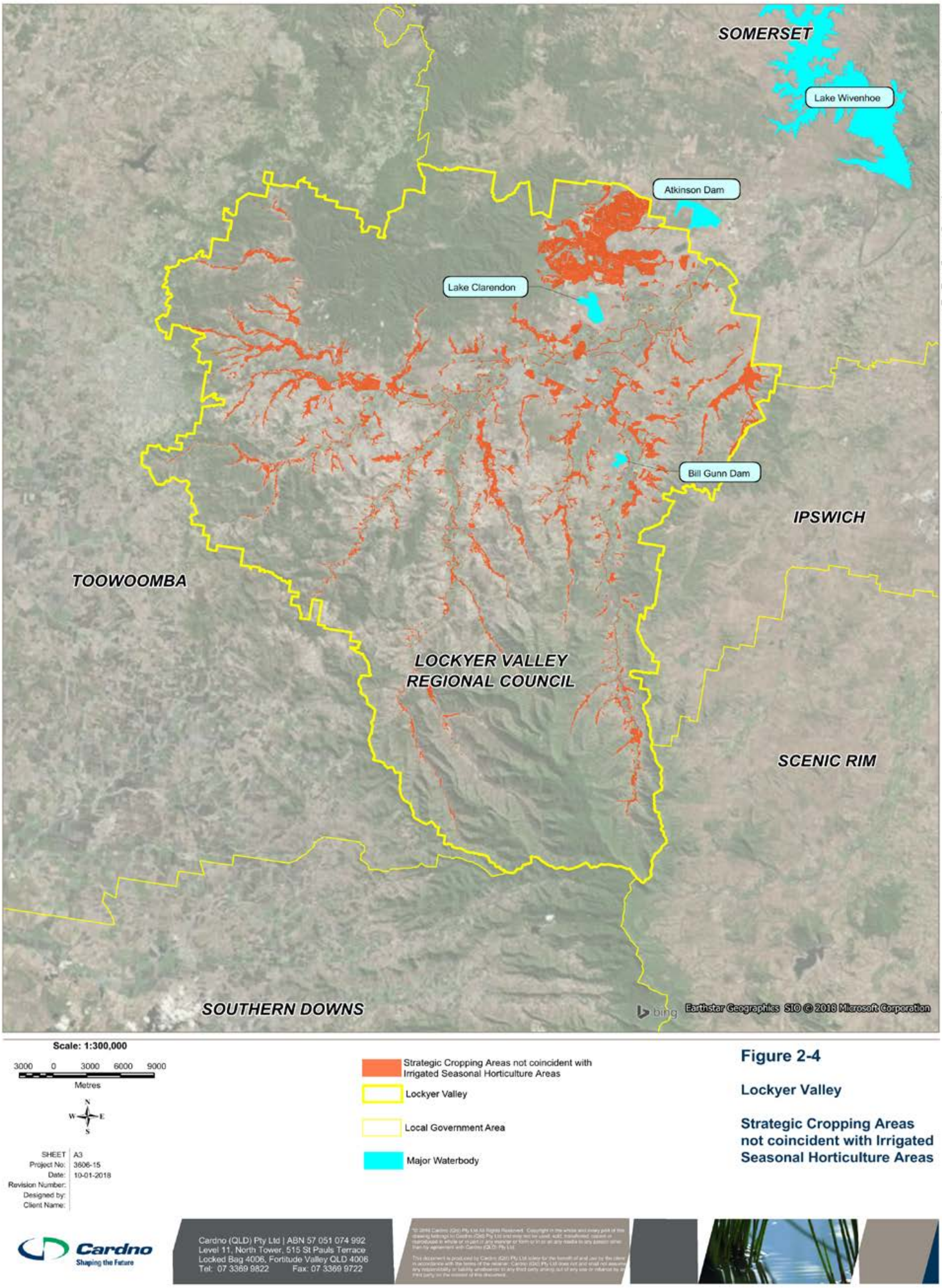

Figure 2-5 Strategic Cropping Areas currently not in use for agricultural production

2.4 More productive use of existing land

Lockyer Valley Regional Council reports that recent years have seen increased intensive irrigated agriculture in the Lockyer Valley through the construction of greenhouses. Greenhouses allow greater production per land area, protect crops from weather, reduce pests and can allow more crop cycles per year. However, not all crop types grow well in greenhouses. Greenhouses are also becoming larger and more permanent structures. More intensive use of existing land will increase demand for water with all else being equal. This land use also requires more reliable water to support year round cropping.

More intensive use of existing land in economic terms could also arise where producers move from less valuable to more valuable crops, e.g. from hay and silage into vegetables or turf, or where intensive animal husbandry is introduced. Across the region, the production of vegetables for human consumption has increased by 24% in the five years between 2010/11 and 2015/16 (Australian Bureau of Statistics, 2012) (Australian Bureau of Statistics, 2017). This suggests that the region has intrinsic locational advantages and improving productivity which could support further growth in this sector should water availability be improved.

2.5 Potential for value adding

Currently, there is limited processing of agricultural produce in the Lockyer Valley (The Stafford Group, 2013). A cannery has been proposed for a number years but is yet to secure funding. Increased reliability of water for agriculture may increase value adding locally and economic development in the region.

2.6 Climate change

Research has found that the Lockyer Valley and neighbouring Fassifern Valleys are more likely to be impacted by climate change than competing regions (Mainstream, 2013). Impacts are anticipated to include:

- Declining average annual rainfall (Mainstream, 2013)
- Less reliable groundwater levels. Under median climate scenarios, groundwater levels typical of drought conditions may occur twice as frequently under the current extraction rates (Wolf, 2013).

The potential for reduced rainfall and decreased reliability of groundwater is a threat to the productivity and sustainability of agriculture in the Lockyer Valley.

2.7 Performance of existing water sources

Water for agriculture in the Lockyer Valley is supplied from multiple sources including groundwater, watercourses and on farm storages. There are two regulated water supply schemes in the Lockyer Valley: the Central Lockyer Water Supply Scheme (WSS) and the Lower Lockyer WSS. The Central Lockyer WSS includes two storages – Lake Clarendon and Lake Dyer (Bill Gunn Dam). The Lower Lockyer WSS includes one storage – Lake Atkinsons. Water from these storages is released into natural water courses to supply downstream entitlements, transferred into the Morton Vale Pipeline system and released to recharge groundwater supplies through recharge weirs (Section 3 provides more information on the existing water resources in the Lockyer Valley).

It is recognised that the regulated water supply schemes in the Lockyer Valley do not reliably provide water for agriculture. This can be seen through the trend in releases from the three storages shown in Figure 2-6. Since 1995, the sum of the median releases from all three dams has been 5.8GL/year. This is less than 10% of the estimated total of water used for agriculture in the Lockyer Valley each year.

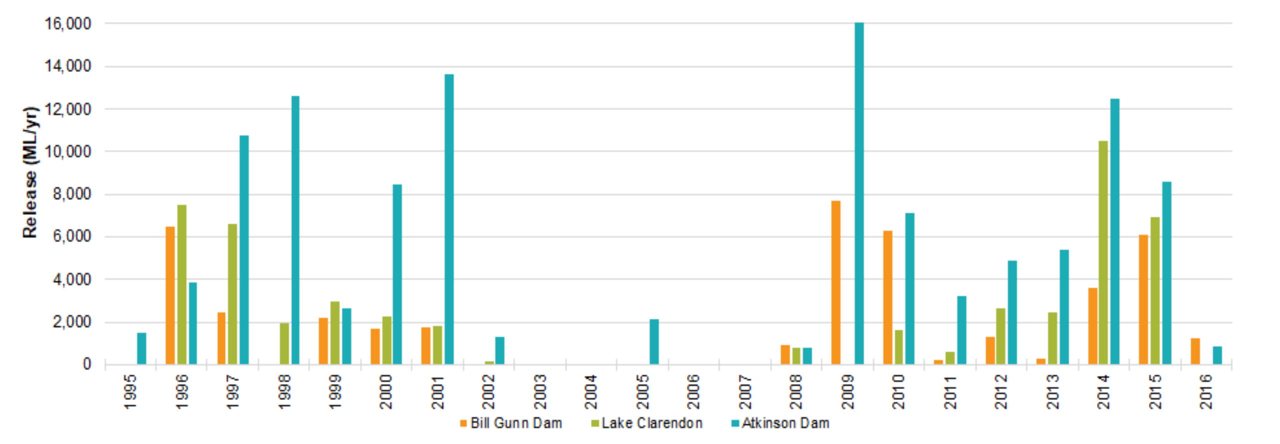

Figure 2-6 Releases from Lockyer Valley water storages

The alluvial groundwater aquifers in the Lockyer Valley experience stress in times of low rainfall although can be recharged relatively quickly following sustained rainfall.

2.8 Proposed changes to groundwater management

The State Government is currently considering submissions in response to a Statement of Proposals to amend the Moreton Water Plan. One of the aims of the proposed amendments is to convert all water entitlements supplemented by the operation of the Central Lockyer Valley WSS to tradeable, volumetric water allocations. Currently supplemented groundwater is unregulated. The new arrangements which are yet to be defined are intended to specify entitlements and provide equitable access to groundwater. To the extent that these new arrangements reduce the availability of groundwater in some instances production of agricultural products may be reduced. As the entitlements are intended to be tradeable, their value should be transparently known. This proposed change to management arrangements has clear implications for the productivity and sustainability for agriculture in the Lockyer Valley if progressed; perhaps most importantly that groundwater in the Central Lockyer will now have an obvious market value and more clearly defined availability.

2.9 Increased global demand for food and fibre

Growing global demand for food and fibre has been identified as a strategic opportunity by the Queensland Government (Department of Agriculture and Fisheries, 2017). The Queensland Government released the *Queensland Food and Fibre Policy* (Department of Agriculture and Fisheries, 2015) which includes driving growth, efficiency and sustainability as a priority area. Water for agricultural productivity and sustainability in the Lockyer Valley can help realise the strategic opportunity of growing global demand for food and fibre and supports the existing policy.

At the Commonwealth level, the *Agricultural Competitiveness White Paper* details five priority areas to which the Government has committed investment of $4 billion. A priority area identified is to build the infrastructure of the 21st century with a stated aim to "*invest in reliable, efficient and cost-effective infrastructure to support the development and growth of the agriculture sector"*. This initiative is supported by the $509.5 million National Water Infrastructure Fund through which the Commonwealth Government wishes to partner with State Governments to secure water supplies and deliver regional economic development.

2.10 Environmental benefits

There is significant evidence of degradation of land and water resources in the Lockyer Valley (Haigh, 1970) (The Division of Land Utilisation, Department of Environment and Resource Management, 1979), (Department of Natural Resources and Mines, 2005). Specific areas of concern include:

> Extraction of groundwater from alluvial aquifers placing stress on these aquifers

> Land degradation particularly of riparian zones which has led to increased sediment loading in the Brisbane River and Moreton Bay and consequential impact on these aquatic ecosystems

> Reduced surface water flows due to extraction of surface water (and connected groundwater systems) impacting on the aquatic ecosystems in local waterways. The waterways of the Lockyer Valley were awarded a grade of D+ in the 2017 Healthy Land and Waterways Report Card.

Environmental benefits may be realised from increased water security in the Lockyer Valley were groundwater extraction to be reduced. This would lead to higher groundwater levels and higher flows in surface watercourses. However, investment in riparian rehabilitation is anticipated to be required to reduce sediment loading and realise the associated benefits (Queensland Water Commission / South East Queensland Healthy Waterways Partnership, 2007).

Where recycled water sourced from wastewater treatment plants that discharge into the Brisbane River and Moreton Bay is used to increase water security, there is also potential benefit from reduced nutrient loading into these environments. However, more highly treated recycled water typically contains less nutrients which will offset this benefit. More highly treated recycled water also requires more electricity in the treatment process. A separate study funded under NWIDF arrangements is in progress which considers the technical and economic feasibility of making recycled water from the Western Corridor Recycled Water Scheme available to the Lockyer Valley and Darling Downs agricultural areas.

2.11 Current and potential additional demand for water

Establishing demand for water for agricultural use in the Lockyer Valley is made difficult because of the disparate supply sources which are both regulated and unregulated. Much of the use is also unmetered.

Department of Natural Resources Mines and Energy (DNRME) estimates that water use for irrigation in the Lockyer Valley is around 60GL/year with 44GL/year sourced from groundwater and the balance from surface water (DNRME, 2017). This represents irrigation in the Lower Lockyer, Clarendon, Morton Vale, Upper Lockyer and Gatton Esk sub-regions. Other sources have noted an average annual use of groundwater for irrigation of 45GL/year (Wolf, 2013) and 46.5GL/year (Powell et al, 2002).

Another approach to estimating the demand for water for agriculture is through a bottom-up assessment by considering the crops produced and land under production in the Lockyer Valley. As noted, there is around 28,000 ha of land estimated by the Queensland Land Use Mapping Program (Remote Sensing Centre, Science Division, 2014) to be in use for irrigated agriculture. Of this, 6,700 ha is estimated to be used for growing vegetables for human consumption (The Stafford Group, 2013). The balance of land is used for hay and silage, broad acre crops and nurseries, flowers and turf. Based on water usage for different crop types (Australian Bureau of Statistics, 2017) and these land areas, estimated total usage is in the range of 54 GL/year to 65 GL/year which is in line with the DNRME estimate. Note that these estimates exclude water usage for intensive animal husbandry.

Potential additional demand for water may arise from:

- Utilisation of high quality land that is currently not in production
- More intensive use of existing land for cropping or animal husbandry
- Substitution for other sources if volumetric entitlements are in place for groundwater.

Estimating the level of potential additional demand is very difficult because of the uncertainties involved. A simple estimate of demand arising from utilisation of high quality land that is currently not in production can be made by multiplying the land not in production (approximately 15,000ha) by typical usage rates (1-3ML/ha/year) to arrive at 15 – 45 GL/year. This is an upper bound for potential additional demand from usage of this land not in production and does not account for ability or willingness to pay. Potential additional demand arising from the other two drivers is too uncertain to be estimated even at a high level. A rigorous demand assessment is needed to reliably estimate future potential demand. However, potential future demand will be influenced by whether volumetric entitlements are in place and a demand assessment should not be undertaken until there is certainty in this area.

2.12 Potential economic benefit from increased water security in the Lockyer Valley

A socio-economic study (still in draft) examining the benefits of increased water supply to the Lockyer Valley has been commissioned jointly by Somerset Regional Council, Lockyer Valley Regional Council and the Lockyer Water Users Forum (WSP, 2017). The economic assessment in this study considers gross value and employment impacts from an assumed increase in water supply of 100GL/year (specified by the project Client Group).

For this level of demand, and assuming no supply or demand side constraints and increased production reflecting existing production, the report identifies the following potential benefits of increased water supply:

1. An increase in gross value of $640 million per year (direct impact)
2. An additional 1,409 jobs (direct impact)
3. An additional $73 million in annual wages
4. A total economic impact (direct and flow-on impacts) of $1.3 billion to $3.2 billion per year.

While a robust demand assessment is necessary to confirm the potential economic benefit arising from increased water use across the region, the assumption of 100GL/annum in increased usage is considered high based on the discussion in Section 2.11. This pre-feasibility study will identify and assess potential options to increase water security; the demand assessment is outside the scope of this report

3 Existing water resources and infrastructure in the Lockyer Valley

3.1 Regulatory framework for water

The regulatory framework for water resources is largely governed by the Water Act 2000 and Water Regulation 2016. Appendix E provides an overview of this regulatory framework.

3.2 Surface water

3.2.1 Overview

The water resources and water infrastructure in the Lockyer Valley include:

- Watercourses including Lockyer Creek
- Three major water storages: Atkinson Dam, Lake Clarendon and Lake Dyer (Bill Gunn Dam)
- Recharge weirs that help replenish aquifers with surface water
- Privately owned farm dams, rainwater tanks and groundwater bores.

Within the Lockyer Valley, there are two regulated water supply schemes for irrigated agriculture, both of which are operated by Seqwater. These are the Central Lockyer Valley WSS and the Lower Lockyer WSS.

The water resources and water infrastructure in the Lockyer Valley are described further following.

3.2.2 Local storages and diversion

Local storages and diversions involve either capturing rainfall that lands within an individual's property or retaining a portion of water that flows through a property whether it is intermittent stormwater or regular stream flows. Individual landowners can store a portion of water that flows through their property, but the volume of water that can be stored is restricted by legislation. Where the storage is for irrigation, the maximum overland flow storage for an individual landholder is 5ML.

Rainwater tanks have been used in Australia for a long period of time for both household consumption and outdoor and agricultural consumption. Rainwater tanks can be used to supplement other water sources and can provide greater security by storing rainfall from wetter periods for use in later, drier periods.

Local storages and diversions do not increase water availability – all water is regulated under the Water Plan.

3.2.3 The Central Lockyer Valley Water Supply Scheme

The Central Lockyer Valley WSS includes the off-stream storages of Lake Dyer and Lake Clarendon, which receive diverted flood flows from Laidley Creek and Lockyer Creek respectively. Lake Clarendon also receives diverted flow from Redbank Creek.

Table 3-1 shows the current ownership of entitlements in the Central Lockyer Valley WSS. Entitlements include 9.3GL for groundwater, and 3.4GL for the Morton Vale Pipeline. A total of 16.3GL is available for 250 customers as entitlements.

Table 3-1 Ownership of entitlements in the Central Lockyer WSS[1]

Customer Type	Number of customers	Medium priority WAE (ML)	High priority WAE (ML)
Irrigation – Moreton Vale pipeline	43	3,470	-
Irrigation – Risk A & Risk B	85	3,115	-
Irrigation – Groundwater	115	9,335	-

[1] Data from p. 4 of Seqwater. (2015, September). *Central Lockyer Valley Water Supply Scheme: Annual Network Service Plan 2015-16*. Retrieved from http://www.seqwater.com.au/sites/default/files/PDF%20Documents/Irrigators/CL%20Annual%20NSP%20-%202015-16%20-%20published%20version_0.pdf

Other	5	10	-
Laidley Golf Club	1	60	-
Crowley Vale Water Board	1	325	-
Seqwater (losses)	-	-	184
Total	**250**	**16,315**	**184**

Announced allocations are only made for entitlements for the Morton Vale pipeline (3.5GL) and Crowley Vale (0.33GL) Water Board. Allocation procedures have not been developed or implemented for groundwater or the other surface water entitlements. The announced allocation for the Morton Vale pipeline and Crowley Vale Water Board had been 100% between 2009 and 2016. The allocation was reduced to 0% for 2006/07 and 73% for 2016/17 reflecting reduced water availability at these times.

3.2.4 The Lower Lockyer Valley Water Supply Scheme

The Lower Lockyer Valley WSS major infrastructure features the Lake Atkinson, Buaraba Creek Diversion Weir; along with the Sippels, Brightview, Potters and O'Reillys Weirs. The main watercourse attributed to Lower Lockyer Valley is the Buaraba Creek.

There is 12.6 GL of medium priority entitlement in the Lower Lockyer WSS. Of this, 11.1GL is held by irrigation customers as set out in Table 3-2.

Table 3-2 Ownership of entitlements in the Lower Lockyer Valley WSS[2]

Customer type	No. of customers	Medium priority water allocation (ML)
Irrigation	141	11,110
Seqwater	7	1,510
Total	**148**	**12,620**

Announced allocations represent the proportion of a customer's allocation that will be fulfilled within a year. Announced allocations in the Lower Lockyer WSS show considerable variability. Announced allocations since 2006/07 are shown in Table 3-3.

Table 3-3 Announced allocations for Lower Lockyer WSS[3]

Year	Announced allocation
2006/07	0%
2007/08	0-16%
2008/09	13-63%
2009/10	27-100%
2010/11	100%
2011/12	100%
2012/13	100%
2013/14	100%
2014/15	81%
2015/16	31%
2016/17	0%

[2] Data from Seqwater. (2015, September). *Lower Lockyer Valley Water Supply Scheme: Annual Network Service Plan 2015-16*. Retrieved from http://www.seqwater.com.au/sites/default/files/PDF%20Documents/Irrigators/LL%20Annual%20NSP%20-%202015-16%20-%20published%20version_0.pdf

[3] Seqwater. (2016, September). *Lower Lockyer Valley Water Supply Scheme: Annual Network Service Plan 2016-17*. Retrieved from http://www.seqwater.com.au/sites/default/files/PDF%20Documents/Irrigators/LL%20Annual%20NSP%20-%202016-17%20-%20published%20version.pdf

Year	Announced allocation
2017/18	17%

In only five out of the last twelve years has the full allocation been available to entitlement holders. This reinforces the observations in Section 2.7 regarding the poor performance of the existing water schemes.

3.3 Groundwater

Historically groundwater management within the Lockyer Valley has been limited to the former Clarendon Subartesian Area (now Lockyer Valley Groundwater Management Area, Implementation Area 1) and to extractions from the Great Artesian Basin (GAB) sediments (Department of Natural Resources and Mines, 2017). As such, groundwater extraction data is limited to these areas. Much of the groundwater extracted is sourced from the shallow alluvial aquifers which underlie much of the Central Lockyer Valley region.

It is estimated that between 20 to 40 GL of groundwater is extracted annually from a network of over 5,000 bores (Powell et al, 2002; Wolf, 2013; Department of Primary Industries, 1994). Groundwater use in the Central Lockyer Valley is subject to proposed changes to volumetric entitlements. DNRM’s Water Management System (WMS) currently records a total annual entitlement of 630 ML for the Lockyer Valley Groundwater Management Area. This entitlement figure is limited to the licences within Implementation Area 1 and does not include those yet to be transitioned from area based entitlements to water allocations under the proposed Water Plan amendments.

Additionally, there is currently an annual entitlement of 9,573.52 ML of groundwater from the Clarence Moreton Management Area of the GAB (Department of Natural Resources and Mines, 2017). All recorded annual entitlements in the Clarence Moreton Management Area are located within the Lockyer Creek sub-basin. They are not, however, likely all within the study area. Whilst licences within the LVRC area do not account for all of this allocation, this indicates that a large proportion of groundwater use within the area is possibly from the GAB sediments. At this time, it is unknown as to the exact location and quality of the extraction bores.

3.4 Recycled water

3.4.1 Local wastewater treatment plants

Queensland Urban Utilities owns and operates five wastewater treatment plants in the Lockyer Valley. These treatment plants produce recycled water, of which some is being used for agricultural production. Table 3-4 and Table 3-5 (Queensland Urban Utilities, 2017) summarise the current inflows and treated effluent produced at each treatment plant currently and for the long term planning horizon (2046).

Table 3-4 Summary of Lockyer Valley wastewater treatment plants – Current (2016/17)

Town	Population served (persons)	Annual flow received (ML/year)	Annual effluent produced (ML/year)	Annual effluent reused (ML/year)	Effluent quality / class
Gatton	8,455	456	443	415	C
Helidon[1]	857	21	29	29	C
Laidley	4,002	299	188	72	C
Forest Hill[2]	507	45	24	NA	NA
Grantham[3]	40	3	NA	NA	NA
Total	**13,861**	**824**	**684**	**516**	**NA**

Table 3-5 Summary of Lockyer Valley wastewater treatment plants – Long term (2046)

Town	Population served (persons)	Annual flow received (ML/year)	Annual effluent produced (ML/year)	Effluent quality / class
Gatton	15,957	990	990	C
Helidon	2,018	125	125	C
Laidley	6,417	398	398	C
Forest Hill	521	32	32	TBA

Grantham	TBA	TBA	TBA	TBA
Total	**24,913**	**1,545**	**1,545**	**NA**

Notes:

1. Note that at Helidon effluent exceeds influent for 2016/17. This is due to meter inaccuracy
2. There is no recycled water at Forest Hill. The effluent is currently collected in a farmer's dam and evaporated.
3. Due to lower growth than anticipated, the existing sewage treatment plant at Grantham is currently offline and sewage is being taken by tanker to Gatton STP.

This data shows that current use of recycled effluent from local treatment plants is around 0.5GL/year and that over the long term, it is expected that the volume of recycled effluent available for use will rise to 1.5GL/year.

3.4.2 Western Corridor Recycled Water Scheme

In 2007, Brisbane was facing severe drought leading to water supplies reaching critically low levels. A range of emergency measures were introduced including purified recycled water (PRW) to avert the impending crisis. The Western Corridor Recycled Water Scheme was completed in late 2008 to provide recycled water to a standard appropriate for indirect potable re-use (IPR).

The Western Corridor scheme consists of three advanced water treatment plants – located at Bundamba, Luggage Point and Gibson Island – that can purify secondary treated wastewater to exceed drinking water standards by passing it through seven barriers, including microfiltration, reverse osmosis and advanced oxidation by UV radiation. The combined capacity of the treatment plants is 182ML/day (66GL/year) (Seqwater, 2017).

However, due to a change in Government policy on indirect potable re-use, lack of alternative customers and high costs, the scheme is not producing water and was placed in care and maintenance mode in June 2013 by Seqwater and the Queensland Government. The aim of this decision was to reduce the impact of operating costs on bulk water charges. Under current planning, if south east Queensland's combined dam levels drop to 60%, the scheme will be recommissioned with the aim of having the scheme fully operational at 40%.

3.5 Potable water for urban use

Potable water within the Lockyer Valley is provided by Seqwater, from the Lowood Water Treatment Plant (WTP). The Lowood WTP supplies an estimated 40,000 people across both LVRC and Somerset Regional Council. Distribution and retail functions for the region are then provided by Queensland Urban Utilities.

The Lowood WTP receives water from the Brisbane River downstream of Wivenhoe Dam. The Lowood WTP is an off the grid network, in that the treatment plant and scheme is not connected to the South East Queensland water grid. The Lowood WTP has an upper capacity of approximately 18.5ML/day. Based on the projected demands, an augmentation to provide 35ML/day is proposed by Seqwater in 2020.

The Lowood WTP has a LOS yield of 12,700ML per year against a projected demand ranging from 3,400ML/year currently to a projected 5,900ML/year by 2046. A trunk water supply network from the Lowood WTP provides supply via a network of key reservoirs and trunk distribution mains supplying the townships of Lowood, Gatton, Helidon, Laidley and Forest Hill.

4 Product specification

4.1.1 Introduction

There is a need to define water security options in terms of the quality of water provided, the quantity of water able to supplied and the reliability with which this quantity can be supplied. This is because the quality of water supplied impacts on the types of crops able to be produced and the reliability of supply will impact on the decision making of producers across a range of areas including crop types and long term investment decisions.

4.1.2 Quality

In Queensland, the quality of recycled water for irrigation is regulated in accordance with the *Public Health Regulation 2005* which was enacted under the *Public Health Act 2005*. This standard defines varying classes of water based on factors, the primary of which is the presence of microbial indicators as summarised in Table 4-1.

Table 4-1 Water quality standards[4]

Class of water	Factor	Frequency of sampling	Short term sample value *(if in any sample taken the required factor value is not met, a follow-up sample must be taken and re-tested)*	Resample value[5]	Annual value[6] *(required value in 95% of the samples taken for a 12-month period)*
A+	Chlorine residual of the water	Daily	> 0.2 mg/L	> 0.5 mg/L	> 0.5 mg/L
	Clostridium perfringens	Weekly	< 10 cfu/100mL	< 1 cfu/100mL	< 1 cfu/100mL
	Escherichia coli	Weekly	< 10 cfu/100mL	< 1 cfu/100mL	< 1 cfu/100mL
	F-RNA bacteriophages	Weekly	< 10 pfu/100mL	< 1 pfu/100mL	< 1 pfu/100mL
	Somatic coliphages	Weekly	< 10 pfu/100mL	< 1 pfu/100mL	< 1 pfu/100mL
	Turbidity	Daily	< 5 NTU	< 2 NTU	< 2 NTU
A	*Escherichia coli*	Weekly	< 100 cfu/100mL	< 10 cfu/100mL	< 10 cfu/100mL
B	*Escherichia coli*	Weekly	< 1,000 cfu/100mL	< 100 cfu/100mL	< 100 cfu/100mL
C	*Escherichia coli*	Weekly	< 10,000 cfu/100mL	< 1,000 cfu/100mL	< 1,000 cfu/100mL
D	*Escherichia coli*	Weekly	< 100,000 cfu/100mL	< 10,000 cfu/100mL	< 10,000 cfu/100mL

The regulation also stipulates standards for the quality of water required for irrigating minimally processed food crops as shown in Table 4-2.

[5] If the value of the sample is not met, the responsible entity (the scheme manager, other declared entity or the recycled water provider) must notify the regulator. This matter must also be included in the annual report for the scheme.

[6] If the annual value exceeds the required criteria, then the responsible entity must notify the regulator. This matter must also be included in the annual report for the scheme.

Table 4-2 Standards for quality of water required for irrigating minimally processed food crops

Type of crops	Example of crops	Method of irrigation	Class of water required
Root crops	Carrot, onion	Spray, drip, flood, furrow or subsurface	A
Crops with produce, other than rockmelons, grown on or near the ground if the produce is normally eaten with the skin removed	Pumpkin	Spray	B
		Spray, drip, flood, furrow or subsurface	C
	Rockmelons	Spray, drip, flood, furrow or subsurface	A+
Crops with produce grown on or near the ground, other than crops with produce normally eaten with the skin removed	Broccoli, cabbage, tomato	Spray, flood or furrow	A+
		Drip	A
		Subsurface	C
Crops with produce grown away from the ground if the produce is normally eaten with the skin removed	Avocado, banana, mango	Spray	B
		Drip, flood, furrow or subsurface	C
Crops with produce grown away from the ground, other than crops with produce normally eaten with the skin removed	Apple, olive, peach	Spray	A+
		Drip, flood or furrow	B
		Subsurface	C
Crops for produce grown in hydroponic conditions	Herb, lettuce	Hydroponic	A+

Based on Australian Bureau of Statistics data, agricultural production in the Lockyer and Fassifern Valleys can be mapped to the water classes defined in the *Public Health Regulation 2005* as shown in Figure 4-1.

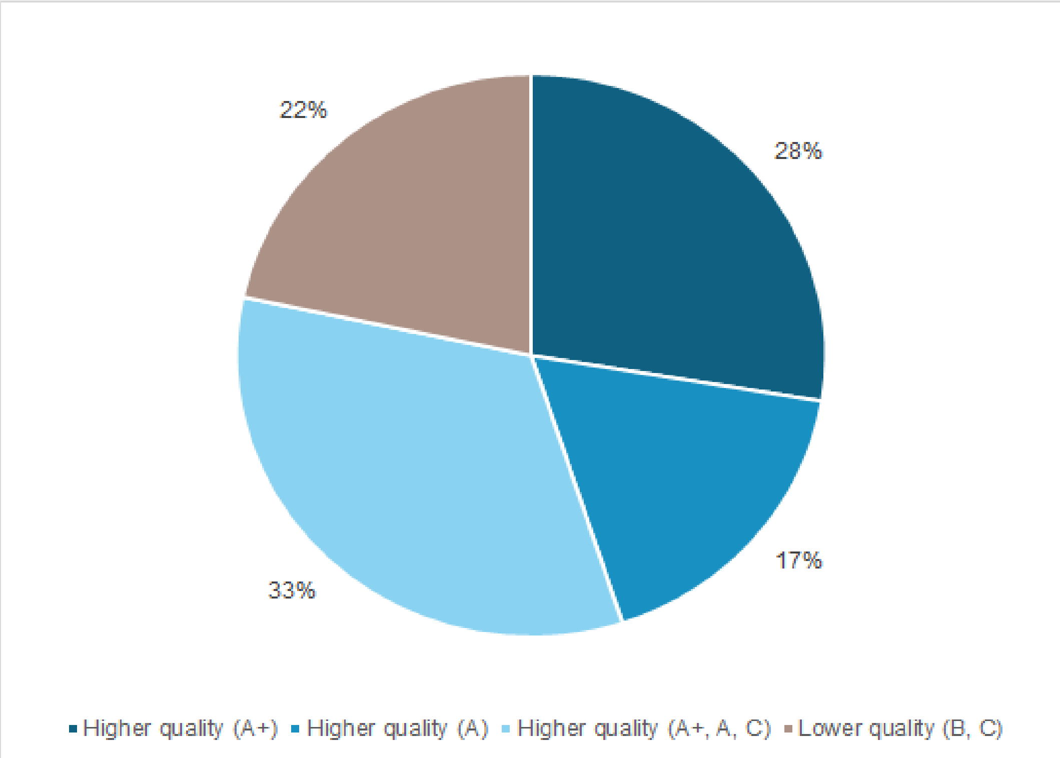

Figure 4-1 Mapping of current production in the Lockyer Valley and Fassifern Valley to water class (percentages by value of production)

This analysis demonstrates for more than three quarters of current production, a high quality (Class A or Class A+) product is required. Of this category, 33% of the value of production could be produced with lower class water (Class C) using sub-surface irrigation. However, this would generally require an investment in sub-surface irrigation. The response of irrigators to different qualities of water requires an assessment of market prospects, costs and future intentions. This should be addressed in a demand assessment.

4.1.3 Reliability

A water allocation is an authority allowing end-users to retrieve water and is an entitlement to a share of the water resource available in a catchment or storage. Water allocations are generally classified into two priority groups: high priority and medium priority. Within the Moreton Water Plan, security objectives relating to each priority group are specified in Schedule 8. Following are the general characteristics of each priority group (Sunwater, 2017).

4.1.3.1 High priority water

General characteristics of high priority water allocations include:

- Most reliable water allocation
- Typically used for town water supply, industrial use including mining and power generation and for high value cropping
- Water allocation holders will usually be able to access water more frequently and with less restriction on availability than those with medium priority water
- During extended dry periods, high priority water allocations are the last group to be placed on restrictions. Holders of high priority water allocations pay higher fees and charges than medium priority water allocations in order to have more reliable access.

4.1.3.2 Medium priority water

General characteristics of medium priority water allocations include:

- Medium priority water allocations generally have lower reliability compared to high priority water allocations and are mainly used for agricultural production
- This means during drier conditions and when the storage level is low, these water allocations are the first to be restricted
- Holders of medium priority water allocations pay lower fees than high priority water allocation holders and are often significantly less.

5 Potential future water resources

5.1 Overview

This section sets out to identify potential water resources available to the Lockyer Valley region for supporting future agricultural expansion. Future resources have been categorised as surface water, recycled water, groundwater and efficiency gains in irrigation practices.

5.2 Surface water

The current regulatory framework for managing water include a process for granting, reserving or otherwise dealing with unallocated water. Under the current water planning regime, unallocated water reserve can be made available for future use without compromising the environmental values within a catchment or the security of existing users. The unallocated water reserves are generally categorised by its intended purpose, namely:

> General reserve – Can be used for any purpose

> Strategic reserve (state) – For projects considered to be of regional significance for the plan area or for coordinated projects under the State Development and Public Works Organisation Act 1971

> Strategic reserve (water infrastructure) – To facilitate the development of particular water infrastructure projects (e.g. new dams) in the relevant water plan area

> Indigenous reserve – For projects that advance the social and economic aspirations of indigenous people.

Under the context of this study, potential water resources had been identified in forms of general reserve and strategic reserve.

5.2.1 General reserve

Table 5-1 summarises the general reserve volume available in regions relatively close to the Lockyer Valley. These volumes are small compared to existing usage in the Lockyer Valley and likely future demand.

Table 5-1 Volumes of general reserve unallocated surface water[7]

Water plan area	Total volume (ML)
Mary Basin	2,010
Burnett Basin	2,000
Condamine and Balonne	6,660
Moonie	3,680
Border Rivers	3,418
Gold Coast	500
Logan Basin	No general reserve volume specified
Moreton	No general reserve volume specified

5.2.2 Strategic reserve

Table 5-2 summarises the strategic reserve volumes available in regions relatively close to the Lockyer Valley. The most significant volume of unallocated water is the 150GL/year strategic reserve in the Mary Basin.

[7] Data from Department of Natural Resources, Mines and Energy. (n.d.). Water for Queensland Map. Retrieved September 6, 2017, from Department of Natural Resources, Mines and Energy: https://www.dnrm.qld.gov.au/online-tools/water-for-queensland/water-map

Table 5-2 Volumes of strategic reserve unallocated surface water[8]

Water plan area	Strategic reserve for a State purpose (ML)	Strategic water infrastructure reserve (ML)	Total strategic reserve (ML)
Mary Basin	150,000	-	150,000
Burnett Basin	1,000	25,845	26,845
Condamine and Balonne	-	-	-
Moonie	100 (for town water supply use only)	-	100
Border Rivers	4,500 (3,000ML for irrigation and associated industry; remainder for town water supply use only)	-	4,500
Gold Coast	-	-	-
Logan Basin	-	-	-
Moreton	-	-	-

While the Mary Basin is to the north of the Lockyer Valley, the water security objectives for all of south east Queensland and the South East Queensland Water Grid infrastructure mean that conceptually, there is potential for the Mary Basin strategic reserve to be used for urban water security for south east Queensland which could be offset by allocation from Wivenhoe Dam. Note that while this is conceptually possible this has not been considered in Seqwater's Water Security strategy so would require significant investigation.

5.3 Recycled water

5.3.1 Western Corridor Recycled Water Scheme

As set out, the WCRWS is capable of delivery of up to 66GL/year and is considered to be integral to south east Queensland's urban water security. The scheme is currently in care and maintenance mode to reduce the overall impact of operating costs on bulk water charges and under current planning arrangements, will only be recommissioned if the region's combined dam levels drop to 60%.

As part of its long term water security planning, Seqwater is considering options for the long term operation of the Scheme. Seqwater is open to the possibility of supplying recycled water for agriculture in the Lockyer Valley either directly or indirectly from Wivenhoe Dam subject to technical and financial considerations.

5.3.2 Regional recycled water resources

Table 5-3 summarises the current cumulative inflows and treated effluent produced at wastewater treatment plants at locations across south east Queensland. These figures exclude volumes from the Brisbane and Ipswich areas as the majority of these areas currently supply the WCRWS.

Table 5-3 Potential regional recycled water resources[9]

Utilities	Volume of recycled water supplied (ML/year)	Volume of sewage treated effluent (ML/year)	Potential recycled water resource (ML/year)
Gold Coast City Council	9,241	52,795	43,554
Southern Downs Regional Council	1,538	1,483	-
Logan City Council	784	17,164	16,380
Unitywater	969	50,468	49,499

[8] *Water Plan (Moreton) 2007* (Qld)
[9] Data from Australian Bureau of Meteorology. (2017, March). *Urban national performance report: National performance report 2015–16: urban water utilities*. Retrieved from Australian Bureau of Meteorology: http://www.bom.gov.au/water/npr/

Utilities	Volume of recycled water supplied (ML/year)	Volume of sewage treated effluent (ML/year)	Potential recycled water resource (ML/year)
Toowoomba Regional Council	2,773	7,527	4,754
Redland City Council	113	9,478	9,365
Western Downs Regional Council	-	1,361	1,361
		TOTAL (ML)	124,913

While Table 5-3 provides an indication of the magnitude of recycled water resources currently available, the Lockyer Valley would need to compete with other end uses local to the sources. Any solutions developed to utilise regional recycled water resources will likely attract high upfront capital costs in order to establish the infrastructure required to operate the recycled water scheme(s) and will also require infrastructure to transport the water to the Lockyer Valley which would make use in the Lockyer Valley more expensive than local uses close to supply. Given that the WCRWS is existing adjacent to the Lockyer Valley region, this is considered as the reference recycled water source within this study.

5.4 Groundwater

Constraints on the alluvial aquifers in the Lockyer Valley have been discussed throughout this report.

The Lockyer Valley also overlies Great Artesian Basin water resources. A new Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017 commenced on 2 September 2017. Table 5-4 details the general reserves from groundwater sub-areas that underlie the Lockyer Valley. The Southern Clarence Moreton area generally underlies the southern part of the Lockyer Valley.

Table 5-4 Volumes of general reserve unallocated groundwater[10]

Groundwater unit	Groundwater sub-area	Total volume (ML)
Hutton	Crows Nest Marburg Southern Clarence Moreton Marburg	425
Precipice	Crows Nest Woogaroo Southern Clarence Moreton Woogaroo	425
Springbok Walloon	Southern Clarence Moreton Walloon	425

5.5 Efficiency

Water use efficiency gains are likely to be possible for protected cropping facilities and field horticulture within the Lockyer Valley region. This is made possible through initiatives such as the Rural Water Use Efficiency for Irrigation Futures (RWUE-IF) initiative where it is a partnership arrangement between rural irrigation industries and the government (Business Queensland, 2017). In the past three years, more than $6 million was invested over 17 projects to improve the use and management of on-farm irrigation water. Water savings of up to 30% (depending on crop type) could be achieved through implementation of best practice irrigation technology and programmed irrigation using computerised systems. Water use efficiency also leads to more efficient fertiliser use and improves overall cost efficiency.

[10] Data from *Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* (Qld) Sch 4

6 Options assessment

6.1 Options long list

Based on literature review, stakeholder engagement and further research and analysis, a long list of potential water security options was generated. The long list of options is included in Appendix D and is summarised in Table 6-1.

Table 6-1 Options long list

Category	Option	Description
Surface water	Water from Wivenhoe/Somerset dam	A new large diameter trunk main supplying raw water to Atkinsons Dam, Lake Clarendon and Lake Dyer
Surface water	Water from other area in south east Queensland	As above but with water sourced from a source other than Wivenhoe/Somerset
Groundwater	Recharge of aquifers with surface water	There are nine existing recharge weirs in the Lockyer Valley. Increase the volume of water going to groundwater through more weirs, increasing the effectiveness of existing weirs (potentially through desilting) or other infrastructure such as injection wells. Possibly discharge directly to creeks
Groundwater / recycled water	Recharge aquifers with recycled water	Recharge of groundwater aquifers with recycled water from either the WCRWS or local treatment plants. Possibly discharge directly to creeks
Groundwater	Treatment of saline groundwater	There are some saline groundwater resources in the Lockyer Valley that could be treated for use
Groundwater	Water from coal seam gas extraction	When coal seam gas is extracted, water is a by-product. There are coal seam reserves nearby to Lockyer Valley (not currently being accessed) and further away in the Surat Basin
Recycled water	Recycled water from local wastewater treatment plants	QUU owns and operates five wastewater treatment plants in the Lockyer Valley from which recycled water may be sourced.
Recycled water	Western Corridor Recycled Water Scheme (WCRWS) – Higher class water	The WCRWS (although currently in care and maintenance mode) can be operated to supply high quality (Class A or A+) via an offtake from the existing pipeline. If the WCRWS is discharging to Lake Wivenhoe, water could be taken from there. Recycled water could then be transferred to the Lockyer Valley using new infrastructure or discharged into waterways.
Recycled water	Western Corridor Recycled Water Scheme (WCRW) – Lower class water	WCRWS is operated to supply low class (Class B or C) water directly to the Lockyer Valley through an offtake from the existing transfer pipeline
Recycled water	Greywater reuse	Centralised or decentralised greywater (typically water from laundry, taps and showers) capture, treatment and reuse
Surface water	Stormwater harvesting	Stormwater harvesting from large open areas and storage in tanks or dams for later use. Could be transferred to existing storage or recharged into aquifers
Water trading	Trading of permanent and seasonal water	Trading of permanent and seasonal water from other supply schemes in the Water Plan area
Efficiency	Improve on-farm irrigation efficiency	Enable irrigators to use higher efficiency irrigation equipment and/or farming techniques

6.2 Assessment criteria

From the long list of options, a number of alternatives can be removed from further consideration because they have significant flaws that mean that they cannot meet the project objective or because there are substantial cost constraints. The project objective is to sustainably provide water for agriculture in the Lockyer Valley. This objective can be further defined to include the following measures which are used to filter options in Table 6-2:

> Supply of water in the very long term (*sustainability*) – agriculture should be a sustainable land use far beyond traditional planning horizons (20-50 years). Sustainability means water supply and agricultural production in perpetuity.
> Supply of sufficient volume of water to meet demand (*yield*) – while demand cannot be accurately assessed without a demand study and with reference to the various water products able to be supplied and the likely cost of supply of these products, the potential magnitude of demand can be estimated. The analysis in Section 2.11 suggests that there is potential for additional demand of greater than 15 GL/year from bringing existing high quality land into production. Additional demand may also result from more intensive cropping, switching to higher water use (and higher value) crops and substitution away from groundwater. For the analysis that follows in this study, a low case of 20GL/year and a medium case of 40GL/year of additional demand are considered. This is not to preclude lower yielding solutions that may benefit end users locally.
> Supply option cost (*cost*) – levelised cost has been determined for options based on the particular parameters of the option or with reference to levelised costs reported in literature. At this stage, only options with an obviously high cost or higher cost than a close alternative have been excluded. An assessment of the financial and economic viability of options is outside the scope of this study.

6.3 Options filter

Table 6-2 details the assessment of options against the criteria of sustainability, yield and cost.

Table 6-2 Options filtering

Option	Discussion	1. Sustainable in the long term		2. Yield		3. Cost		Progress option?
		Discussion	Assessment	Discussion	Assessment	Discussion	Assessment	
Water from Wivenhoe/Somerset dam	Water from Lake Wivenhoe could be transferred to the Lockyer Valley through a new pipeline or reusing the existing Lake Wivenhoe to Cressbrook Dam pipeline in part. A distribution system would likely include the existing storages along with distribution pipelines to customers. This option requires that a water resource is available.	Lake Wivenhoe is replenished by rainfall and therefore is sustainable in the long term	✓	No General Reserve or Strategic Reserve available. Conceptually able to use Mary River strategic reserve for south east Queensland water security	?	Levelised cost of approximately $500/ML to 600ML estimated through this study for the assumed supply configuration. This range is under the supply costs estimated by the 2004 *Lockyer Valley Water Reliability Study* (Department of State Development and Innovation, 2004) of $880/ML (upper bound pricing and indexed to current prices). However given the uncertainties in the estimates they are broadly consistent. Note that this cost does not include any opportunity cost for the purchase of water and includes all costs, i.e. no allowance has been made for potential subsidies.	✓	Yes. Although there are uncertainties over water availability for this option, this is a relatively low cost option compared with the other considered.
Water from other area in south east Queensland	Lake Wivenhoe is the largest storage in south east Queensland and also in close proximity to the Lockyer Valley. As detailed in Section 5.2 there are general and strategic reserves available in other areas in south east Queensland. However, the general reserve volumes are relatively small. The Mary River strategic reserve is relatively large. However, use of this strategic reserve is at the discretion of the State Government. For this pre-feasibility study, the reference option for surface water will be from Lake Wivenhoe as this is closer than the Mary River and conceptually, there is potential for the Mary River strategic reserve to be used for urban water security for south east Queensland which could be offset by allocation from Lake Wivenhoe. Note that while this is conceptually possible this has not been considered in Seqwater's Water Security strategy so would require significant investigation.	Other water storages in south east Queensland are replenished by rainfall and therefore are sustainable in the long term	✓	< 4 GL/year in General Reserve and up to 150GL/year in Strategic Reserve	✓	As Lake Wivenhoe is the closest major water storage to the Lockyer Valley, it is progressed as the reference case.	×	No. This is a higher cost option than the preceding, comparable option.
Recharge of aquifers with surface water	There are concerns over the performance of the existing recharge weirs. Improving the efficiency of recharge weirs would potentially increase the amount of water going to groundwater but would then also reduce surface water flows. However, this option does not generate any 'new' water – all available water is currently subject to planning arrangements. This option would therefore only potentially improve water security locally. Further, while the aquifer provides storage, it has limitations as a distribution system with inconsistent transmission and accessibility.	Aquifer recharge with surface water is replenished by rainfall and therefore is sustainable in the long term	✓	Aquifer recharge with surface water does not generate any new water resources but transfers it from surface water to groundwater	×	Recharge costs reported as $960/ML and O&M costs of $320/ML (Dillon, 2009). However, small scale schemes significantly more expensive at around $6,000/ML (Cardno, 2014). Lower cost for recharge weirs.	×	No. This option does not provide 'new water' and is a relatively high cost option
Recharge aquifers with recycled water	Recharge of groundwater aquifers with recycled water (injection) faces the following obstacles: 3. Prior to recycled water being introduced to the aquifers, an environmental monitoring program would need to be undertaken to understand the capability of the aquifer to take on recycled water	Aquifer recharge is sustainable as long as recycled water is available. Current wastewater collection and treatment technologies	✓	Assuming supply from WCRWS, upper limit of 66 GL/year although this supply will be interrupted	✓	Cost components include purchase of recycled water, transmission and injection to aquifer as well as on-farm extraction costs. Recycled water purchase costs vary depending on quality. Current Class A water purchase from Queensland	× - aquifer recharge ✓ - discharge to waterways	No – for aquifer recharge as this is a relatively high cost option Yes - for lower cost options such as discharge of recycled

Option	Discussion	1. Sustainable in the long term – Discussion	1. Sustainable in the long term – Assessment	2. Yield – Discussion	2. Yield – Assessment	3. Cost – Discussion	3. Cost – Assessment	Progress option?
	and the quality of recycled water required to not adversely impact the aquifer. This monitoring program would likely to be in the order of five to ten years (Natural Resource Management Ministerial Council, Environment Protection and Heritage Council and National Health and Medical Research Council, 2009). 4. A means for transparently and equitably sharing and paying for the recycled water introduced into the aquifer would need to be established. This would require extractions to be metered and a recycled water purchasing and cost sharing mechanism agreed between users. The recycled water injected into the aquifer would need to be purchased (for example from the WCRWS) whereas natural recharge of the aquifer has no cost associated with it. Providing large volumes of recycled water into the aquifers would require a transfer pipeline from the WCRWS. It therefore has much in common with providing recycled water piped to users – for this option the aquifer can be thought of as a storage and distribution system. However, groundwater injection has its own costs for injection wells and other infrastructure and as noted above, the aquifer does not perform well as a distribution system due to inconsistent transmission and access. Recycled water injection of aquifers is not considered further because of the relatively high cost. Further discussion of this option is included in UWSRA Technical Report No. 103 (Wolf, 2013). However, lower aquifers may be recharged with recycled water through lower cost alternatives such as discharge of recycled water into creeks which also has the benefit of providing environmental flows. This option should be considered further.					Urban Utilities is $128/ML (Queensland Urban Utilities, 2017). Class A+ water (Queensland Audit Office, 2013) from WCRWS O&M cost only at full supply estimated at $968/ML. Transfer costs if taken from Lowood Balance tank in order of $200-400/ML depending on scale of transfer. As noted above, injection costs vary widely and reported at $960ML (Dillon, 2009) but may be higher. Costs estimated do not include cost for monitoring program before and during operation or additional governance costs. Low cost option to discharge recycled water into creeks and allow to replenish aquifers.		water to waterways which may also recharge aquifers
Treatment of saline groundwater	Consultation with DNRM identified that there are some small volumes of saline groundwater available in the Lockyer Valley. However desalination of small volumes of groundwater is costly compared with other alternatives.	Where extraction is within the sustainable yield of the aquifer, this option would be sustainable in the long term	✓	GABORA Water Plan identifies that there is 1,275ML/year of general reserves from groundwater sub-areas that generally underlie the Lockyer Valley. However, yield will vary with locations and the quality at different locations is uncertain	?	Levelised cost of $700/ML to $1400/ML for decentralised treatment using package plants to treat to a standard for horticulture. Treatment cost varies with water quality. Additional costs for groundwater extraction.	×	No. This is a relatively high cost option
Water from coal seam gas extraction	Water produced as a by-product of coal seam gas extraction could be transferred to the Lockyer Valley for beneficial reuse. Coal seam gas extraction currently occurs on a large scale in the Surat Basin over 100km from the Lockyer Valley. While there are coal seam gas reserves closer to the Lockyer Valley, these are currently not in production and there are no proposals to develop these reserves.	Coal seam gas water has a finite period of availability – when the coal seam gas is in production which is around 20-25 years for a gas field. This does not meet the project objective to provide water in the very long term.	×	Coal seam gas extraction occurs over many wells spread over a large area requiring by-product water to be aggregated.	?	Levelised cost of $1500/ML to $2500/ML assuming a 113km transfer pipeline from the Surat Basin and including an allowance for treatment	×	No. This option is not sustainable in the long term and relatively high cost.
Recycled water from local wastewater treatment plants	QUU's long term planning to 2046 suggests that effluent production from the local treatment plants will be around 1.5 GL/year. At the upper limit of long term and total population of 61,000 people, an upper bound for local recycled water production is around 4.4 GL/year. Note also that around 0.5 GL/year of effluent from local treatment	Recycled water is sustainable in the long term based on existing wastewater collection and treatment technologies	✓	The upper limit of yield is <5GL/year suggesting that this option is suitable for meeting demand locally to treatment plants	Local only	Supply prices through Queensland Urban Utilities (Queensland Urban Utilities, 2017) Class A+: By negotiation Class A: $128.80/ML	✓	Yes. While the yield available will only benefit some end users locally this is a relatively low cost option.

Option	Discussion	1. Sustainable in the long term		2. Yield		3. Cost		Progress option?
		Discussion	Assessment	Discussion	Assessment	Discussion	Assessment	
	plants is currently reused.					Class B: $119.20/ML Class C: $11.00/ML Additional costs for transfer to end use which will vary based on location.		
Western Corridor Recycled Water Scheme (WCRWS)	Recycled water may be supplied to the Lockyer Valley in large volumes from the WCRWS when this scheme is not required to meet urban demand. Recycled water could be supplied through a direct offtake from the existing scheme (e.g. from the Lowood recycled water balancing tank) or from Lake Wivenhoe as a shandy of raw water and recycled water. The demand for recycled water of different levels of quality needs to be ascertained by a robust demand assessment that considers the willingness to pay for these varying products.	Recycled water is sustainable in the long term based on existing wastewater collection and treatment technologies	✓	Currently, the WCRWS has a capacity of 66GL/year. However, this supply is primarily for urban water security so would be interrupted. Current operating rules are for preparation for supply when storage levels are at 60% and production at 40%. Estimating the likelihood of interruption is outside the scope of this study	✓	Class A+ water (Queensland Audit Office, 2013) from WCRWS O&M cost only at full supply estimated at $968/ML. Transfer costs if taken from Lowood Balance tank in order of $200-400/ML depending on scale of transfer. Separate NWIDF funded study currently in progress considering costs to supply lower class recycled water to the Lockyer Valley and Darling Downs. Levelised cost should also include an allowance for capital costs for treatment but this requires consideration of fair allocation between end users (urban and others).	?	Yes. Cost of supply of recycled water potentially cost prohibitive if A+. However, potential that lower class water can be provided cost effectively.
Greywater reuse	Greywater reuse has the same upper limit of production of local recycled water production – around 4.4 GL/year and therefore may only provide water in local areas, it is not a regional solution. Greywater reuse has very high costs to install, operate and maintain – with levelised costs an order of magnitude greater than recycled water. Recycled water produced centrally at treatment plants is therefore taken forward in this analysis due to its cost advantages over decentralised greywater reuse.	Greywater treatment technologies are currently not widely used, likely because of their high cost and because of concerns over maintaining product quality. New technologies may address these concerns.	?	The upper limit of yield is <5GL/year suggesting that this option is suitable for meeting demand locally to treatment plants	**Local only**	Levelised costs vary widely between reported sources including: ▪ $2,082/ML - $14,240/ML (Cardno, 2014) ▪ $2,440/ML – $26,120/ML (Strategic Economics Consulting Group, 2012) ▪ $5,000/ML - $6,000/ML (Marsden Jacob Associates, 2006)	×	No. This a very high cost option.
Trading of permanent and seasonal water	DNRME is actively considering this option through stakeholder consultation, modelling and considering regulatory amendments.	Trading is sustainable in the long term within the exiting regulatory framework	✓	Trading does not increase the availability of water at the aggregate level within the regions that water is able to be traded but enables water to be used where it realises greater value	?	There are regulatory costs for implementing and managing trading although there are existing systems and tools in place. There are no infrastructure costs.	✓	Yes – although outside the scope of this study as being progressed by DNRME
Improve on-farm irrigation efficiency	On-farm efficiency can lead to savings in water use of up to 30% based on Queensland Government programs. The viability of this option will vary from farm to farm.	Sustainability of efficiency measures is linked to the life of the assets	✓	Yield is dependent on existing arrangements, existing use and the efficiency measure implemented. As note, a current Queensland Government program is realising water usage reduction of up to 30%	?	Levelised costs vary widely depending on situation. Typical range $500/ML – $2500/ML.	✓	Yes

6.4 Further assessment of shortlisted options

Following the filtering of options in the preceding section, the following options remain for further consideration:

> Water from Lake Wivenhoe
> Recycled water from local wastewater treatment plants
> Recycled water from the Western Corridor Recycled Water Scheme
> Trading of permanent and seasonal water
> Improved on-farm efficiency.

Seqwater's 30-year Water Security Program (*Water for life: South East Queensland's Water Security Program 2016 – 2046* (Seqwater, 2017)) identifies that operation of the WCRWS providing indirect potable use via Wivenhoe Dam is an integral part of the future water supply mix for south east Queensland. The Water Security Strategy identifies treatment plant upgrades and network reconfiguration works that together with earlier than previously planned operation of the WCRWS in response to drought will increase the yield of the water sources in south east Queensland from 440 GL/year to 495GL/year.

Under the medium demand scenario, this also defers the requirement for the development of a new water source until 2040 (although this becomes 2031 under the high demand scenario). With the WCRWS being integral to the future water supply mix, the option to provide surface water from Lake Wivenhoe would in time provide a shandy of surface water and recycled water from the WCRWS.

Water trading is being actively progressed by DNRME through stakeholder consultation, modelling and consideration of regulatory amendments. This option is therefore not discussed further in this study.

The remaining options are assessed further in the following sections.

6.4.1 Basis for options of assessment

The assessment of options is based on the following assumptions:

> For the first two options, two demand scenarios – 20 GL/year and 40 GL/year – have been assessed. These are considered reasonable based on the circumstances. Actual demand will vary depending on the cost, quality and reliability of the water supplied. A robust demand assessment is a necessary next step to take the identified options through Building Queensland's Building Case Development Framework.
> Costs exclude the cost of purchasing water as this depends on the potential source of water and the commercial terms on which water is purchased. Capital cost estimates therefore include costs for transfer and distribution infrastructure only.
> Distribution infrastructure has been assumed to be consistent with the 2004 *Lockyer Valley Water Reliability Study (Department of State Development and Innovation)*. That is the customer distribution and length of distribution mains has been assumed as in this report. A future demand assessment would also provide an up to date understanding of the need for distribution infrastructure.
> Capital costs are planning level estimates to +/- 30% accuracy. Lifecycle costs are based on an assumed electricity tariff of $0.23 per kWh, pump station annual maintenance at 2% of capital costs, pipeline annual maintenance at 0.2% of capital costs and a discount rate of 7%.
> No allowance has been made for capital or operating subsidies.

6.4.2 Water from Lake Wivenhoe

Table 6-3 Assessment of option to provide water from Lake Wivenhoe

Description of option	Water from Lake Wivenhoe provided to the Lockyer Valley through transfer and distribution infrastructure likely including the existing storages of Lake Atkinson, Lake Clarendon and Bill Gunn Dam.
Water resource	The following are potential resources that may be accessed from Lake Wivenhoe providing that the identified constraints can be overcome: 1. Trading to allow water allocations from other supply schemes in the

<table>
<tr><td></td><td>Plan Area to be used in the Lockyer Valley<ol start="2">
A commercial agreement between water users and Seqwater for access to Seqwater’s allocations where Seqwater considers that it can still meet the south east Queensland water security objectives. Also, a commercial agreement between water users and Seqwater to access water from Lake Wivenhoe supplemented by recycled water from the WCRWS.
Access to volumes of water released in flood situations.
A change in water user allocations under the water planning arrangements. This would likely require compensation to be paid to any existing user disadvantaged by a change in allocations.</td></tr>
<tr><td>Product specification - quality</td><td>Water in Lake Wivenhoe is surface water runoff from the contributing catchment. The south east Queensland Water Security Strategy plans for recycled water to be provided to Lake Wivenhoe to supplement supplies in drought conditions. Therefore the water may be a shandy of raw surface water and recycled water.</td></tr>
<tr><td>Product specification – reliability</td><td>While the resource is to be confirmed, it is likely to be have a reliability corresponding to medium priority</td></tr>
<tr><td>Supply volume</td><td>Dependent on access to water resource</td></tr>
<tr><td>Infrastructure requirements</td><td>Transfer pipeline and pump station from Lake Wivenhoe likely to the three major storages – Lake Atkinson, Lake Clarendon and Bill Gunn Dam. The proposed trunk network totals approximately 48.3km, with diameters ranging in size from DN750 to DN1000. There is potential to use part of the existing Lake Wivenhoe to Cressbrook Dam pipeline as part of the transfer pipeline.
Distribution pumping and pipelines from the three major storages. Estimates project a network equal to approximately 150km of reticulation mains ranging in size from DN375 to DN100.
Customer metering and telemetry</td></tr>
<tr><td>Capital cost</td><td><table><tr><th></th><th>20 GL/annum</th><th>40 GL/annum</th></tr><tr><td>Transfer pump station</td><td>$7 M</td><td>$18 M</td></tr><tr><td>Transfer pipeline</td><td>$38 M</td><td>$49 M</td></tr><tr><td>Distribution (including metering)</td><td>$26 M</td><td>$41 M</td></tr><tr><td>Total</td><td>$71 M</td><td>$108 M</td></tr></table></td></tr>
<tr><td>Annual operating cost</td><td><table><tr><th></th><th>20 GL/annum</th><th>40 GL/annum</th></tr><tr><td>Annual operating costs</td><td>$9.2 M</td><td>$21.6 M</td></tr></table></td></tr>
<tr><td>Benefits</td><td>Securing water to existing users that are likely to be impacted by limits on abstraction in the Central Lockyer
Potential to support increased agricultural production on arable land that is not in production</td></tr>
<tr><td>Social impact considerations</td><td>Increased water security from other sources will help mitigate the impact on local communities of possible restrictions on abstractions of</td></tr>
</table>

	surface water ▪ Noise, dust and traffic impacts during construction of pipeline and ancillary infrastructure ▪ Disruption to local properties during construction including access restrictions and disruption to farming ▪ Housing of construction workforce ▪ During operation a transfer pump station will impact on visual amenity and create noise and vibration ▪ Creation of easement for transfer and distribution infrastructure may impact on local planning and land values
Environmental impact considerations	▪ Transfer and reticulation pipeline may require clearing of vegetation ▪ Potential disturbance of contaminated land or acid sulphate soils during construction ▪ Change in water balance in Brisbane River and Lockyer Creek catchments. This may include positive impacts where streamflows in the Lockyer Creek catchment are increased
Regulatory considerations	▪ Access to water allocation ▪ Land tenure ▪ Native Title ▪ Planning and environmental approvals

6.4.3 Recycled water from local wastewater treatment plants

Table 6-4 Assessment of option to provide water from local wastewater treatment plants

Description of option	QUU owns and operates five wastewater treatment plants in the Lockyer Valley from which recycled water may be sourced.
Water resource	Treated effluent from local wastewater treatment plants
Product specification - quality	Existing quality available from nearby treatment facilities is typically C Class. Where financially viable, a higher class water could be provided through the provision of additional treatment
Product specification – reliability	Wastewater treatment flows are generally reliable but decrease in times of drought when potable water restrictions are in place
Supply volume	Long term (2046) production forecast at 1.5GL/year with an upper limit of 4.4 GL/year based on population projection. Currently only around 0.5GL/year is available.
Infrastructure requirements	Local recycled water distribution network which may include storage for low demand periods
Supply Costs	QUU publish supply costs on their website, the current costs are:

Class	Price per kL
Class A+	By negotiation
Class A	$1.288

	Class B | $1.192 Class C | $0.110
Benefits	▪ Supplementing water supplies local to the treatment plants ▪ Reduced discharge of nutrients to waterways
Social impact considerations	▪ Public perception of recycled water use for agriculture ▪ Increased water security from other sources will help mitigate the impact on local communities of possible restrictions on abstractions of surface water ▪ Construction and operation impacts as for previous option but generally to a lesser degree due to reduced infrastructure requirement and likely to be close to existing treatment plants
Environmental impact considerations	▪ Impacts on nutrient levels in soil and groundwater including waterways that drain from sites ▪ Potential for increase in salt accumulation in soil ▪ Construction and operation impacts as for previous option but generally to a lesser degree due to reduced infrastructure requirement and likely to be close to existing treatment plants
Regulatory considerations	▪ Requirement for Recycled Water Management Plans for end uses

6.4.4 Recycled Water from the Western Corridor Recycled Water Scheme

Table 6-5 Assessment of option to provide water from the WCRWS

Description of option	Water from the WCRWS provided to the Lockyer Valley through transfer and distribution infrastructure likely including the existing storages of Lake Atkinson, Lake Clarendon and Bill Gunn Dam. The likely offtake point would be the Lowood Balance Tank at approximately 129m AHD.
Water resource	Water for this option would be purchased from Seqwater on commercial terms
Product specification - quality	The response of irrigators to different qualities of water requires an assessment of market prospects, costs and future intentions. This should be addressed in the Detailed Business Case. Consultation with stakeholders has identified some concerns regarding the application of recycled water on crops, even within the parameters set out in the *Public Health Regulation 2005* discussed in Section 5.3. Box 1 provides a case study of the largest scheme providing high quality recycled water for vegetable production in Australia, the Virginia Recycled Water Scheme.
Product specification – reliability	As the WCRWS is required to meet the urban water security objective, supply will be interrupted at times when the scheme is required to meet urban demand requirements.
Supply volume	Upper limited by capacity of WCRWS – up to 66 GL/year less other uses
Infrastructure requirements	▪ Transfer pipeline and pump station from the Lowood Recycled Water Balance Tank to the three major storages – Lake Atkinson, Lake Clarendon and Bill Gunn Dam. The proposed trunk network totals

<table>
<tr><td></td><td>approximately 53.8km, with diameters ranging in size from DN750 to DN1200.
▪ Distribution pumping and pipelines from the three major storages. Estimates project a network equal to approximately 150km of reticulation ranging in size from DN375 to DN100.
▪ Customer metering and telemetry
▪ Alternatively, recycled water may be discharged into local creeks which would recharge aquifers and the creeks would act as natural carriers. This would substantially reduce infrastructure requirements.</td></tr>
<tr><td>Capital cost</td><td><table><tr><th></th><th>20 GL/annum</th><th>40 GL/annum</th></tr><tr><td>Transfer pump station</td><td>$1.5M</td><td>$6 M</td></tr><tr><td>Transfer pipeline</td><td>$44 M</td><td>$56 M</td></tr><tr><td>Distribution (including metering)</td><td>$26 M</td><td>$41 M</td></tr><tr><td>Total</td><td>$71 M</td><td>$104 M</td></tr></table></td></tr>
<tr><td>Annual operating cost</td><td><table><tr><th></th><th>20 GL/annum</th><th>40 GL/annum</th></tr><tr><td>Annual operating costs</td><td>$2.2 M</td><td>$5.3 M</td></tr></table></td></tr>
<tr><td>Benefits</td><td>▪ Securing water to existing users that are likely to be impacted by limits on abstraction in the Central Lockyer
▪ Potential to support increased agricultural production on arable land that is not in production</td></tr>
<tr><td>Social impact considerations</td><td>▪ Increased water security from other sources will help mitigate the impact on local communities of possible restrictions on abstractions of surface water
▪ Noise, dust and traffic impacts during construction of pipeline and ancillary infrastructure
▪ Disruption to local properties during construction including access restrictions and disruption to farming
▪ Housing of construction workforce
▪ During operation a transfer pump station will impact on visual amenity and create noise and vibration
▪ Creation of easement for transfer and distribution infrastructure may impact on local planning and land values
▪ Public perception of recycled water use for agriculture</td></tr>
<tr><td>Environmental impact considerations</td><td>▪ Transfer and reticulation pipeline may require clearing of vegetation
▪ Potential disturbance of contaminated land or acid sulphate soils during construction
▪ Change in water balance in Brisbane River and Lockyer Creek catchments. This may include positive impacts where streamflows in the Lockyer Creek catchment are increased
▪ Electricity consumption in producing treated water</td></tr>
<tr><td>Regulatory considerations</td><td>▪ Land tenure
▪ Native Title</td></tr>
</table>

	▪ Planning and environmental approvals ▪ Requirement for Recycled Water Management Plans for end uses

Box 1 – Virginia Water Recycling Scheme Case Study

The Virginia Water Recycling Scheme in South Australia is one of the largest recycled water schemes in Australia. A $30 million filtration/ disinfection plant was built to treat effluent from the Bolivar sewage treatment plant, producing Class A recycled water which is used without restriction for irrigation of horticultural and agricultural produce. The water is used to irrigate a wide range of fruit and vegetables which supply local and interstate markets including beans, broccoli, cabbage, capsicum, carrots, cucumber, eggplants, lettuce, melons, onions, parsnips, pears, potatoes, pumpkins, tomatoes, zucchini, nuts, olives and wine grapes.

The water recycling scheme provides 20 GL per year of Class A recycled water to 400 connections. This quantity of water would otherwise have been discharged to the Gulf of St Vincent and diminishing groundwater reserves in the region used for irrigation instead. The scheme consists of 135km of distribution pipelines along with transfer pump stations.

The Virginia Pipeline Scheme is the most substantial scheme in Australia for producing food crops using recycled water. The scheme has successfully operated for more than 10 years with no human health issues.

Recycled water has delivered nearly half the water required by growers at Virginia. This water helped produce about $110 million of product on average each year at the farmgate in the Virginia area. This equates to approximately $50 million of produce grown a year with recycled water.

According to ABS data, recycled water has delivered a substantial portion of agricultural water required by growers at Virginia – ranging from 26% to 34% in the past five years. The remaining demand is mainly supplied through groundwater and surface water.

6.4.5 Improved on-farm efficiency

Table 6-6 Assessment of option to provide water from on-farm efficiency

Description of option	Enable water efficiency to be improved through the use of higher efficiency irrigation equipment and/or farming techniques
Water resource	Increased water efficiency enables increased farm production for the same water output
Product specification - quality	Water quality will be as for existing resources
Product specification – reliability	Increased efficiency should improve the reliability of existing resources
Supply volume	State Government programs report on-farm water use efficiency gains of up to 30%.
Infrastructure requirements	On-farm infrastructure may include: ▪ Monitoring equipment (e.g. soil moisture) ▪ Supervision and control equipment for irrigation ▪ Farm layout remodelling ▪ More efficient irrigation devices

Capital cost	Varies depending on opportunities available
Annual operating cost	Varies depending on opportunities available
Benefits	▪ Securing water to existing users that are likely to be impacted by limits on abstraction in the Central Lockyer ▪ Added efficiency for energy consumption and higher crop yield can also be achieved by review of irrigation practices
Social impact considerations	▪ Increased water security from other sources will help mitigate the impact on local communities of possible restrictions on abstractions of surface water ▪ Equity issues if efficiency improvements are implemented for some landholders but not others
Environmental impact considerations	▪ Increased on-farm efficiency may reduce farm run-off that has environmental benefits, e.g. replenishing groundwater or contributing to streamflows ▪ Increased efficiency may place less pressure on existing water resources (e.g. where a proportion of efficiency gains are converted to an allocation for the environment)
Regulatory considerations	▪ Metering should comply with the principles in the National framework for non-urban metering policy

6.5 Further technical investigations

This report has identified the need for a robust demand assessment to confirm the need for water for agricultural productivity and sustainability in the Lockyer Valley. This would also inform a financial and economic assessment.

The preceding analysis has identified for each shortlisted option technical areas for further investigation to confirm the option's feasibility. These are summarised in Table 6-7.

Table 6-7 Further technical investigations for shortlisted options

Option	Further technical investigations
Water from Lake Wivenhoe	▪ Identify availability of surface water ▪ Determine cost to access water if available ▪ Determine if there it is more cost effective to use part of the existing Lake Wivenhoe to Cressbrook pipeline to transfer water to the Lockyer Valley or if a dedicated pipeline is preferable. ▪ Based on demand assessment, optimal transfer and distribution infrastructure to meet location and magnitude of demand
Recycled water from local wastewater treatment plants	▪ As this option is already available, the investigation to confirm feasibility are generally based on the end user's own circumstances in consultation with Queensland Urban Utilities
Recycled water from the Western Corridor Recycled Water Scheme	▪ Confirm potential for WCRWS to supply different classes of water (A+ and A generally required for current production mix in the Lockyer Valley). This needs to consider existing and alternative technologies, water quality management requirements and operating protocols. ▪ Confirm lifecycle costs to supply varying water classes ▪ Confirm reliability (interruption to supply) of WCRWS for agriculture given primary purpose of securing urban water supplies ▪ Confirm whether it is preferable for recycled water to be taken from the existing pipeline or from Lake Wivenhoe (shandied with surface water) ▪ Determine if there it is more cost effective to use part of the

Option	Further technical investigations
	existing Lake Wivenhoe to Cressbrook pipeline to transfer water to the Lockyer Valley or if a dedicated pipeline is preferable. ▪ Based on demand assessment, optimal transfer and distribution infrastructure to meet location and magnitude of demand ▪ Investigation of cost and benefits of recycled water discharge to creeks and potential to recharge aquifers
Improved on-farm efficiency	▪ Confirm need for on-farm efficiency programs outside existing programs

7 Conclusions

The Lockyer Valley is an important agricultural region in Queensland and Australia, producing agricultural output of $670 M per year. Vegetables for human consumption comprise just over half of all agricultural output and the Lockyer Valley produces one third of all the vegetables grown in Queensland.

The following is evidence that water security is a current and future constraint to agricultural productivity and sustainability in the Lockyer Valley:

> *High quality land not in use* – around 35% (15,000ha) of the high quality agricultural land in the Lockyer Valley is currently not in use. There is an opportunity to increase agricultural output by bringing this land into production. However, this will require additional water to be supplied

> *More productive use of existing land* – there is a move to more intensive irrigated agriculture in the Lockyer Valley in large scale greenhouses. Greenhouses generally use more water and produce more for the same area under production. They also require more reliable supplies to support year round production. Increased intensive animal husbandry has a similar requirement for increased volumes of more reliable water. Across the region, the production of vegetables for human consumption has increased by 24% in the five years between 2010/11 and 2015/16 (Australian Bureau of Statistics, 2012) (Australian Bureau of Statistics, 2017). This suggests that the region has intrinsic locational advantages and improving productivity which could support further growth in this sector should water availability be improved.

> *Potential for value adding* – there is currently limited processing of agricultural produce in the Lockyer Valley. Processing would benefit the regional economy but generally requires reliable water supply.

> *Climate change* – climate change is anticipated to more likely impact the Lockyer Valley than competing regions. Anticipated impacts include declining average annual rainfall and reduce groundwater reliability. Both of these impacts challenge future water security for agriculture.

> *Performance of existing water sources* – the alluvial groundwater aquifers in the Lockyer Valley experience stress in times of low rainfall although they can be recharged relatively quickly following sustained rainfall. The two regulated supply schemes do not provide reliable water. The Lower Lockyer Valley WSS has had an announced allocation of 100% in only five out of the last twelve years. The combined median releases from the three large storages in the Lockyer Valley since 1995 represent less than 10% of estimated average annual usage.

> *Proposed changes to groundwater management* – the Queensland Government is considering new water-resource management arrangements for groundwater areas benefited by operation of the Central Lockyer Water Supply Scheme. The new arrangements which are yet to be defined are intended to specify entitlements and provide equitable access to groundwater. To the extent that these new arrangements reduce the availability of groundwater in some instances production of agricultural products may be reduced.

> *Increased global demand for food and fibre* – the Queensland and Commonwealth governments both recognise the opportunity for agricultural production in Australia to supply growing global demand for food and fibre and accordingly have policies to support growth in agricultural exports.

> *Environmental benefits* - Environmental benefits may be realised from increased water security in the Lockyer Valley were groundwater extraction to be reduced. This would lead to higher groundwater levels and higher flows in surface watercourses. However, investment in riparian rehabilitation is anticipated to be required to reduce sediment loading and realise the associated benefits. Environmental benefits may also be realised where recycled water is used and reduces nutrient loading into watercourses and Moreton Bay.

There is no existing plan for securing water for the Lockyer Valley to meet these challenges and capitalise on the opportunities.

Estimating the amount of water currently used for agriculture in the Lockyer Valley is made difficult because much of the use is unregulated and unmetered. DNRME estimates that water use for irrigation in the Lockyer Valley is around 60GL/year with 44GL/year sourced from groundwater and the balance from surface water (DNRME, 2017). This study has tested this estimate and it is considered reasonable based on current land use.

Potential additional demand for water may arise from:

> Utilisation of high quality land that is currently not in production
> More intensive use of existing land for cropping or animal husbandry
> Substitution for other sources if volumetric entitlements are in place for groundwater.

Estimating the level of potential additional demand is very difficult because of the uncertainties involved. A simple estimate of demand arising from utilisation of high quality land that is currently not in is 15 – 45 GL/year. Potential additional demand arising from the other two drivers is too uncertain to be estimated even at a high level. A rigorous demand assessment is needed to reliably estimate future potential demand. However, potential future demand will be influenced by whether volumetric entitlements are in place and a demand assessment should not be undertaken until there is certainty in this area.

A socio-economic study examining the benefits of increased water supply to the Lockyer Valley (WSP, 2017) identifies the following potential benefits of increased water supply (100 GL/year):

1. An increase in gross value of $640 million per year (direct impact)
2. An additional 1,409 jobs (direct impact)
3. An additional $73 million in annual wages
4. A total economic impact (direct and flow-on impacts) of $1.3 billion to $3.2 billion per year.

While a robust demand assessment is necessary to confirm the potential economic benefit arising from increased water use across the region, the assumption of 100GL/annum in increased usage is considered high based on the discussion in Section 2.11.

A long list of options for providing water security for agriculture in the Lockyer Valley has been identified through research, analysis and stakeholder consultation. This option long list is summarised in Table 7-1.

Table 7-1 Options long list

Category	Option	Description
Surface water	Water from Wivenhoe/Somerset Dam	A new large diameter trunk main supplying raw water to Atkinsons Dam, Lake Clarendon and Lake Dyer
Surface water	Water from other area in south east Queensland	As above but with water sourced from a source other than Wivenhoe/Somerset
Groundwater	Recharge of aquifers with surface water	There are nine existing recharge weirs in the Lockyer Valley. Increase the volume of water going to groundwater through more weirs, increasing the effectiveness of existing weirs (potentially through desilting) or other infrastructure such as injection wells. Possibly discharge directly to creeks
Groundwater / recycled water	Recharge aquifers with recycled water	Recharge of groundwater aquifers with recycled water from either the WCRWS or local treatment plants. Possibly discharge directly to creeks
Groundwater	Treatment of saline groundwater	There are some saline groundwater resources in the Lockyer Valley that could be treated for use
Groundwater	Water from coal seam gas extraction	When coal seam gas is extracted, water is a by-product. There are coal seam reserves nearby to Lockyer Valley (not currently being accessed) and further away in the Surat Basin
Recycled water	Recycled water from local wastewater treatment plants	QUU owns and operates five wastewater treatment plants in the Lockyer Valley from which recycled water may be sourced.
Recycled water	Western Corridor Recycled Water Scheme (WCRWS) – Higher class water	The WCRWS (although currently in care and maintenance mode) can be operated to supply high quality (Class A or A+) via an offtake from the existing pipeline. If the WCRWS is discharging to Lake Wivenhoe, water could be taken from there. Recycled water could then be transferred to the Lockyer Valley using new infrastructure or discharged into waterways.
Recycled water	Western Corridor Recycled Water Scheme (WCRW) – Lower class water	WCRWS is operated to supply low class (Class B or C) water directly to the Lockyer Valley through an offtake from the existing transfer pipeline
Recycled water	Greywater reuse	Centralised or decentralised greywater (typically water from laundry, taps and showers) capture, treatment and reuse

Category	Option	Description
Water trading	Trading of permanent and seasonal water	Trading of permanent and seasonal water from other supply schemes in the Water Plan area
Efficiency	Improve on-farm irrigation efficiency	Enable irrigators to use higher efficiency irrigation equipment and/or farming techniques

This long list of options has been filtered through testing how each option meets the project objective measures of:

> Supply of water in the very long term (*sustainability*) – agriculture should be a sustainable land use far beyond traditional planning horizons (20-50 years). Sustainability means water supply and agricultural production in perpetuity.

> Supply of sufficient volume of water to meet demand (*yield*) – while demand cannot be accurately assessed without a demand study and with reference to the various water products able to be supplied and the likely cost of supply of these products, the potential magnitude of demand can be estimated. The analysis in Section 2.11 suggests that there is potential for additional demand of greater than 15 GL/year from bringing existing high quality land into production. Additional demand may also result from more intensive cropping, switching to higher water use (and higher value) crops and substitution away from groundwater. For the analysis that follows in this study, a low case of 20GL/year and a medium case of 40GL/year of additional demand are considered. This is not to preclude lower yielding solutions that may benefit end users locally.

> Supply option cost (*cost*) – levelised cost has been determined for options based on the particular parameters of the option or with reference to levelised costs reported in literature. At this stage, only options with an obviously high cost or higher cost than a close alternative have been excluded. An assessment of the financial and economic viability of options is outside the scope of this study.

Table 7-2 details the outcomes of filtering the long list of options.

Table 7-2 Outcomes of option filter

Option	Description	Progress?
Water from Wivenhoe/Somerset Dam	Water from Lake Wivenhoe could be transferred to the Lockyer Valley through a new pipeline or reusing the existing Lake Wivenhoe to Cressbrook Dam pipeline in part. A distribution system would likely include the existing storages along with distribution pipelines to customers. This option requires that a water resource is available.	Yes. Although there are uncertainties over water availability for this option, this is a relatively low cost option compared with the other considered.
Water from other area in south east Queensland	Lake Wivenhoe is the largest storage in south east Queensland and also in close proximity to the Lockyer Valley. As detailed in Section 5.2 there are general and strategic reserves available in other areas in south east Queensland. However, the general reserve volumes are relatively small. The Mary River strategic reserve is relatively large. However, use of this strategic reserve is at the discretion of the State Government. For this pre-feasibility study, the reference option for surface water will be from Lake Wivenhoe as this is closer than the Mary River and conceptually, there is potential for the Mary River strategic reserve to be used for urban water security for south east Queensland which could be offset by allocation from Lake Wivenhoe. Note that while this is conceptually possible this has not been considered in Seqwater's Water Security strategy so would require significant investigation.	No. This is a higher cost option than the preceding, comparable option.

Option	Description	Progress?
Recharge of aquifers with surface water	There are concerns over the performance of the existing recharge weirs. Improving the efficiency of recharge weirs would potentially increase the amount of water going to groundwater but would then also reduce surface water flows. However, this option does not generate any 'new' water – all available water is currently subject to planning arrangements. This option would therefore only potentially improve water security locally. Further, while the aquifer provides storage, it has limitations as a distribution system with inconsistent transmission and accessibility.	No. This option does not provide 'new water' and is a relatively high cost option
Recharge aquifers with recycled water	Recharge of groundwater aquifers with recycled water (injection) faces the following obstacles: 1. Prior to recycled water being introduced to the aquifers, an environmental monitoring program would need to be undertaken to understand the capability of the aquifer to take on recycled water and the quality of recycled water required to not adversely impact the aquifer. This monitoring program would likely to be in the order of five to ten years (Natural Resource Management Ministerial Council, Environment Protection and Heritage Council and National Health and Medical Research Council, 2009). 2. A means for transparently and equitably sharing and paying for the recycled water introduced into the aquifer would need to be established. This would require extractions to be metered and a recycled water purchasing and cost sharing mechanism agreed between users. The recycled water injected into the aquifer would need to be purchased (for example from the WCRWS) whereas natural recharge of the aquifer has no cost associated with it. Providing large volumes of recycled water into the aquifers would require a transfer pipeline from the WCRWS. It therefore has much in common with providing recycled water piped to users – for this option the aquifer can be thought of as a storage and distribution system. However, groundwater injection has its own costs for injection wells and other infrastructure and as noted above, the aquifer does not perform well as a distribution system due to inconsistent transmission and access. Recycled water injection of aquifers is not considered further because of the relatively high cost. Further discussion of this option is included in UWSRA Technical Report No. 103 (Wolf, 2013). However, lower aquifers may be recharged with recycled water through lower cost alternatives such as discharge of recycled water into creeks which also has the benefit of providing environmental flows. This option should be considered further.	No – for aquifer recharge as this is a relatively high cost option Yes - for lower cost options such as discharge of recycled water to waterways which may also recharge aquifers
Treatment of saline groundwater	Consultation with DNRM identified that there are some small volumes of saline groundwater available in the Lockyer Valley. However desalination of small volumes of groundwater is costly compared with other alternatives.	No. This is a relatively high cost option
Water from coal seam gas extraction	Water produced as a by-product of coal seam gas extraction could be transferred to the Lockyer Valley for beneficial reuse. Coal seam gas extraction currently occurs on a large scale in the Surat Basin over 100km from the Lockyer Valley. While there are coal seam gas reserves closer to the Lockyer Valley, these are currently not in production and there are no proposals to develop these reserves.	No. This option is not sustainable in the long term and relatively high cost.

Option	Description	Progress?
Recycled water from local wastewater treatment plants	QUU's long term planning to 2046 suggests that effluent production from the local treatment plants will be around 1.5 GL/year. At the upper limit of long term and total population of 61,000 people, an upper bound for local recycled water production is around 4.4 GL/year. Note also that around 0.5 GL/year of effluent from local treatment plants is currently reused.	Yes. While the yield available will only benefit some end users locally this is a relatively low cost option.
Western Corridor Recycled Water Scheme (WCRWS)	Recycled water may be supplied to the Lockyer Valley in large volumes from the WCRWS when this scheme is not required to meet urban demand. Recycled water could be supplied through a direct offtake from the existing scheme (e.g. from the Lowood recycled water balancing tank) or from Lake Wivenhoe as a shandy of raw water and recycled water. The demand for recycled water of different levels of quality needs to be ascertained by a robust demand assessment that considers the willingness to pay for these varying products.	Yes. Cost of supply of recycled water potentially cost prohibitive if A+. However, potential that lower class water can be provided cost effectively.
Greywater reuse	Greywater reuse has the same upper limit of production of local recycled water production – around 4.4 GL/year and therefore may only provide water in local areas, it is not a regional solution. Greywater reuse has very high costs to install, operate and maintain – with levelised costs an order of magnitude greater than recycled water. Recycled water produced centrally at treatment plants is therefore taken forward in this analysis due to its cost advantages over decentralised greywater reuse.	No. This a very high cost option.
Trading of permanent and seasonal water	DNRME is actively considering this option through stakeholder consultation, modelling and considering regulatory amendments.	Yes – although outside the scope of this study as being progressed by DNRME
Improve on-farm irrigation efficiency	On-farm efficiency can lead to savings in water use of up to 30% based on Queensland Government programs. The viability of this option will vary from farm to farm.	Yes

Following the filtering of options in the preceding section, the following options remain for further consideration:

- Water from Lake Wivenhoe
- Recycled water from local wastewater treatment plants
- Recycled water from the Western Corridor Recycled Water Scheme
- Trading of permanent and seasonal water
- Improved on-farm efficiency.

Water trading is being actively progressed by DNRME through stakeholder consultation, modelling and consideration of regulatory amendments. This option is therefore not discussed further in this study.

This report has identified the need for a robust demand assessment to confirm the need for water for agricultural productivity and sustainability in the Lockyer Valley. This would also inform a financial and economic assessment. For each of the short-listed options, further technical investigations required to confirm their feasibility have been identified.

8 Recommendations

1. The demand for and perceived value of potential water security options depends on whether volumetric entitlements are in place for groundwater abstraction or not. This is because groundwater when available is a substitute to potential water security options. Therefore, the proposed amendments to the Moreton Water Plan should be resolved as soon as possible to reduce the uncertainty over water security in the Lockyer Valley.

2. Based on the identified need to secure water supply for existing agriculture in the Lockyer Valley and the existence of potential supply options identified in this pre-feasibility study, it is recommended that:

    D. The service need (demand) across the region be defined in detail

    E. The identified shortlisted water supply options be further progressed

    F. The above, (A) and (B), be progressed utilising the Business Queensland Preliminary Business Case and Detailed Business Case frameworks (as the preferred options likely require capital funding support from the Queensland Government and the potential capital investment may exceed $50M - $100M).

    Particular issues identified in this pre-feasibility study that the Preliminary Business Case and Detailed Business Case need to consider are:

    1. The demand for different water products from both existing irrigators and potential new entrants across the region and by locality across varying end uses including horticulture and intensive animal husbandry

    2. The impact on demand for other water products arising from proposed amendments to the Moreton Water Plan to groundwater use within the Lockyer Valley

    3. The potential for access to water resources which may include:

        a. Existing allocations held by others, including the medium priority allocations in Mid-Brisbane

        b. Existing Strategic Reserves in south east Queensland

        c. Recycled water from the Western Corridor Recycled Water Scheme either through a direct offtake or sourced indirectly from Wivenhoe Dam.

    4. The potential for the Lake Wivenhoe to Cressbrook Dam pipeline to form part of a bulk transfer system as an alternative to a new pipeline

    5. Other public infrastructure requirements necessary to support the identified demand and supply options be identified

    6. In meeting the identified demands across the region, the option or combination of options, with the highest net economic and social benefit to the Lockyer Valley be identified and prioritised.

    7. Environmental benefits arising from increased water security in the Lockyer Valley.

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APPENDIX

A

TERMS OF REFERENCE

APPENDIX

B

PREVIOUS STUDIES

There is a significant body of existing work that considers options for improving water security and agricultural productivity in the Lockyer Valley with studies dating back more than 40 years. The following table provides a short summary of some significant previous studies that have informed this pre-feasibility report. The final column of the table details the relevance of the previous study to this report.

Year	Author	Client	Title	Summary	Relevance to this study
1979	The Division of Land Utilisation, Department of Environment and Resource Management	State of Queensland	Land Degradation in the Lockyer Catchment	The purpose of this study was to assess the nature and extent of land degradation which has taken place in the Lockyer Creek Catchment. The study area covered an area of 200,000ha which included most of the highly productive alluvial plains where irrigation from groundwater is the basis for a diverse range of crop production. Of the study area 17% was assessed as degraded. Sheet erosion was observed mainly on land which was cultivated or had previously been. Gully erosion with an average severity of 18.7m per ha was most severe on the naturally unstable Hillwash Alluvium and Colluvium mapping unit. An area of 500ha was recorded as severely salt affected. Land slips were concentrated in the cleared areas of the Heifer Creek Sandstone unit with an estimated 20% being affected. Without action to reverse the processes initiated by clearing unstable lands of the upper catchment, more serious land degradation and effects on water quality are inevitable.	This study demonstrates the land degradation has been a concern in the Lockyer Valley for a long period of time. This study also quantifies and describes the extent of degradation.
1983	Queensland Water Resources Commission Surface Water Branch	State of Queensland	Lower Lockyer Creek System Atkinson Dam Performance	This report is an analysis of the performance of Atkinson Dam, several attempts were made in the 1960's to analyse the behaviour but they have all been hampered due to inadequate basic data. It describes the derivation of basic hydrologic data for the system and the reservoir system analysis. Atkinson Dam was constructed in 1970 and has a capacity of 31,300ML with a dead storage of 1,800ML. It is an off stream storage with only a small natural catchment of 36km2. The major inflows into the dam are from diversions at Buaraba Creek Diversion Weir and from the Lake Clarendon/Seven Mile Lagoon catchment with catchment areas of 250km2 and 130km2 respectively. Releases from Atkinson Dam flow to Lockyer Creek and to Buaraba Creek downstream of the diversion weir.	This report assesses the performance of the Lower Lockyer System and estimates yield for given levels of performance. The report highlights some of the difficulties in determining yield namely obtaining data, modelling approach and the system complexities. Note that there are other studies available on the planning and performance assessment of the assets within the Central Lockyer and Lower Lockyer Water Supply Schemes, e.g. for Lake Clarendon.

Year	Author	Client	Title	Summary	Relevance to this study
				The yield allocation from Atkinson Dam ponded area and the two feeder channels is 1282ML, in the case where Atkinson Dam falls below 6150ML the yield allocation is restricted to 77% of normal. According to the first analysis it was found that the 'safe yield' for Atkinson Dam was 1001ML/yr. The new analysis concludes that the existing allocations and restriction policies are reasonable for the yield study results.	
1999	Queensland Government Natural Resources and Mines	State of Queensland	Sustainability of Agricultural Systems using Recycled Water in the Lockyer Valley and Darling Downs Area	In this report the feasibility of using recycled water for the sustainable irrigation of crops in the Lockyer Valley was investigated. Three representative soils were chosen for each location to characterise the soils of the area and to investigate the effects of irrigation with recycled water on the soils. The investigations revealed that the use of recycled water for irrigation on the major cropping soils was sustainable, provided the impacts of recycled water on groundwater and soil salinity and sodicity were managed and monitored. Irrigation with recycled water in the Lockyer Valley will decrease the soil profile salt load, as compared to current practice. Therefore, root zone salinity should not pose a limitation to effluent irrigation in this region. However, the interaction between salinity and sodicity will require careful management of those soils with a history of irrigation with poor quality groundwater, to ensure soil structural problems are not induced. Modelling indicates that a fertiliser management strategy which incorporates information on nutrient levels of recycled water is essential in order to minimise nitrate leaching. Where recycled water contributes a significant amount of nitrogen and phosphorous to the cropping system, a reduction in fertiliser application will be required.	This report was the first technical report identified which considered the suitability of the soils in the Lockyer Valley and Darling Downs for recycled water application. The report concludes that the soils are suitable for recycled water application and that nutrient loading can be managed alongside fertiliser use.
2002	GHD	Brisbane City Council	SEQ Recycled Water Project – Infrastructure Costs Study	The South East Queensland Recycled Water Project was conceived to address two significant water-related issues; the environmental impact of effluent discharge to the Brisbane River and Moreton Bay; and the current water shortages for agricultural irrigation in the Lockyer Valley and	This report identified options for providing recycled water to the Lockyer Valley and the potential benefit of reduced effluent discharges to Moreton Bay. This report informed a later 2004 study. While the subsequent construction of the Western Corridor Recycled Water

Year	Author	Client	Title	Summary	Relevance to this study
				eastern Darling Downs. This study was conducted to determine the most cost-effective strategy to recycle treated water. With regards to distribution 11 options were put forward of which five were presented which involved supply to Lockyer Valley only. ▪ Option 1 – L1 provided full supply of 21GL/year, with a capital cost of $189M and a O&M cost of $150/ML ▪ Option 2 – L2 truncated supply of 15GL/yr, with a capital cost of $110M and a O&M cost of $142/ML ▪ Option 3 – L2a same as L2 but with an alternate pipeline route had a capital cost of $109.1M and a O&M cost of $133/ML ▪ Option 4 – L3 truncated supply of 15GL/year with Wivenhoe water via Kholo Crossing, had a capital cost of $114.8M and a O&M cost of $142/ML ▪ Option 5 – L5 truncated supply of 15GL/year with the use of Lake Clarendon as seasonal storage, had a capital cost of $126M and a O&M cost of $182/ML Option 1 would use less than 10% of the available water available from the scheme in 2025. These options would allow irrigation of important agricultural area resulting in significant economic and social benefits.	Scheme has changed the landscape with respect to supply of recycled water, there is useful investigation in their report on distribution infrastructure and other feasibility components.
2002	Halliburton KBR Pty Ltd	Brisbane City Council	Lockyer Valley Hydrological Consultancy	The purpose of this project was to develop predictive tools based on sound hydrological modelling techniques to identify the areas where additional irrigation water is required, evaluate possible groundwater level rises and increases in stream base-flow within the study areas and to evaluate the impacts of recycled water irrigation on regional groundwater and surface water quality using solute transport models. Five scenarios were tested. ▪ Scenario 1 – do nothing ▪ Scenario 2 – supply all recycled water demanded at $150/ML maintaining existing	This study sought to predict the hydrological and hydrogeological impacts of different scenarios of recycled water supply and groundwater extraction. The analysis included financial and economic considerations. While the understanding of surface water and groundwater behaviour and impacts in the Lockyer Valley has progressed since this time, this work underlines the importance of an integrated approach to planning for water security in the Lockyer Valley.

Year	Author	Client	Title	Summary	Relevance to this study
				groundwater and surface water use ▪ Scenario 3 – Same as scenario two except only supply recycled water were deemed economical ▪ Scenario 4 – Supply all recycled water demanded at $150/ML and reduce existing groundwater in most areas by 50% and in the Sandy Creek area by 100% ▪ Scenario 5 – Same as 4 except only supply recycled water where deemed economical Scenarios 1, 2 and 3 resulted in extensive and frequent deletion of aquifer levels. Under scenarios 4 and 5 groundwater levels recover substantially and the frequency of aquifer depletion reduces across most of the Valley. Should the recycled water scheme be implemented there should be a conjunctive used scheme with groundwater use continuing at approximately 50% of existing usage levels across most of the valley in order to control groundwater level rises.	
2004	GHD	State of Queensland, Department of State Development and Innovation	Lockyer Valley Water Reliability Study	It has been identified that the existing groundwater extraction rates were unsustainable and could potentially significantly reduce the agricultural capacity of the Lockyer Valley, this has directed investigations into the viability of supply from a range of sources. The aims of this report were to develop the options to supply irrigators and/or industry from Wivenhoe Dam or municipal and industrial recycled water. 13 schemes were developed supplying water from Wivenhoe Dam to irrigation areas. Seven schemes were developed supplying recycled water to irrigation areas and industrial users. Based on economic and financial analyses two Wivenhoe supply options and two recycled water options were identified as 'preferred' options for further analysis. These options were as follows: ▪ RUL1 – Recycled water piped to the Upper Lockyer valley. Supplying 9,300ML with a capital cost of $76.9M and an upper bound supply cost of $1023/ML. With a BC ratio of 0.72	This report considered both surface water and recycled water supply options to the Lockyer Valley and estimated capital and operating costs for each. A financial and economic assessment was undertaken. The study identified preferred surface and recycled water supply options. Under the assumptions made, it was found that the surface water supply options were cost beneficial but the recycled water supply options were not. While the Western Corridor Recycled Water scheme has changed the landscape with respect to recycled water supply, surface water supply options are broadly similar. However, the demand assessment likely does not reflect current circumstances in the Lockyer Valley.

Year	Author	Client	Title	Summary	Relevance to this study
				▪ WUL1 – Wivenhoe water piped to the whole of the Lockyer Valley. Supplying 19,695ML with a capital cost of $78.4M and an upper bound supply cost of $563/ML. With a BC ratio of 1.97. ▪ WLL1 – a reduced scheme piping water to the Lower Lockyer Valley only. Supplying 5,404ML with a capital cost of $14.0M and an upper bound supply cost of $440/ML. With a BC ratio of 2.83 ▪ RILWB1 – recycled water for Swanbank and the Upper Lockyer Valley. Supplying 23,212ML with a capital cost of $147M and an upper bound supply cost of $913/ML. With a BC ratio of 0.38. While many of the options based on supplies from Wivenhoe Dam have demonstrated benefit cost ratios greater than one, there is considerable uncertainty over the availability of supplies in the mid-long term. The current estimates for recycled water presented no options to supply recycled water for rural purposes that were economically or financially viable.	
2005	The Department of Natural Resources and Mines	State of Queensland	NR&M Discussion Paper – Declaration of the Whole Lockyer Valley as a Subartesian Area	This discussion paper is to inform of NR&M's proposal to declare the whole Lockyer Valley as a Subartesian Area. Central Lockyer Valley already has all groundwater use from irrigation bores licensed and metered, this proposal would be to extend these activities into other areas of the valley. Groundwater regulation can provide a means to addressing a number of that need to be resolved if the Lockyer Valley is to maintain its status as a productive and sustainable vegetable and lucerne growing region.	This report sets out proposed changes to management of groundwater in the Lockyer Valley to address stresses on the system. The proposed governance arrangements would require licences and metering for all bores in the Lockyer Valley. This proposal was not progressed.
2007	Lockyer Valley Water Users Forum INC & Capital Strategies Pty Ltd	Lockyer Valley Water Users Forum	Lockyer Valley Recycled Water Distribution Project Grant Application	With LWUF entering an agreement with the Queensland Government for the supply of up to 25,000ML/year of recycled water to the Lockyer Valley an application was submitted to the National Water Commission to assist with the funding of a 32,000ML water distribution project. The project involves the recharging of aquifer and catchment water resources with Class A+ treated water and	This submission provides a broad overview of what ongoing governance and operating arrangements for a long term water supply scheme may be. It also demonstrates the desire of local water users to increase their water security.

Year	Author	Client	Title	Summary	Relevance to this study
				delivery to individual farm storage systems. It was envisaged that more than 300 land owners would connect to the project. This water distribution project had an estimated capital cost of $115.5m. Where it was proposed that 25% ($28.9m) would be funded by LWL and 75% ($86.6) by the Federal Government Water Smart Australia Program. An upfront capital/infrastructure charge of $1000/ML of treated water contracted to irrigators will be used to fulfil the 25% capital cost share of LWL. All operating costs were estimated to be $283m over 30 years will be met by LWL. After discussions with Veolia, it was advised that $150-$200/megalitre should be achievable and that $150/megalitre was appropriated for forecasting purposes at the time. A consensus has been reached by stakeholders of the QWC that treated water is the only environmentally and financially sound option for freeing up desperately incremental potable water resources for the rapidly growing southeast Queensland region.	
2009	South East Queensland Healthy Waterways Partnership	Queensland Water Commission	Implications of supply of purified recycled water to the Lockyer and Warrill Valleys and mid-Brisbane River for groundwater recharge and irrigation purposes	This briefing paper provides an expert opinion from the South East Queensland Healthy Waterways Partnership scientific expert panel on the implications of supplying recycled water to these areas. Discussing the potential for sediment load reductions for water entering the Brisbane River and Moreton Bay, including preliminary quantification of potential reductions and associated timing. Four scenarios were proposed by the QWC being: **1.** Groundwater extraction is significantly decreased to sustainable yields (~25,000ML/year) with an additional 25,000ML/year of PRW supplied via pipeline reticulation for irrigation purposes. **2.** Groundwater extraction is significantly decreased to sustainable yields (~25,000ML/year) with up to an additional	This study highlights the importance of taking an integrated approach to surface water and groundwater management and the assessment of environmental impacts. It identifies the potential benefits that may be gained from riparian rehabilitation in conjunction with reduced groundwater extraction.

Year	Author	Client	Title	Summary	Relevance to this study
				21,000ML/year of Class A recycled water delivered to the groundwater aquifers via the surface water network, in association with the delivery of up to an additional 25,000ML/year of PRW via existing surface water network, in at least the Central and Lower Lockyer areas. **3.** As per scenario 1 with a properly planned and implemented riparian rehabilitation program. **4.** As per scenario 2 with a properly planned and implemented riparian rehabilitation program. Assuming that the groundwater table replenishes over time, the gradient between surface water and groundwater levels will be diminished. Which could result in increased run-off. This effect is more prominent for the smaller rain events as they are less likely to recharge the groundwater table and instead retain base-flow within the surface water channels. Case 1 & 2 would likely sediment flux will increase as flows would increase, and hence exacerbate the existing erosion problem. Case 3 & 4 is likely that a 50% sediment load reduction could result, but it will take time for riparian vegetation to establish. It is estimated that it would take 10 years until there would be measurable impact.	
2012	Tim Ellis and Leif Wolf	Urban Water Security Research Alliance	Impacts of Applying Purified Recycled Water (PRW) in the Lockyer Valley, Qld: Soil Physical Assessment of PRW Application to Local Soils	This study investigated the possible effects on soil structure of the use of purified recycled water (PRW) for irrigation. The productivity of clay soils depends heavily on their macro structure, good soil structure implies the existence of peds, crumbs and pores and the associated interstices that allow the passage of water and nutrients and the growth of plant roots. The application of PRW following irrigation with more saline groundwater could cause structural breakdown in sodic clays. In this study a test on the behaviours of four soils if PRW were to be applied as irrigation water was performed. This was compared against demineralised water, Logan Dam water and groundwater from two bores (Voigt and the University of Queensland). It was found there was no risk of spontaneous dispersion with any of the soil-water combinations. However, there was	This report concludes that supplying purified recycled water is unlikely to have adverse impacts on soil characteristics.

Year	Author	Client	Title	Summary	Relevance to this study
				mechanical dispersion risk in all cases. Two mechanical dispersion tests were performed. The first being agitation and qualitative turbidity observation and the second being a quantified dispersion test. Results from the first test aligned with theory that predicted a greater tendency for dispersion of slightly sodic soils with decreasing EC (demineralised and PRW). The second test gave contradicting results where the highest risk for dispersion was related to the highest EC water (bore water). Despite this in a broader perspective, it is unlikely that the application of PRW to even mildly sodic soils in the Lockyer Valley, will cause structural degradation worse than is already reported from rainfall during summer storms.	
2013	Leif Wolf	Urban Water Security Research Alliance	Implications of using Purified Recycled Water as an Adjunct to Groundwater Resources for Irrigation in the Lockyer Valley	This report explores the feasibility of linking a large agricultural area and an extensive alluvial aquifer in the Lockyer Valley with the technically advanced reuse concept of the Brisbane metropolis where wastewater is treated to high standards for indirect potable reuse. The capacity of the Lockyer Valley alluvial aquifer to store water is expected to rain between 230 and 350 GL. There are 14 chapters in this report, each chapter covers a different area as follows: ▪ Introduction ▪ General assessment framework that evolved during the project and which now serves to structure the research ▪ Background knowledge on the hydrogeology of the Lockyer Valley ▪ Summary of PRW and other local water sources tests on soil structure ▪ Primary data which is used later as inputs for soil water balance modelling and salt transport modelling ▪ Field investigations to assess groundwater ▪ Initial screening for trace organics in selected groundwater, surface water and treated wastewater sampling points	This work compiles various detailed studies that consider the feasibility of using recycled water in the Lockyer Valley. The study components suggest various management arrangements to address potential impacts.

Year	Author	Client	Title	Summary	Relevance to this study
				▪ Analyse the changing crops and land use in the valley based on remote sensing satellite data ▪ Soil water balance modellings to estimate irrigation demand and deep drainage ▪ Numerical modelling of depths greater than 20m below ground to find how slow salty water is moving downwards ▪ Groundwater table fluctuation methods to demonstrate storage and buffer functionalities ▪ Quantify the need to import water into the Lockyer Valley ▪ The impact of the available climate change scenarios for SEQ on the water resources in the Lockyer Valley ▪ The implications and recommendations for PRW, how the methods can apply to other qualities of imported water, how the tools could be used in other areas where there is conjunctive use. PRW comes at a relatively high production cost >$500/ML when compared to the current water charges of a maximum of $30/ML in the Lockyer Valley. For this reason, irrigators will go a long way to avoid using PRW at all, as long as groundwater is available.	
2013	The Stafford Group	Lockyer Valley Regional Council	Regional Food Sector Strategy	The purpose of the report was to provide the Lockyer Valley Regional Council with key findings for the Regional Food Sector Strategy. It lists a number of agricultural, supporting sector and key infrastructure challenges. One of the agricultural challenges noted was the reliability of water supply. It recognises that there have been challenges relating to the unreliability of surface water and ground water which makes long-term planning and investment decisions commercially risky. The issue is merely noted as without regular water supply the production capacity of the Lockyer risks being compromised. It refers to a separate economic study that was undertaken by Regional Development Australia to assess the regular supply of reliable water for	This report highlights the importance of agricultural production to the Lockyer Valley's economy and strategies to support this industry. Water security is identified as an important factor in supporting agricultural production.

Year	Author	Client	Title	Summary	Relevance to this study
				ongoing agricultural production. Agricultural stakeholder feedback indicates that salt and soil based issues that were particularly prevalent during drought periods within the Lockyer Valley need strategies to be put in place to address these issues that can significantly impact on future agricultural production.	
2016	Lisa Mary Kelly	The University of Queensland	Further Closing the Integrated Total Water Cycle in the Lockyer Valley: A Catchment Scale Integrated Water Resource Management Conceptual Model	The purpose of this thesis was to contribute to the resolution of the integrated water resource management (IWRM) problem in the Lockyer Valley by adding a new definition of IWRM and providing analytical tools for the assessment of water catchments issues, conditions and improvement management. A comprehensive definition and model was sought that included the integrated total water cycle (ITWC) – all sources including natural and recycled water. Three research questions were developed. ▪ What are the key components of the new IWRM conceptual model required to close the ITWC and better manage water as a common pool resource? ▪ Can the application of sound principles and theory of ecological economic and hydrogeology assist in the development of a new IWRM catchment scale conceptual mode, which will achieve these aims? ▪ Can the new IWRM model aid management of the demands on water cause by climate variability, population growth and intensification of agriculture, in view of limited further viable above ground water storage options and unused wastewater? The concerns raised in the research studies and consultancies supported the use of artificial aquifer recharge in salt affected areas to safeguard groundwater levels in the Lockyer Valley. The research however, raised concerns about clay dispersion following the recharge with recycled water. These findings confirmed that the application of sound principles and theory of hydrogeology assisted in the development of IWRM catchment scale conceptual model to	This report is a comprehensive overview of previous studies undertaken relating to water security in the Lockyer Valley. It includes references to reports that were not available for this study. The thesis emphasises the need for an integrated approach to improving water security in the Lockyer Valley.

Year	Author	Client	Title	Summary	Relevance to this study
				achieve the aims of further closing the ITWC.	

APPENDIX

C

STAKEHOLDER CONSULTATION

Stakeholder consultation

The following table summarises the stakeholders that were consulted during this pre-feasibility study along with a summary of the main topics discussed.

Stakeholder	Date	Attendees	Discussion points
Department of Energy and Water Supply	10/03/17, 11am	Virginia Hunter - DEWS Darren Thompson - DEWS Paul Hope - DEWS Paul Cranch - LVRC Belinda Whelband - LVRC Stephen Walker - Cardno Josh Lake - Cardno Sean Murphy - GWAS	▪ Background to NWIDF and administration by DEWS on behalf of Queensland Government ▪ Draft Project Plan has been provided by LVRC. Some minor amendments required, e.g. time and cost change mechanism ▪ Draft outputs to be provided to DEWS for review and approval before Project Plan milestones considered as achieved. ▪ DEWS also has role as the representative of one of the responsible Ministers for Seqwater, the Minister for Main Roads, Road Safety and Ports and Minister for Energy, Biofuels and Water Supply ▪ Ensure that we consult widely with government agencies to understand the lay of the land currently, but also where the agencies are moving to ▪ Discuss with Department of Environment and Heritage Protection regarding requirements for end water use ▪ When developing options, define the product and the cost of the product. Compare new options with the product specification and cost of existing products ▪ Also compare performance / reliability of options ▪ Note that DEWS also is responsible for a number of weirs in the Lockyer Valley ▪ Options should be costed using National Water Initiative pricing principles ▪ As this is a pre-feasibility study, we are to flag what is possible within the current planning /regulatory environment and also where the current planning/regulatory environment is a constraint ▪ Identify what regulatory changes would make possible ▪ Discussion around scope of this study and clarification that as a pre-feasibility study the focus will largely be on supply options. DEWS noted that understanding demand will be essential at the next stage and should be included at a high level in this study. Demand should be linked to the regional economic benefit that will result from pursuing the options.
Department of Natural Resources and Mines	13/03/17, 11.30am	Fred Hundy – DNRM Paul Cranch - LVRC Stephen Walker - Cardno Dan Wood - Cardno Sean Murphy - GWAS	▪ Technical working group has been established to draft the new operating rules. Modelling and policy development is being undertaken considering questions such as what allocations might look like and trading rules. Note that this is tightly focused on the Central Lockyer WSS. Statement of proposals has been released for consultation and feedback received. ▪ Groundwater data is available from Department of Science, Information Technology and Innovation (DSITI) – modelling team at Boggo Road. Submit data request to them ▪ Groundwater recharge weirs are located within the Lockyer Valley. However, it is believed that these are not performing well due to sediment build-up. What are the economics of desilting? Does it stack up for Seqwater? ▪ Source the data for metered use data for entitlements / authorised use. ▪ Surface water – no unallocated general reserve water / strategic reserves available in south east

Stakeholder	Date	Attendees	Discussion points
			Queensland and unlikely in the foreseeable future. Would require a re-writing of the Water Plan ▪ Water in Wyaralong Dam is allocated for High Priority Use ▪ Any new surface water storage would not create 'new' water – already considered under the Water Plan. Similarly, overland flow captured in farm dams already subject to regulation with respect to storage size. ▪ Ensure that pre-feasibility study also recognises the Great Artesian Basin groundwater areas in the Lockyer Valley. ▪ Some saline groundwater likely to be available but volumes not likely to be large and need to be taken in accordance with Great Artesian Basin Water Plan
Seqwater	15/03/17, 10.00am	Mick Drews – Seqwater Mike Foster – Seqwater Paul Cranch - LVRC Stephen Walker - Cardno	▪ Version 2 of *Water for Life* (30-year Water Security Program) to be released on 24/03/17. This document confirms that the Western Corridor Recycled Water Scheme (WCRWS) is a critical part of urban water supply to south east Queensland in the future ▪ WCRWS currently in care and operation mode with requirement to be able to be brought back into service within two years. Longest activity is 100days to gain approval to discharge to Lake Wivenhoe. ▪ Current trigger for recommissioning is Key Bulk Water Storages (KBWS) at 60% level (down from 70% in Version 1 of Water for Life). But desire to have WCRWS available prior to 2026 (current government direction) as this will increase Level of Service yield to required level ▪ Water for Life Version 2 states that "*As total water demand grows over time, a higher trigger to commence operation will be required to maintain water security and compliance with the LOS objectives. The increased frequency of use means there is unlikely to be any financial benefit gained from decommissioning the WCRWS between droughts. Decommissioning would be of benefit only where the WCRWS would not be operational for a long period of time. Once recommissioned, the WCRWS will remain in hot standby mode of operation. Ongoing maintenance of the WCRWS will be continually optimised."* In these circumstances, it may be cost beneficial to provide WCRWS water for non-urban uses where doing so does not compromise water security ▪ The importance of the WCRWS to urban water security makes the prospect of re-purposing the scheme to supply lower class recycled water some or all of the time unlikely to be feasible ▪ Any existing urban water supply diverted to non-urban supply would need to be made up to enable Seqwater to continue to meet its Level of Service objective. The appropriate cost for accessing an existing water supply source would be the cost of developing a new supply source
Department of Environment and Heritage Protection	20/03/17, 2.00pm	Brad Dines – DEHP Michael Newham - DEHP Paul Cranch - LVRC Stephen Walker - Cardno	▪ Note that water quality objectives for South East Queensland are currently being revised ▪ Note the Building Queensland requirements for consideration of environmental impacts ▪ Also consider any requirements under the Environment Protection and Biodiversity Conservation Act ▪ Advised to confirm if there any groundwater dependent ecosystems. Reference the wetland information website. Include in considerations potential for recycled water recharge into aquifers to impact groundwater dependent ecosystems ▪ State Planning Policy modules under review. May be impacts for WSUD and stormwater

Stakeholder	Date	Attendees	Discussion points
			harvesting ▪ Include State and Commonwealth matters of importance ▪ Nutrient trading – policy on website for credits and offsets. Beaudesert trial underway. What are the avoided costs? Also trial on Laidley Creek near Mulgowie for offset
Department of Natural Resources and Mines	23/03/17	Ashley Bleakley – DNRM Sean Murphy - GWAS	▪ Water Allocation amendments continuing, aim for completion September 2017 ▪ Weirs constructed 1940, more in 1970's ▪ Weirs desilted 1990 to 1994, important to groundwater recharge ▪ Former Sub-artesian area metered in 1992 ▪ Meters in disrepair – being repaired / replaced ▪ Some irrigation efficiencies adopted leading to decrease in water use since 1992 ▪ Greywater schemes – LVRC Gatton recharge scheme, Jordans Weir, Redbank Farms ▪ Brisbane treat and pump scheme – individual farms interested, large area scheme proposed, CSIRO conducted a study ▪ Coal seam gas water option reviewed by CSIRO, appears to be limited water availability and not likely to happen ▪ Desalination of groundwater – was of the opinion that Woogaroo subgroup water is of good quality and Marburg Formation water is limited in the area and insufficient for a viable supply ▪ DNRM will provide estimated extraction figures based on previous investigations
Queensland Urban Utilities	27/03/17	Shane Tyrrell – QUU Abel Immaraj – QUU Maryam Charehsaz – QUU Cameron Jackson – QUU Paul Cranch – LVRC (by phone) Belinda Whelband – LVRC (by phone) Stephen Walker – Cardno Sean Murphy - GWAS	▪ QUU serves customers and the community – catchment to the bay outlook in line with its activities ▪ Consider wider benefits possible through recycled water use – nutrient offset. This benefit needs to be accounted for ▪ Note – have we considered ability to trade off drought resilience in areas across south east Queensland? See Warrill Creek Water Plan. ▪ Also, consider harvesting flood water volume when Wivenhoe returns to 100% level over 7 days as in operating rules ▪ Optimisation of the SEQ grid is an opportunity to realise additional supply ▪ QUU consider that the option of using the WCRW for a lower quality product should be considered. Should be technically possible and therefore it becomes a financial consideration. ▪ WCRWS likely to be a cost effective option for managing nutrients ▪ QUU would like to discuss with Seqwater the possibility of providing lower quality treated water through the WCRWS – technical and financial considerations. Consideration of nutrient abatement benefits ▪ Local recycled water from QUU treatment plants provide only relatively low volumes. But nutrient abatement possibly a bigger benefit
Lockyer Valley Water Users Forum	21/04/17	Paul Cranch – Lockyer Valley Regional Council	▪ High level discussion on potential demand for varying product quality including current and potential uses

Stakeholder	Date	Attendees	Discussion points
		Richard Collins – Lockyer Valley Regional Council Gordon Van Der Est – Water Users Forum Stephen Walker – Cardno Joshua Lake - Cardno	▪ Recycled water quality specifications ▪ High level discussion on potential options – benefits and constraints ▪ Considerations for potential distribution arrangements within the valley
Seqwater	11/07/17	Mike Foster – Seqwater Mick Drews – Seqwater Kate Lanskey – Seqwater Stephen Walker - Cardno	▪ Current performance of surface water supply schemes in the Lockyer operated by Seqwater ▪ Potential for WCRWS to supply water to the Lockyer. High level discussion on availability and constraints ▪ Usage data for Seqwater's water supply schemes in the Lockyer Valley
Queensland Urban Utilities	15/8/17	Shane Tyrrell – QUU Abel Immaraj – QUU Stephen Walker – Cardno	▪ Pricing and access to recycled water from QUU's wastewater treatment plants in the Lockyer Valley ▪ Current and potential discharge limits for QUU's wastewater treatment plants in the Lockyer Valley
Department of Natural Resources and Mines	06/09/17	Stephenie Hogan – DNRM Dennis O'Neil – DNRM Bob Tomkins – DNRM Stephen Walker – Cardno	▪ Update on proposed amendments to the Moreton Water Plan ▪ Potential for water trading within the Moreton Water Plan area ▪ Regulatory considerations relating to aquifer recharge ▪ Consideration relating to flood harvesting and associated environmental objectives

Community consultation

LVRC hosted a number of community consultation meetings throughout July 2017 to gain community views on the objective of water security for the Lockyer Valley and opportunities and constraints relating to this objective. Engagement activities included informal drop-in sessions with feedback provided verbally, through questionnaires and via responses to prompt materials (e.g. maps of the region). The dates and locations of meetings held are detailed in the following table.

Date	Location	Duration
Tuesday, 4 July 2017	Gatton Shire Hall 52 North Street, Gatton	4:00pm to 7:00pm
Thursday, 6 July 2017	Laidley Sports Complex Whites Road, Laidley	4:00pm to 7:00pm
Tuesday, 11 July 2017	Glenore Grove Hall 11 Brightview Road, Glenore Grove	4:00pm to 7:00pm
Thursday, 13 July 2017	Tenthill Pub Mt Sylvia Road, Tenthill	4:00pm to 7:00pm

LVRC had promoted the pre-feasibility study within the broader community and with key stakeholders in various ways, namely through Council's website; social media (Facebook, Twitter, Instagram); newspaper (Valley Voice); customer service areas in Gatton and Laidley; media releases and mail out to specific stakeholders/ groups.

The following is a list of questions that had been included as part of the questionnaire survey:

- Name (optional)
- Age group
- What are your interests in this study? (tick all that apply)
- Are you a member of a group with interests in water for agriculture?
- If yes, please provide the group name (optional)
- How many years have you lived in the Lockyer Valley?
- What do you see as the benefits of increased water security in the Lockyer Valley?
- Does water security constrain you at the present time?
- Do you have any comments or concerns about the possibility of bringing additional irrigation water into the Lockyer Valley?
- Are there additional water supply opportunities we may not have identified?
- Are there any issues or constraints we may not have identified?
- Do you have any other comments?
- If you would like to receive updates on the project, please provide your email address or phone number
- How did you find out about this event?

Following is a short summary of input gained from the community engagement under the themes in the questionnaire.

Key themes	General findings
Perceived benefits of increased water security in the Lockyer Valley	There is a general consensus in the community that increased water security in the region will lead to economic benefits.
Perceived constraints due to current water security level in the Lockyer Valley	More than half of the respondents stated current water security level is constraining the growth of their business.
Comments/ concerns about the possibility of bringing additional irrigation water into the Lockyer Valley	Main concerns regarding additional water supplies were affordability, water quality and future groundwater supply.

APPENDIX

D

LONG LIST OF OPTIONS

Category	Option	Description	Outcomes / Benefits achieved	Infrastructure requirements	Non-infrastructure requirements	Stakeholders affected	Timeframe	Scalability	Potential adverse impacts
Surface water	Water from Wivenhoe/Somerset dam	A new large diameter trunk main supplying raw water to Atkinsons Dam, Lake Clarendon and Lake Dyer	▪ Increased volume and reliability of existing supply	▪ Installation of a large diameter trunk main and pumping stations to convey flows ▪ Distribution infrastructure from storages	▪ As there is currently no unallocated surface water within the Moreton Water plan area, water would need to be made available. This could be through for example allowing trading of medium priority allocations, harvesting flood releases, a change in how water is shared between users or through increased yield from existing sources	▪ DNRM and DEWS as water resource planner and regulator ▪ End users ▪ DEHP as environmental regulator for any potential change in the share of water in the plan area going to the environment	▪ Capital works 1-3 years ▪ Legislation changes potential a number of years	▪ Limited to available water	▪ Decisions on changing how water is shared in the plan area need to balance environmental, social and economic benefits and impacts
Surface water	Water from other area in south east Queensland	As above but with water sourced from a source other than Wivenhoe/Somerset	▪ As above	▪ As above	▪ As above	▪ As above	▪ Capital works 1-3 years ▪ Legislation changes potential a number of years	▪ Limited to available water	▪ Decisions on changing how water is shared in the plan area need to balance environmental, social and economic benefits and impacts
Groundwater	Recharge of aquifers with surface water	There are nine existing recharge weirs in the Lockyer Valley. Increase the volume of water going to groundwater through more weirs, increasing the effectiveness of existing weirs (potentially through desilting) or other infrastructure such as injection wells. Possibly discharge directly to creeks	▪ Increased reliability of supply by storing water when available for later use ▪ Possibly increased flows in waterways leading to environmental benefits and reduced catchment management costs	▪ Possibly new recharge weirs or upgrade to existing weirs ▪ Possibly injection wells and infrastructure to transfer water to recharge locations	▪ As there is currently no unallocated surface water within the Moreton Water plan area, water would need to be made available. This could be through for example a change in how water is shared between users or through increased yield from existing sources ▪ Regulatory approach to equitably sharing increased or more reliable yield	▪ DNRM and DEWS as water resource planner and regulator ▪ End users ▪ DEHP as environmental regulator for any potential change in the share of water in the plan area going to the environment	▪ Capital works 1-3 years ▪ Legislation changes potential a number of years	▪ Limited to available water	▪ Decisions on changing how water is shared in the plan area need to balance environmental, social and economic benefits and impacts
Groundwater / recycled water	Recharge aquifers with recycled water	Recharge of groundwater aquifers with recycled water from either the WCRWS or local treatment plants. Possibly discharge directly to creeks	▪ Increased reliability of supply by storing water when available for later use ▪ Possibly increased flows in waterways leading to environmental benefits and reduced catchment management costs	▪ Transfer pipelines ▪ Injection wells	▪ Understanding of impact of recycled water on aquifer and necessary water quality ▪ Regulatory approach to equitably sharing increased or more reliable yield	▪ DNRM as groundwater regulator ▪ DEHP as environmental regulator ▪ Seqwater and QUU as recycled water suppliers ▪ End users	▪ Capital works 2-5 years ▪ Potentially many years to understand and put in place mechanisms to manage environmental impact	▪ Scalable but limited by throughput of local treatment plant based on population growth (1.5GL/year in long term planning) or from WCRWS (32-66 GL/year)	▪ Potential impact on aquifer health characteristics ▪ Soil quality may be impacted if recycled water not managed properly ▪ Resistance to uptake ▪ Impact on organic farming

Category	Option	Description	Outcomes / Benefits achieved	Infrastructure requirements	Non-infrastructure requirements	Stakeholders affected	Timeframe	Scalability	Potential adverse impacts
Groundwater	Treatment of saline groundwater	There are some saline groundwater resources in the Lockyer Valley that could be treated for use	▪ Increased volume and reliability of existing supply	▪ Extraction bores ▪ Treatment plant ▪ Transfer to existing storages and distribution	▪ Depending on where groundwater is sourced from, there may not be unallocated water available ▪ Approach to sharing costs and yield	▪ DNRM as groundwater regulator ▪ Landholders where groundwater extraction would take place ▪ End users	▪ Capital works 3-6 years	▪ Scalable but upper limited to sustainable yield	▪ Any decision on changing how water is shared in the plan area need to balance environmental, social and economic benefits and impacts ▪ Possibly impact on other aquifer layers by abstracting saline resources
Groundwater	Water from coal seam gas extraction	When coal seam gas is extracted, water is a by-product. There are coal seam reserves nearby to Lockyer Valley (not currently being accessed) and further away in the Surat Basin	▪ Increased volume and reliability of existing supply	▪ Assume coal seam gas producer responsible for extraction and treatment of water ▪ Transfer to existing storages and distribution	▪ Agreements for water supply between producers and end users ▪ Regulatory approval for use of coal seam gas water	▪ Coal seam gas producers ▪ Landholders ▪ Local communities	▪ No coal seam gas currently in production near to Lockyer Valley	▪ CSG production typically spread over large area ▪ Upper limit based on groundwater in coal seams ▪ Finite period of production	▪ Significant impacts on land and communities associated with extraction of coal seam gas ▪ Likely to be community resistance to CSG production outside of the existing production areas
Recycled water	Recycled water from local wastewater treatment plants	QUU owns and operates five wastewater treatment plants in the Lockyer Valley from which recycled water may be sourced.	▪ Recycled water of desired quality provided to local irrigators ▪ Reduced (or no) nutrient discharge to waterways	▪ Effluent treatment at each of the wastewater treatment plants to meet desired water quality ▪ Distribution pipelines	▪ Agreements for water supply between QUU and end users ▪ Recycled water management plans for end users	▪ QUU ▪ Landholders along distribution pipeline routes ▪ End users regarding effluent quality	▪ Recycled water currently being provided – 0.5Gl/yr ▪ Upgrade in capacity provided likely to take 2-5 years	▪ Scalable but upper limited by throughout of treatment plant based on population growth (1.5GL/year in long term planning). Needs connected population to reach upper limit	▪ Soil quality may be impacted if recycled water not managed properly ▪ Resistance to uptake
Recycled water	Western Corridor Recycled Water Scheme (WCRWS) – Higher class water	The WCRWS (although currently in care and maintenance mode) can be operated to supply high quality (Class A or A+) via an offtake from the existing pipeline. If the WCRWS is discharging to Lake Wivenhoe, water could be taken from there. Recycled water could then be transferred to the Lockyer Valley using new infrastructure or discharged into waterways.	▪ Recycled water of desired quality provided to local irrigators	▪ Installation of a large diameter trunk main and pumping stations to convey flows from Lake Wivenhoe ▪ Distribution infrastructure from storages	▪ Regulatory and management measures to make WCRWS available for increasing the yield of the Wivenhoe system and making this water available for agricultural use ▪ Contracts for water supply between Seqwater and end users ▪ Recycled water management plans for end users	▪ DNRM and DEWS as water resource planner and regulator ▪ Seqwater ▪ Landholders along distribution pipeline routes	▪ Upgrade to pipeline infrastructure 2-5 years ▪ Supply agreements	▪ Scalable limited by throughput of treatment plants and conveyance infrastructure. Potential 32-66GL/year	▪ Negative publicity related to recycled water being used for agriculture
Recycled water	Western Corridor Recycled Water Scheme (WCRW) – Lower class water	WCRWS is operated to supply low class (Class B or C) water directly to the Lockyer Valley through an offtake from the existing transfer pipeline	▪ Recycled water of desired quality provided to local irrigators	▪ Transfer and distribution infrastructure to take recycled water from the existing WCRW pipeline to the Lockyer Valley ▪ Intermediate storages likely also required	▪ Contracts for water supply between Seqwater and end users ▪ Recycled water management plans for end users ▪ Management plan and costs for switching production to high quality water when required	▪ DEWS as water supply LoS regulator ▪ Seqwater as scheme operator ▪ Landholders along distribution pipeline routes	▪ Upgrade to pipeline infrastructure 2-5 years ▪ Upgrade to supply agreements	▪ Scalable limited by throughput of treatment plants and conveyance infrastructure. Potential 32-66GL/year	▪ Negative publicity related to recycled water being used for agriculture ▪ Management planning and costs associated with switching between high quality and low quality operating modes

Category	Option	Description	Outcomes / Benefits achieved	Infrastructure requirements	Non-infrastructure requirements	Stakeholders affected	Timeframe	Scalability	Potential adverse impacts
Recycled water	Greywater reuse	Centralised or decentralised greywater (typically water from laundry, taps and showers) capture, treatment and reuse	▪ Recycled water of desired quality provided to local irrigators	▪ Additional plumbing (often referred to as third pipe) to segregate potable/non-potable water and sewerage from greywater ▪ Local or centralised treatment ▪ Distribution	▪ Contracts for supply ▪ Greywater reuse guidelines	▪ DHPW as greywater use regulator ▪ Homeowners ▪ End users	▪ 1-5 years	▪ Scalable but limited to the number of individuals willing to participate. Potential maximum yield 0.5-1.5GL/year	▪ Resistance to uptake ▪ Poor maintenance leads to poor quality water
Surface water	Stormwater harvesting	Stormwater harvesting from large open areas and storage in tanks or dams for later use. Could be transferred to existing storage or recharged into aquifers	▪ Increased reliability of supply	▪ Capture infrastructure, e.g. channel ▪ Storages ▪ Possibly transfer to existing storage	▪ As there is currently no unallocated surface water within the Moreton Water plan area, water would need to be made available. This could be through for example a change in how water is shared between users or through increased yield from existing sources. Provision currently exists for water harvesting when Wivenhoe returns to 100% level over 7 days ▪ Standards for stormwater treatment and reuse ▪ State approval to capture volumes that exceed 5 ML ▪ Supply agreements ▪ Mechanism for sharing water	▪ DNRM as resource regulator ▪ LVRC as land use planner	▪ Capital works will require 1-5 years	▪ Limited to available water	▪ Upkeep of decentralised water systems is challenging and failure to do so leads to water quality and reliability issues
Water trading	Trading of permanent and seasonal water	Trading of permanent and seasonal water within the Plan Area	▪ Create the potential for water to move to a higher use. Increased security and reliability	▪ None for trading itself. However, infrastructure may be required to move water from other supply schemes to the Lockyer	▪ Amendments to the planning framework which currently do not allow for this trading	▪ DNRM ▪ Current holders of medium priority allocations	▪ 1 year	▪ Limited to extent of medium priority allocations	▪ Possible impact on environmental values through changed flows of water in the Brisbane River and Lockyer Creek (however, the Lockyer Creek discharges into the Brisbane River) ▪ Changed production and land use in supply schemes from which water is taken
Efficiency	Improve on-farm irrigation efficiency	Enable irrigators to use higher efficiency irrigation equipment and/or farming techniques	▪ Increased value of production from existing water	▪ Varies	▪ Consultation and engagement with irrigators	▪ End users ▪ Seqwater as irrigation scheme operator	▪ Capital works will require 1-5 years ▪ Improved outreach program will require 1-2 years to develop	▪ Scalable. Depends on existing efficiency of irrigation	▪ Improved efficiency may impact groundwater recharge ▪ Potential resistance to change and difficulty in communicating benefits of efficiency programs

APPENDIX

E

REGULATORY FRAMEWORK

Regulatory framework

A new water planning framework has been introduced to the *Water Act 2000* (Water Act) by the *Water Reform and Other Legislation Amendment Act 2014* (WROLA Act). The new framework replaces the previous water resource plans and resource operations plans.

The new framework continues the catchment based approach to water planning, but uses different documents to deliver the water planning outcomes. The intent is to make the planning process more flexible and efficient in its delivery of planning outcomes, to be better able to respond to stakeholder and community needs.

The Water Regulation 2016 which replaces the Water Regulation 2002, has been expanded to take a greater role in supporting the water planning process. Specifically the regulation now (Department of Natural Resources, Mines and Energy, 2017):

> Allows for unallocated water to be reserved outside of a water plan, in addition to prescribing the process for releasing unallocated water
> Establishes generic criteria for converting water allocations
> Provides for water allocation dealings and the process for seasonal water assignments
> Provides for Minister's reporting requirements on water plans
> Provides the works requirements for taking or interfering with water
> Includes additional prescribed activities where a water entitlement or permit is not required.

Water Plan and Resource Operation Plan

The Lockyer Valley Region sits within the Moreton Catchment. This catchment is governed by the *Moreton Water Plan*, originally released in 2007 and then amended in 2008. In 2016 the Minister published the *Water Resource (Moreton) Plan (Postponement of Expiry) Notice 2016* to postpone the expiry of the Moreton Water Plan to 14 December 2026.

The purpose of the Moreton Water Plan is:

5. To define the availability of water in the plan area
6. To provide a framework for sustainably managing water and the taking of water
7. To identify priorities and mechanisms for dealing with future water requirements
8. To provide a framework for reversing, where practicable, degradation that has occurred in natural ecosystems
9. To provide a framework for:
    a. Establishing water allocations to take surface water; and
    b. Granting and amending water entitlements for groundwater; and
    c. Granting water entitlements for overland flow water.

The *Moreton Resource Operations Plan* was approved in December 2009. This document was amended in 2014 to include the Warrill Valley and Lower Lockyer water supply schemes. The *Moreton Resource Operations Plan* implements the *Moreton Water Plan*, approved by the Governor in Council.

Currently DNRM are proposing to amend the Moreton Water Plan and Resource Operations Plan. We discuss this further in this appendix.

Lockyer Valley groundwater management area

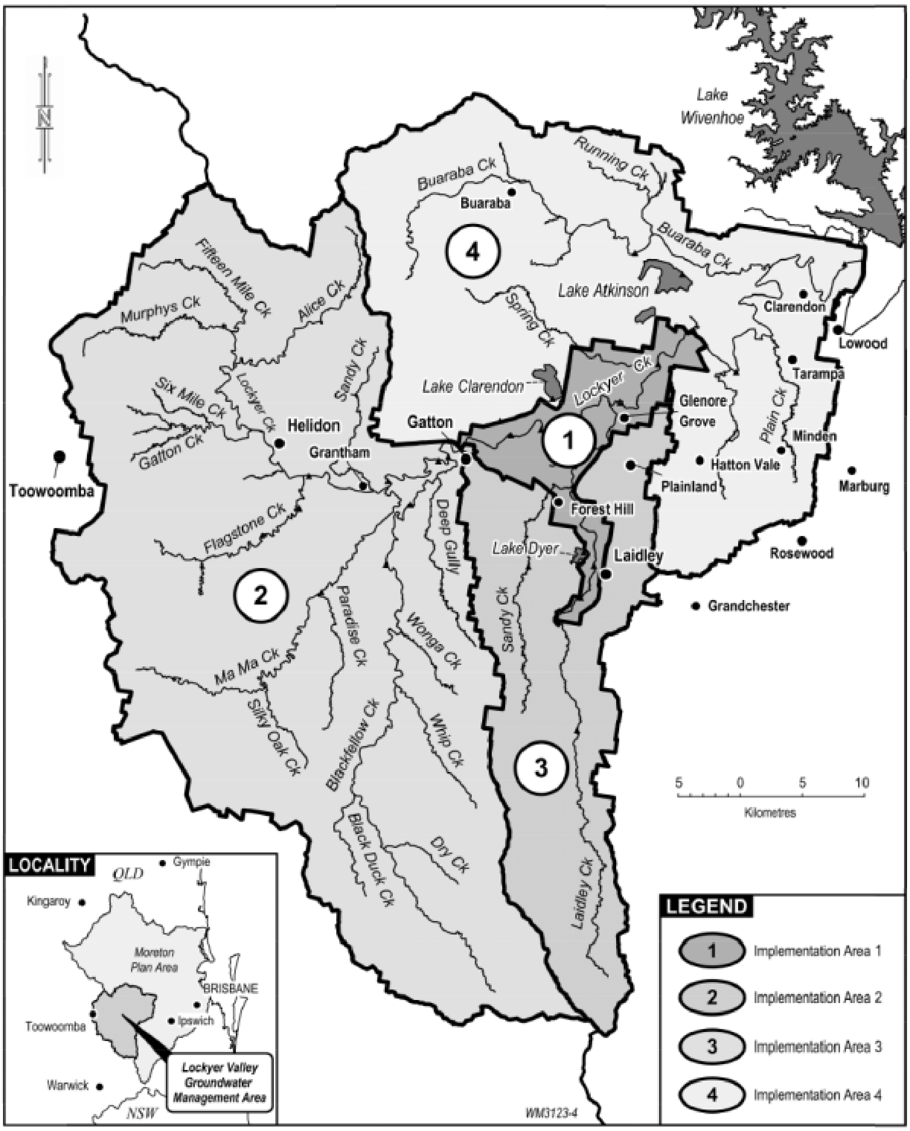
Groundwater resources within the Lockyer Valley are predominantly accessed from the alluviums associated with the major streams of Lockyer, Ma Ma, Sandy, Laidley, Flagstone, Tenthill, Murphys and Buaraba Creeks and their tributaries. Additional groundwater supplies are obtained from the Great Artesian Basin (GAB) sediments of the Jurassic Helidon Sandstone, the Walloon Coal Measures and the Marburg Formation as well as the overlying Tertiary Basalts in the south of the region.

Historically, the groundwater management within the Lockyer Valley has been confined to the Central Lockyer area within the former Clarendon Declared Subartesian Area. The Central Lockyer has been traditionally the only area to be managed through licensing and water use meterage.

The alluvial aquifers along with some of the GAB areas have long been identified as areas with groundwater use in excess of sustainable yields (where sustainable yield is the amount of groundwater available in an average year over the long term). DNRM under the *Water Plan (Moreton) 2007* and the *Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* has initiated steps to manage groundwater use within the Lockyer Valley region.

The *Water Plan (Moreton) 2007* defines the Lockyer Valley Groundwater Management Area within which all Subartesian groundwater resources are managed under that Plan. The Groundwater Management Area has been further defined to include the following Implementation Areas and associated Groundwater Units:

- Implementation Area 1: Central Lockyer Creek
  - Groundwater Unit 1 (alluvial aquifers)
    - Supplemented groundwater (from Central Lockyer Valley WSS)
    - Unsupplemented groundwater
- Implementation Area 2: Upper Lockyer Creek, Flagstone Creek, Tenthill Creek and Ma Ma Creek
  - Groundwater Unit 1 (alluvial aquifers)
  - Groundwater Unit 2 (hard rock aquifers)
- Implementation Area 3: Sandy Creek (parish of Blenheim) and Upper Laidley Creek
  - Groundwater Unit 1 (alluvial aquifers)
  - Groundwater Unit 2 (hard rock aquifers)
- Implementation Area 4: Lower Lockyer Creek and Buaraba Creek
  - Groundwater Unit 1 (alluvial aquifers)
  - Groundwater Unit 2 (hard rock aquifers).



Lockyer Valley Groundwater Management Area and Implementation Areas

Source: Water Plan Moreton (2007). Schedule 3 Implementation areas for Lockyer Valley groundwater management area

Implementation Area 1 replaces the former Clarendon Declared Subartesian Area and as such has existing groundwater management in place. Implementation Areas 2, 3 and 4 are being transitioned to groundwater regulation and management through processes set out in the Water Plan and associated *Moreton Resource Operation Plan 2009* and amendments (Department of Natural Resources and Mines, 2017).

Great Artesian Basin Groundwater Management Units

Groundwater within the GAB sediments are regulated by the Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017. Great Artesian Basin associated groundwater within the LVRC area is contained within the Hutton, the Precipice and the Springbok Walloon Groundwater Units as defined by the GABORA Water Plan.

The Hutton Groundwater Unit within the LVRC area is further divided into the following Sub Areas:

> Gatton Esk Road Marburg Sub Area
> Murphys Creek Marburg Sub Area and
> Southern Clarence Moreton Marburg Sub Area. (*Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* (Qld))

The Precipice Groundwater Unit within the LVRC area is further divided into the following Sub Areas:

> Gatton Esk Road Woogaroo Sub Area

- Murphys Creek Woogaroo Sub Area
- Southern Clarence Moreton Woogaroo Sub Area and
- Portion of Redbank Creek Woogaroo Sub Area. (*Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* (Qld))

The Springbok Walloon Groundwater Unit within the LVRC area is limited to the presence of the Southern Clarence Moreton Walloon Sub Areas (*Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* (Qld)).

Proposal to amend the Water Plan

The Water Plan (Moreton) 2007 was due to expire during 2017. However, the Minister for Natural Resources and Mines, on 10 November 2016, extended the duration of the *Water Plan (Moreton) 2007* until 14 December 2026 through the *Water Resource (Moreton) Plan (Postponement of Expiry) Notice 2016*. While the Water Plan has been extended, a number of amendments to the Water Plan and associated Resource Operations Plan have been proposed.

A Statement of Proposals was released in October 2015 for public comment and focuses on water allocation and management arrangements in the Central Lockyer Valley WSS. While submissions have closed, with over 150 received, the Department has stated that consultations will continue during the development of the draft amendments.

Proposed amendments directly affecting groundwater use within the Moreton Water Plan area are limited to those areas within the Lockyer Valley groundwater management area Implementation Area 1 which are recognised as benefitting from water supplied by the Central Lockyer Valley WSS (supplemented groundwater).

The Central Lockyer Valley WSS comprises two off-stream storages (Lake Clarendon and Bill Gunn Dam) and nine groundwater recharge weirs. The two storages are filled by water diversions from nearby creeks during high flow events. The scheme supplies water for the Morton Vale Pipeline, recharges groundwater areas adjacent to Lockyer and Laidley creeks, and supplies downstream surface water entitlements.

Seqwater own and operate the scheme in accordance with the Interim Resource Operations Licence (IROL). The water supply scheme supplies approximately 315 water entitlements including 150 licences to take groundwater. These groundwater entitlements are recognised as supplemented because they receive benefit from the operation of the water supply scheme.

Groundwater entitlement holders in Implementation Area 1 outside the supplemented area are regarded as unsupplemented and are managed by DNRM. Groundwater entitlements in the Central Lockyer Valley WSS are currently specified as groundwater licences for irrigation of state land parcels (expressed as Lot on Plan).

One of the aims of the proposed amendments is to explore options for converting all supplemented groundwater entitlements (and surface water entitlements) within the Central Lockyer Valley WSS to tradeable, volumetric water allocations; creating consistent water entitlement specifications across the scheme and providing water users with the option for water trading.

Additionally, it is proposed that amendments be made to define Water Allocation Security Objectives (WASOs) to include both groundwater and surface water in the Central Lockyer Valley WSS to ensure protection of allocations when changes are made to the scheme's management arrangements (Department of Natural Resources and Mines, 2015).

Providing security for groundwater entitlements

Currently, two supplemented WASOs exist for the Central Lockyer Valley WSS — one for water allocations in the medium priority group in Laidley Creek and another for water allocations in the medium priority group in Lockyer Creek. These WASOs currently only apply to surface water. It is proposed to amend the surface water WASOs to provide a distinct definition of the medium priority groups. Furthermore, the proposed development of groundwater WASOs will provide distinction between surface water and groundwater supplies.

Providing for conversion of entitlement

Currently, the Moreton Water Plan provides for the conversion of Interim Water Allocations in the Central Lockyer Valley WSS to Water Allocations and for the granting of Interim Water Allocations to landowners with water supply arrangements from the Morton Vale Pipeline but does not include Supplemented Groundwater Licences. Each of these groups have different entitlement specifications.

While conversion of Interim Water Allocations to Water Allocations is covered in the Water Plan it does not provide for the conversion of Supplemented Groundwater Licences or Morton Vale Pipeline contracts directly to Water Allocations. It is proposed that the process and details for conversion would be based on previous assessments prepared in conjunction with water users and the Central Lockyer Community Reference Group, alongside additional information gathered about the millennium drought and recent flood events (Department of Natural Resources and Mines, 2015).

Proposal to amend the Resource Operations Plan

Proposed amendments to the Central Lockyer WSS scheme operating rules are to set the volume for each water allocation in the scheme and define the management rules for water sharing, infrastructure operation and water trading within the Central Lockyer Valley WSS (DNRME, 2017).

Boundaries of the supplemented groundwater area

Unsupplemented groundwater (and surface water) entitlements are beyond the scope of the proposed amendments. However, the boundary between supplemented and unsupplemented groundwater entitlement areas of Implementation Area 1 is under review. The boundaries were initially set in 1991 based on the benefits from water from Bill Gunn Dam and reviewed in 1996-97 to account for an extended groundwater benefit from Lake Clarendon.

It is understood that some areas of Groundwater Unit 1 benefit more from the releases from the Central Lockyer Valley WSS than others. A review will be conducted in conjunction with landowners to ensure that the boundary reflects the equitable limit of the supplemented groundwater area (DNRME, 2017).

Infrastructure operating and water sharing rules

Currently water sharing and infrastructure operating rules are stated in the IROL for the Central Lockyer Valley WSS. The current Water Sharing Rules only provide for announced allocations to the Morton Vale Pipeline, Crowley Vale Water Board and Laidley Golf Club. There are currently no announced allocation rules for groundwater entitlements.

The IROL indicates that an announced allocation procedure for groundwater will be prepared following conversion of existing groundwater entitlements to volumetric allocations. In addition, the release rules as currently stated in the IROL may need clarification to improve the way water is shared between the different water user groups.

It is proposed that the current IROL arrangements will be reviewed with the intention of establishing a new set of announced allocation procedures for all surface water and groundwater entitlements supplied by the scheme. These rules will consider both the volume of water throughout the scheme along with rules for the efficient operation of scheme infrastructure to store and release water.

Water trading rules

Water trading within the Central Lockyer Valley WSS is currently limited to Seasonal Water Assignments (Temporary Trades) by holders of interim water allocations with a stated volume on their entitlement. This limits all trading to just the Laidley Golf Club, Crowley Vale Water Board, and Morton Vale Pipeline irrigators. Requests for temporary trades in the Morton Vale Pipeline supplied area are also subject to engineering assessment. As such, there is currently no opportunity for permanent water entitlement transfers as all existing entitlements are still attached to the land. This means that permanent change of water entitlement ownership can only occur as part of the process of land disposal and/or acquisition.

Proposed amendments to the Moreton Water Plan would provide for the conversion of the following to tradeable water allocations:

> Surface water interim water allocations

> Groundwater licences

> Water supplied under Morton Vale Pipeline contract arrangements.

New provisions in the Moreton Operations Manual are proposed to provide for seasonal and permanent trading of water allocations for each of these groups of entitlements holders, supporting more flexible access to water.

South East Queensland water security objective

The *Water Regulation 2016* specifies the desired Levels of Service (LOS) for the provision of bulk water within south east Queensland. The LOS describes the role and function of Seqwater as the bulk water supply provider in the region. The LOS describes broadly that Seqwater needs to supply enough water to meet demand. This is further detailed as:

> To meet the projected regional average urban demand estimated by Seqwater
> So that medium level water restrictions on residential water use will, on average, not occur more than once every ten years, be more severe than 140 litres per person per day or last more than one year
> To provide an essential minimum supply volume of 100 litres per person per day in an extreme drought event (i.e. a 1 in a 10,000 year event).

In addition, the LOS requires that the three key storages (Baroon Pocket, Wivenhoe and Hinze Dam) do not reach their minimum operating level more than once in every 10,000 years on average.

The LOS and Seqwater's objectives are focused primarily on the urban demand within south east Queensland. However, provision of demand to irrigation schemes is also provided with 1,200 existing customers over seven supply schemes. The supply to irrigation schemes is undertaken based on the license conditions prescribed by DNRM. Seqwater's Water For Life, a 30 year regional planning and strategy document, identifies the nature of water for agriculture and urban demand.

Resilient Rivers Initiative

The Resilient Rivers Initiative is a collaborative approach through the South East Queensland Council of Mayors, Queensland Government, Seqwater, Healthy Land and Water, Unitywater and Queensland Urban Utilities with an aim of improving the health of waterways in south east Queensland through coordinated action.

The actions to improve waterway health are documented in Catchment Action Plans. Catchment Action Plans are based on technical assessment and stakeholder consultation. The Lockyer Catchment Action Plan 2015-2018 was released in July 2016. The Plan identifies actions including land stabilisation and community education (Resilient Rivers Initiative, 2016).

Queensland bulk water opportunities statement

The QBWOS provides a statement of the Queensland Government's objectives for bulk water supply when considering the investment and broader competition for public funds. These objectives (in priority order) are (Department of Energy and Water Supply, 2017):

> Safety and reliability of dams and urban water supplies
> Use of existing water resources more efficiently
> Support infrastructure development that provides a commercial return to bulk water providers
> Consider projects that will provide regional economic benefits.

The desired increase in reliability of water supply for agriculture in the Lockyer Valley is consistent with the highest priority objective accorded by the Queensland Government.

The Queensland Government has also outlined a decision-tree for determining the need for infrastructure augmentation. The initial issue is to ascertain whether the infrastructure will have the potential to deliver net economic benefits to Queensland. Subsequent issues relate to the financing and funding of proposed infrastructure.

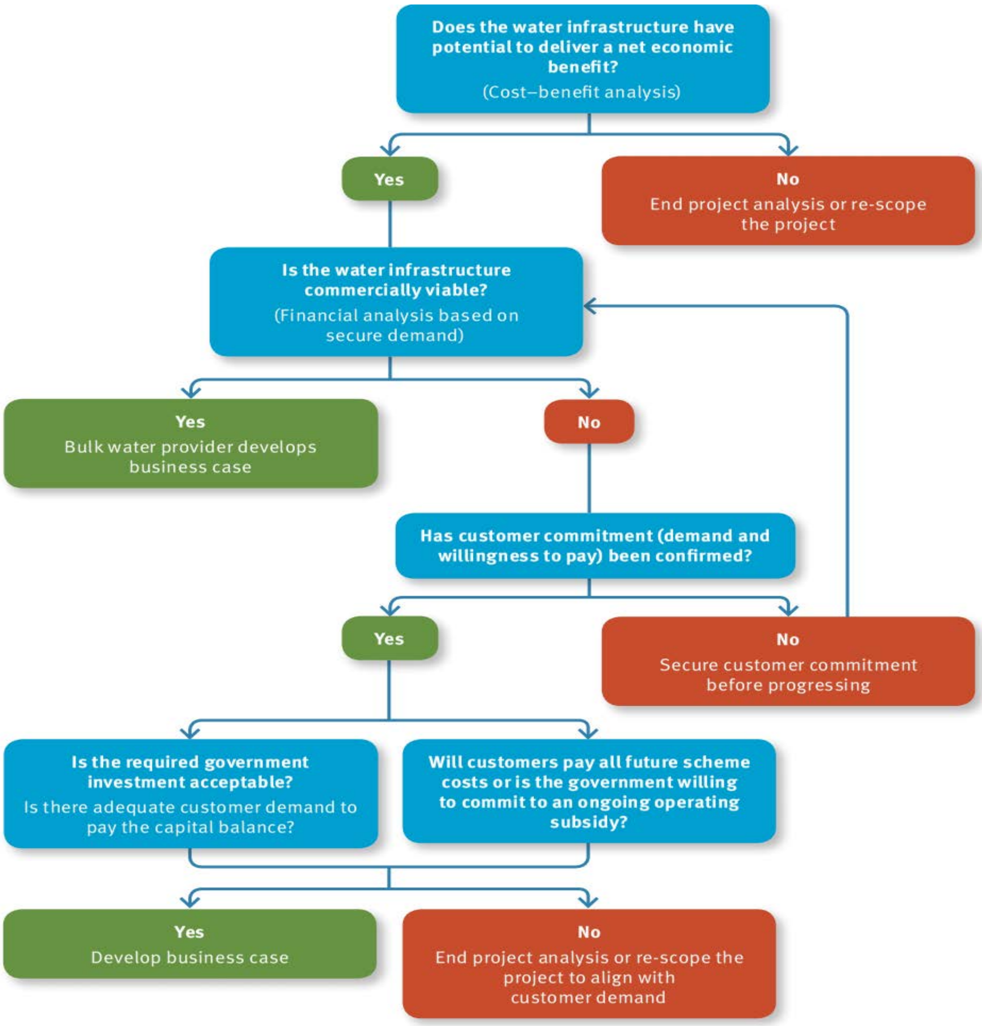


Figure 9-1 Infrastructure decision-tree