Southern Downs Regional Council

Emu Swamp Dam Business Case Stage 1
Final Report

June 2017

Executive Summary

Introduction

This report delivers a strategic assessment of the current and future need for an additional water supply in the Stanthorpe Region for urban, irrigation and regional development purposes. Previous historical work has identified the Emu Swamp Dam as the preferred option. Despite formal environmental approvals, it has not attracted the funding required for it to proceed past the preliminary stages of assessment in the past decade, however, it is the only option considered to date which has an existing environmental impact statement and associated environmental approval.

Funding has recently been provided under the National Water Infrastructure Development Fund to investigate the current feasibility of the Emu Swamp Dam and to consider whether it remains the preferred option to meet the regional demand for urban and irrigation water. Previous reports have indicated that the Dam will require significant public investment if it is to proceed.

The Southern Downs Regional Council has therefore determined that stage one of the feasibility study should be to undertake a strategic assessment of the present and future (out to 2050) urban and irrigation water supply needs and options to supply those needs including the Emu Swamp Dam project. In doing so, the approach aligns with, but goes slightly beyond, the Building Queensland Framework for major infrastructure development that identifies a Strategic Business Case including Investment Logic Mapping (Stage 1) as an initial requirement.

Service need and context

The Southern Downs region, in which the project is proposed to occur, is an important agricultural area that is actively seeking economic growth opportunities in the agribusiness, manufacturing and tourism sectors. It has land available for agricultural and industrial development and has good transport connections to the major population centres. These links may be further enhanced through the proposed Melbourne-Brisbane rail link. A range of stakeholders and previous reports identified water security in Stanthorpe and the wider Granite Belt region as a major constraint to future investment, regional development and economic growth. Stanthorpe has been subjected to water restrictions ranging from Permanent (230 Litres per person per day (L/p/d) target) to Extreme (140 L/p/d target) and currently operates with permanent restrictions in place, although SDRC has advised GHD that these restrictions are often not enforced. Horticultural and agricultural producers face periodic water shortages negatively affecting crop yields and influencing the potential to expand production.

Slow population growth (0.4% per annum) has moderated urban demands for water. Income analysis shows that many urban residents would find it difficult to absorb a significant increase in water service costs. Recent projections show the current water supply for the Stanthorpe region is not sufficient to meet forecast urban water needs beyond 2036.

Agriculture is the major source of employment in the region and is historically vulnerable to water insecurity. Any downturn in agricultural yields due to an extended drought is likely to have flow on effects for regional incomes and employment. Identifying appropriate options to meet future urban and irrigation needs is therefore critical to regional economic sustainability and liveability.

Document review and gap analysis

As part of this strategic assessment (Stage 1 of the feasibility study), GHD has reviewed more than 100 previous reports evaluating urban water security, irrigation and industrial water demand and water supply options. This process indicated that there is a significant strategic reserve of water available (nominated for urban and industrial use) together with a historically accepted need for an additional urban water supply and demand for additional irrigation water. GHD has also reviewed the several alternative dam site options identified and analysed at a very high level in these earlier reports together with options to raise the existing Storm King Dam and construct additional weirs.

Most reports were developed with an emphasis on Emu Swamp Dam and only this option was analysed in detail with other options being considered at a superficial level. Other than Emu Swamp Dam, there is limited information that enables an understanding of hydrological and engineering issues, risk and limitations or an analysis of cost comparativeness across alternative dam sites and dam heights. For most of the alternative dam sites, geological information in previous reports is at too high level to allow assessment or comparison of sites.

As such, risks associated with potential excavation depths, failure planes, water tightness, erosion potential, and construction materials, all of which can significantly affect the cost of a dam, are a significant information gap. Distribution systems have only been designed for the proposed Emu Swamp Dam at pre-concept design configuration. None of the rest of potential dam options have information of pipelines routes, pump stations and storage tanks and associated costs required for the proposed system.

Evidence ruling out the Ballandean dam site in earlier reports lacks clarity, even though it is arguably a more cost-effective dam site due to its superior terrain, shorter dam wall and potentially greater yield having lower surface area for a given volume and being lower down the catchment than Emu Swamp Dam. For example, issues arising from inundation of other major infrastructure are cited in these earlier reports as reasons not to proceed with the Ballandean Dam site without detailed description or analysis of the impact of such.

Previous reports have also not adequately considered lower cost options such as raising Storm King Dam, pipelines from other dams such as Connolly or Leslie Dam coupled with integrated water supply management.

Many of the assumptions used in previous reports underlying the extent of the need for additional supply are also questionable. Population growth has been significantly lower than predicted in original business cases as is current and forecast per capita water consumption and predictions regarding additional industrial demand for water have failed to eventuate.

Significant assumptions have been made on the social benefits of an increase in the volume of urban water supply. While irrigator-expressed willingness to pay has been studied extensively, no commitment has yet been sought from irrigators to underpin an investment in irrigation supply infrastructure. Equally, the willingness of urban users to pay for additional water security has not been considered in previous reports. No analysis has been undertaken to date on the real and perceived impacts of permanent water restrictions on population growth and industrial development in Stanthorpe. Assessments of regional development have not considered the impact of water restrictions on tourism and the tourist experience.

The option of greater surface water harvesting through increased on-farm storages to address demand for irrigation water has not been adequately considered in previous studies. Whilst previous studies have found that agricultural producers in the region have an appetite for additional irrigation water, the studies have not been sufficiently robust to enable a decision to be made on whether to proceed with the construction of the dam and associated distribution infrastructure for irrigation supplies, nor for an alternative option. This is largely due to the absence of any detailed assessment of the on-farm financial return from the use of additional irrigation water and hence economic viability of such infrastructure.

Stakeholder consultation

This Stage 1 strategic assessment has been informed by a structured process of consultation aimed at ensuring that stakeholders and the broader community were informed about project activities and given opportunities to be actively involved and contribute to understanding of needs. A project website was established and social media used to encourage participation in engagement activities:

- 2,551 people were reached through Facebook information sessions with 86 engaging in the update posts. Community announcements were broadcast over local radio and ads placed in local newspapers to encourage attendance at events.
  - Information sessions were held in key regional centres and email updates provided; 40 people attended the information session in Stanthorpe and 10 in Warwick.
- 137 irrigators and other water intensive industry and representatives in stakeholder lists provided by SDRC and the Stanthorpe and Granite Belt Chamber of Commerce were approached directly either by email or via telephone calls and invited to take part in an online survey, attend focus group discussions or engage in one-on-one interviews.
- An online water irrigation survey was used generating 12 responses
- Focus group discussions were held with eight irrigators and a further eight one-on-one interviews were undertaken with irrigators and other water intensive industry representatives.
- 150 local businesses completed the telephone survey.

Government stakeholders across various local, state and national departments were contacted where necessary. GHD considers that the number of contacts made with stakeholders and the process of holding in-depth focus group and on-to-one discussions together with the level of representation are such as to make the resulting responses and detailed data gathered to be robust, valid and representative. Equally, the sample size of the telephone survey is statistically valid.

Urban water demand assessment

The issue of the adequacy of urban water supply and security in Stanthorpe is central to this strategic assessment. An accurate forecast of future urban demand over the next fifty years is required to assess intelligently the need for Emu Swamp Dam and the consideration of other options. Demand forecasting for the reticulated water supply network is driven by future population (as connected to the network), per person average usage and industrial demand predictions. Projections of population growth in Stanthorpe undertaken in previous planning and business cases have been significantly higher in comparison to the actual growth that has occurred. Rates of population growth used in previous planning studies (1.5% annually) have been far greater than actual population growth (0.4%). GHD has used a population growth rate of 0.95% to update the projected population growth. Similarly, historical rates of water usage used to determine future demand (500 litres per capita per day (L/c/d)) are significantly greater than recent historical average (324 L/c/d). The current 324 L/c/d value, which is approximately 100 L/c/d greater than consumption in most of South East Queensland, has been used to update the water urban demand forecast.

There are significant variations in the previous planning and business case documents regarding the reliable long-term supply baseline of the existing Storm King Dam. The current assessment from an extended Integrated Quantity and Quality Model (IQQM) simulation by the Department of Energy and Water Supply is that a yield of 691 Megalitres per annum (ML/a) can be supplied at a monthly reliability of 97.6% (95.1% annual reliability). Storm King Dam can meet a demand of 600 ML/a (at 98% monthly reliability) without experiencing any periods of water supply shortfall (with or without water restrictions). Overall, water demand for Stanthorpe has been far less than predicted in previous studies (1,246 ML/a predicted for 2015 in 2007 versus 590 ML/a actual). Using the revised population and usage values the forecast of water demand by 2050 is 844 ML/a. This is consistent with the most recent forecast by DEWS. On this basis, and using a supply yield of 600 ML/a from Storm King Dam (at circa 98% average monthly reliability), an additional circa 250 ML/a supply capacity is required by 2050 to meet demand with demand exceeding current supply by 2036.

Industrial and irrigation water demand assessment

Irrigated agriculture and horticulture are major economic drivers in the Southern Downs Regional Council area. Most producers use on farm storages and the harvesting of overland flows for irrigation water supply. There are significant areas of land available for the expansion of crop production. Analysis of the proposed Emu Swamp Dam project indicates that it would only provide a marginal increase in water available for irrigation in the region (less than 10% of the estimated 20,700 ML currently used).

To establish the potential demand for additional water, the current demand and supply situation was analysed, consultation with producers was undertaken and farm level financial models for individual crops developed. This analysis indicated that water availability is a key constraint in crop production in the region. Apple and wine producers demand for additional water was based on providing additional water security for existing production areas with limited expansion plans while tomato, capsicum and strawberry producers desired additional water for production expansion within the current farming footprint. Demand for additional irrigation water for all crops is estimated at 2,263 ML/a.

Demand for additional water for industrial use is expected to be limited. Consultation indicated that current regional processing arrangements are operating well and there is little evidence that additional agrifood processing requiring significant volumes of water will be attracted to the Stanthorpe area.

Water planning and availability

Water resource planning in the area is governed under the *Queensland Water Act (2000)* and the associated Borders River Water Plan. The Border Rivers Water Plan identifies that there are unallocated reserves of 3,000 ML per annum for irrigation in the Stanthorpe Water Management Area and 1,500 ML per annum for town water supply. A specific proportion of this strategic reserve for the Emu Swamp Dam has been established in the current plan that may be reviewed in the new plan due in 2019. GHD understands that the current moratorium on new water developments that intercept overland flow or groundwater will also be reviewed as part of the water planning process.

Supply options

Previous studies and consultation have identified a variety of options to increase urban and agricultural water supply. These include a variety of infrastructure solutions such as large dams, small dams, weirs, pipelines, off-stream storages and non-or minor infrastructure solutions. GHD has undertaken an initial filtering of this long list of options through a consideration of yield, ability to meet future demand, costs and environmental and social impact. The filtering process generated several options that GHD then examined using a detailed multi criteria analysis (MCA)[1] to rank their ability to meet the needs of urban and irrigation supply demands. The

[1] The options identified that could potentially meet the needs of urban users and irrigators were considered in a two-step MCA assessment process. Both market / demand side management measures *and* new build / improvements to existing infrastructure

following table presents the key options identified through the MCA process against the project typology outlined by Building Queensland (BQ).

Table 1 Options for urban and irrigation water supply

Response type	Option
Reform	Integrated Water Supply Management, potentially supplemented by on-farm storage
Improve existing	Raising Storm King Dam plus on-farm storage
Improve existing	Connolly Dam and pipeline plus on-farm storage
New build	Emu Swamp Dam: a) "Small" urban only dam plus on-farm storage b) "Large" urban and irrigation supply dam with an irrigation distribution system
New build	Ballandean Dam: a) "Small" urban only dam plus on-farm storage b) "Large" urban and irrigation supply dam with an irrigation distribution system

Box 1 – Providing the Base Case to Compare Options

Provision of base case scenario provides a point of comparison against which all other options can be assessed. In this analysis, the base case is considered one in which there is no change in the current water supply arrangements for Stanthorpe and there is no accessing of the unallocated water reserves. Under the base case scenario water restrictions will remain and will increase in occurrence and severity in line with population growth. Growth in irrigated agriculture will remain constrained and yields will be materially impacted in dry years

Integrated water supply management

Options for minimising water use in the urban area of Stanthorpe is consistent with the principles of least cost planning. Consideration of water efficiency measures is consistent with the Queensland Government Infrastructure Plan and the Building Queensland Guidelines that state a preference for better use of existing resources through demand management rather than constructing new infrastructure. Analysis of the potential of this option shows that permanent water restrictions have been effective in reducing overall demand in Stanthorpe. However, urban water consumption per person remains materially higher than for South East Queensland

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solutions were considered. This approach is consistent with the Building Queensland and Infrastructure Australia requirements to consider the full range of strategic responses, including reform and non-build measures that could defer (or even negate) the need for major capital infrastructure investment. Options were first assessed by their ability to meet the demand forecast for each of the user groups. It was assumed that to be viable, the option must deliver:

- a minimum of 250 ML for urban users (at a high reliability of 98%),
- a minimum of 1740 ML for irrigation users (at a reliability of 94%), or
- a combined total of 1990 ML to meet the demand of both groups.

Where capital build options lacked the capacity to accommodate irrigator demand requirements, it is assumed that on-farm storage (market response) will be sufficient to supplement any irrigation supply shortages, up to a maximum of 1,740 ML.

Subject matter specialists in dam construction, agriculture, irrigation, social impact assessment, environmental impact assessment and capital costing then assessed and scored each of the options against a set of criteria (Engineering, Economic, Environmental, Social) that respond to triple bottom line considerations and project feasibility. Weightings were then assigned at 213 L/p/d (as compared to 194 L/p/d for the whole of South East Queensland and 187 L/p/d for Central Queensland)[2]. This indicates that there is potential to implement cost effective measures to reduce further water demand. Demand reduction, coupled with supply side measures of reticulation system leakage management (collectively termed integrated water supply management (IWSM)), can potentially delay the need for new infrastructure and the triggering of drought restrictions.

The IWSM option scored highest in our MCA and is the least cost option, being an option that does not involve capital infrastructure investment. However, it is unlikely it will be able to achieve the sustained 30% reduction in water demand required to enable Storm King Dam to meet urban water demand up to 2050. This option may best be considered as a mechanism to defer expenditure in a major capital infrastructure project and is recommended for further analysis and potential implementation irrespective of any major capital infrastructure option selected to meet urban or urban and irrigation demand.

On-farm water storage

Current water supplies supporting irrigation enterprises are largely met by on-farm water storage. A moratorium on the development of on-farm storages accompanied the development of the Water Resource Plan in the early 2000s. On-farm storage yields reflect catchment areas and potential base flows, near surface groundwater interception trenches and water harvesting pump facilities. Current on-farm storages are generally relatively small in nature compared to community dams and weirs. However, the comparative cost of construction for on-farm storages is significantly lower than that associated with bigger community dams and weirs. This largely reflects lower specifications and compliance systems. On-farm storages may be expected to provide lower water allocation reliabilities as compared to the Emu Swamp Dam proposal or other dam and irrigation reticulation system proposals. The enhancement of on-farm storages could reasonably expect to utilise, existing on-farm pump and water distribution systems when used to supplement irrigation to existing cropping areas minimising costs associated with on-farm water distribution systems.

Significant (3,000 ML/a) unallocated surface water resources exist in the region, of which 1,750 ML/a is linked to the development of Emu Swamp Dam. The release of unallocated water is guided by the Water Regulation with some flexibility for release through a public auction, tender or fixed price sale. Recent water allocations in the Gilbert, Flinders and Nicolson catchments and the Great Artesian Basin have all involved tender processes. It reasonable to assume that a similar tender held in the Stanthorpe Water Management Area would attract high prices and translate into near term development based on current water demand and existing levels of irrigation development.

A market led solution of auctioning irrigation water reserves and enabling irrigators to expand their ability to harvest surface water through construction of on-farm water storage systems to augment existing, systems is the lowest cost and highest ranked option in our MCA evaluation for meeting irrigator's additional irrigation water supply needs. However, it does not necessarily fully meet the need, identified through stakeholder consultation, for a proportion of the additional irrigation water to be high reliability water to augment water from existing on-farm storages in times of drought to enable irrigators to increase existing production from existing crop areas in the long term. It would, though, meet some of this high reliability water need and allow expansion of cropping areas that, from our consultation with irrigators, represents approximately half of the required additional irrigation water supply.

Given this, GHD considers it necessary to also take forward options, that meet this requirement for high reliability water to supplement existing, lower reliability, irrigation supplies (subject to

[2] SEQ Water consumption data for the 14 day period ending 9 November 2016.

there being potential for government funding support and commitment from irrigators to make up-front capital contributions).

Raising Storm King Dam

This option involves raising Storm King Dam by 4 m and building an additional raw water urban supply main and pump station from Storm King Dam to the Mount Marley Water Treatment Plant. This option is the most cost effective of the capital infrastructure options where yield modelling has demonstrated that the option can meet the forecast required additional supply volumes of 250 ML per annum by 2050. However, there is some uncertainty as to whether the dam wall abutments can withstand this raising of the dam wall (GHD has assumed in its cost analysis that stabilising rock anchors will be needed as a minimum). Given this, together with uncertainties around the previous two options, GHD recommends that at least one other capital-intensive option be considered in Stage 2.

Connolly Dam Pipeline

This option involves installing a pipeline and pumping infrastructure to transfer water from Connolly Dam to the water treatment plant in Stanthorpe. It relies on there being sufficient available yield in Connolly Dam to meet the forecast shortfall in yield from Storm King Dam of approximately 250 ML/a by 2050. DEWS has advised that it has only undertaken yield modelling for Connolly Dam to 2036. As such, this option cannot be relied on as a potential option to meet forecast demand at this stage, although if it could, it is the lowest cost option. However, it is possible, that this option combined with IWSM will be a viable option but this requires more analysis

Emu Swamp Dam

The Emu Swamp Dam can be configured as a smaller urban only supply or a larger urban and irrigation supply. This latter option (10,500 ML dam) will meet the urban water demand and irrigation water demand, including the requirement for high priority (high reliability water) to augment existing irrigation supplies in times of drought. In addition, and given that this option has received much more detailed assessment in previous studies than all other options it suffers none of the uncertainties outlined in the description of the other options. However, it is, by a significant margin, the most expensive option in terms of capital and operating cost based on available information. Water from Emu Swamp Dam would not be gravity fed, necessitating pumping from a static head of approximately 120 m (a significant ongoing operational expense) – this option is almost twice the price of raising Storm King Dam. Operational maintenance is likely to be complex and costly due to the length of pipes and number of pump stations, and the distribution network required for irrigation supply will further add to maintenance costs. Many considerations, such as environmental offsets, have not yet been factored into the costs of the build.

The urban only option involves constructing a 5,000 ML dam at the Emu Swamp Dam site that was previously envisaged to meet urban and irrigation supply needs, together with a raw water pipeline and pumping station to deliver water to the water treatment plant at Stanthorpe. As an urban supply only option, this option does not require the construction of irrigation distribution and pumping infrastructure and is the lowest cost option that is considered, will fully meet the required additional 250 ML of urban demand by 2050.

Ballandean Dam

The Ballandean Dam can be constructed as small urban only or larger urban and irrigation (10,500 ML) supply source. The urban only option involves constructing a 5,000 ML dam at the Ballandean Dam site that was previously envisaged to meet urban and irrigation supply needs, together with a raw water pipeline and pumping station to deliver water to the water treatment plant at Stanthorpe. As an urban supply only option, this option does not require the construction of irrigation distribution and pumping infrastructure and is the lowest cost option that is considered, will fully meet the required additional 250 ML of urban demand by 2050.

The larger Ballandean option, together with an irrigation reticulation system will meet the urban water demand and irrigation water demand, including the requirement for high priority (high reliability water) to augment existing irrigation supplies in times of drought. However, there are possible issues with respect to potential inundation of the New England Highway during flood events that will need to be investigated as a priority. GHD also understands from its review of earlier reports that the dam inundation may impact upon a major Melbourne-Brisbane fibre-optic trunk line, although GHD has not been able to identify this aspect in GIS based infrastructure information. As such, it is possible that this option will need to be excluded relatively early in the more detailed investigation phase (Stage 2 Preliminary Business Case) as the costs of relocating both these pieces of infrastructure may be prohibitive. It is for this reason that GHD also recommends that the urban and irrigation Emu Swamp Dam be taken forward to Phase 2 (subject to the funding commitments mentioned above) in case the Ballandean option proves not to be economically viable.

Conclusions and recommendations

This strategic assessment shows that Storm King Dam will not be able to meet urban water supply needs reliably beyond 2036 and that there is projected to be a circa 250 ML/a shortfall by 2050. From discussions with the irrigation community, there is a clear unsatisfied demand for additional irrigation water supplies, of which, a significant proportion (circa 50%) is high priority water to augment on-farm supplies during times of low rainfall. However, assessment of options available to meet this demand does not clearly and unequivocally find that constructing the previously proposed Emu Swamp Dam as an urban and irrigation supply is either the only or most cost effective option.

Of the options considered for urban water supply, GHD considers that IWSM should be implemented as a least cost measure. However, it will not reduce urban water demand sufficiently to avoid the need of a capital infrastructure solution to meet the projected 2050 demand.

On farm storage coupled with auctioning of water reserves nominated for irrigation supplies is the least costly and only economically viable option for driving the economic benefit arising from additional irrigation water supply. However, on farm storage will not necessarily provide the same level of reliability of water supplies as a large urban and irrigation Emu Swamp Dam or Ballandean Dam solution. By their nature, on-farm storages typically have a greater surface area to volume ratio than dams resulting in higher evaporation loss (although the use of covers can reduce this); irrigators also often rely on re-charge of these storages during the growing season. As such, on-farm storages will be more prone to running dry during periods of long droughts than larger dam storages. However, it is also the case that, during a prolonged drought, urban supplies from a dam will take priority over irrigation supplies that, in part, mitigates the advantages of that a larger dam will provide over on-farm storages.

When considering a solution in the context of the broader needs of the region a large infrastructure solution in the form of either Emu Swamp Dam or Ballandean Dam will be required to meet both urban and irrigation high priority water demand. Comparison of the results of GHD’s economic analysis of net benefit to irrigators per additional ML of water with the levelised costs of water supplied from an urban and irrigation supply Emu Swamp Dam or Ballandean Dam option derived through financial analysis indicates that such solutions are not economically viable.

As such significant government funding support is required of between $59 million and $120 million, depending on whether Ballandean Dam or Emu Swamp Dam is taken forward and whether the funding support is provided only for irrigation related infrastructure or urban and irrigation infrastructure. Whilst Southern Downs Regional Council has a specific obligation in respect of urban water supply, it does not have the same direct obligation with respect to developing and providing water sources to meet irrigation needs. Moreover, the Council is operating under financial stress and limited in its ability to fund or borrow for a large-scale infrastructure solution.

Neither the large capacity urban and irrigation supply Emu Swamp Dam nor Ballandean Dam option to meet urban and irrigation demand are economically viable without significant government subsidy. However, it is recognised that there is a demand for high priority water for irrigation. As such, and as a pre-requisite to this option being progressed beyond the evaluation stage, it is recommend that commitment is sought from irrigators to pay an up-front capital contribution (of approximately $22,000/ML, $38 million in aggregate where government funding support of between 60-68% is available). The approach of securing contractual commitment from irrigators to meet some of the capital cost through one-off payments for allocation has been adopted successfully in Tasmania to secure government funding to enable irrigation infrastructure to be constructed.

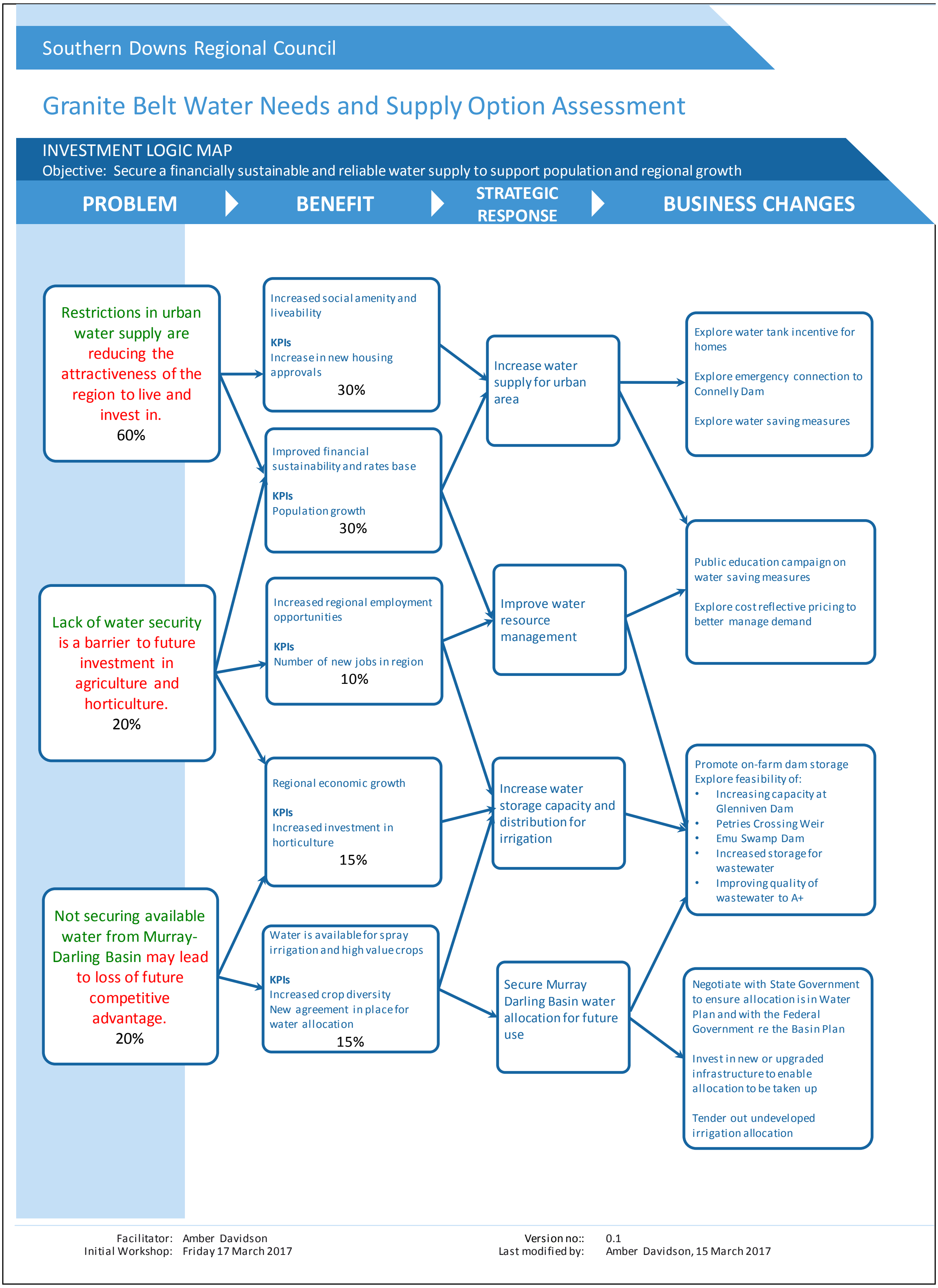
Multiple infrastructure options are available for urban supply that require further investigation to establish a preferred strategy. These range (in increasing capital expenditure, complexity and ability to meet or exceed forecast demand requirements) from constructing a pipeline from Connolly Dam, through increasing the height of Storm King Dam to building a smaller (5,000 ML) urban only supply dam at either the Emu Swamp Dam site or the Ballandean Dam site.

While Emu Swamp Dam has been subject to extensive prior investigations, analysis of the other options is limited. Undertaking a comprehensive study in Stage 2 (Preliminary Business Case) of each dam option at various full supply levels, with a consistent methodology and time frame, that fully explores funding, risk, economic, financial, risk and governance issues will enable robust comparison and potentially identify one preferred option to be taken forwards to Stage 3 (Detailed Business Case).

GHD recommends that that SDRC considers progressing the urban supply strategic options in Stage 2 (Preliminary Business Case) alongside market lead solutions for irrigation supply needs noting that may be necessary re-negotiating the funding deed if an urban only supply is progressed.

GHD also recommends that urban and irrigation supply major infrastructure options of Emu Swamp Dam and Ballandean Dam be progressed to Stage 2 subject to an indication of government interest in providing funding support to the implementation of these options. GHD considers that such indication of interest will be contingent (as in recent irrigation projects in Tasmania) of confirmed willingness of irrigators to commit contractually to pay up-front capital contribution to fund the necessary portion of irrigation infrastructure and fixed operating costs net of government funding support.

Box 2 – Investment Logic Map



Abbreviations and Glossary

Acronym/Abbreviation	Description
ABS	Australian Bureau of Statistics
ACH	Aboriginal Cultural Heritage
ACT	Australian Capital Territory
AD	Average Day
AEP	Annual Exceedance Probability
AFC	Acceptable flood capacity
AHD	Australian Height Datum
ANCOLD	Australian National Committee on Large Dams
ARI	Average Recurrence Interval
BD	Ballandean Dam
BQ	Business Queensland
Capex	Capital Expenditure
CBD	Central Business District
CGER	Coordinator General's Evaluation Report
CHMP	Cultural heritage management plan
CID	Community infrastructure designation
DAF	Department of Agriculture and Fisheries
DAWR	Department of Agriculture and Water Recourses
DEE	Department of Environment and Energy
DERM	Department of Environmental Resources Management
DEWS	Department of Energy and Water Supply
DICL	Ductile iron pipe
DN	Diameter Nominal
DNRM	Department of Natural Resources and Mines
DSD	Department of State Development
DSITI	Department of Science, Information Technology and Innovation
DSITIA	Department of Science, Information Technology and Innovation and the Arts
DSM	Demand-side management
EFO	Environmental flow objective
EIS	Environmental Impact Statement
EPBC	Environment Protection and Biodiversity Conservation
ESD	Emu Swamp Dam
FSL	Full supply Level
GHD	GHD Services Pty Ltd
GIS	Geographical Information Systems
HES	High ecological significance
HNFY	Historical No Failure Yield
IDAS	Integrated Development Assessment System
IGA	Intergovernmental Agreement
IQQM	Integrated Quantity and Quality Model
IWSM	Integrated Water Supply Management

kL	Kilo litres
LCOW	Levelised cost of water
LCP	Least Cost Planning
L/c/d	Litres per capital per day
L/p/d	Litres per person per day
MAD	Mean Annual Diversion
MCA	Multi Criteria Analysis
MCU	Material change of use
ML	Megalitres
ML/a	Megalitres per annum
MNES	Matters of national environmental significance
MSES	Matters Of State Environmental Significance
NC	National Conservation
NSW	New South Wales
NWIDF	National Water Infrastructure Development Fund
OFS	On farm storage
Opex	Operational Expenditure
OSS	Off Stream Storage
P50	50 Percent probability of exceedance
PAF	Performance Assessment Framework
PAR	Population at Risk
PBC	Preliminary Business Case
PMAV	Property Map of Assessable Vegetation
PMF	Probable maximum flood
PV	Present Value
RCC	Roller Compacted Concrete
RL	Reduced level
ROP	Resource Operations Plans
RWSSA	Regional Water Supply Security Assessment
SDIP	Sustainable Development Investment Portfolio
SDRC	Southern Downs Regional Council
SEQ	South East Queensland
SKD	Storm King Dame
SKM	MWH
SLA	Statistical Level Area
SWIM	Statewide Water Information Management
TEC	Threatened Ecological Community
TWL	Top water level
TWS	Town Water Supply
UWSRA	Urban Water Security Research Alliance
WASO	Water allocation security objective
WWBW	Waterway barrier works
WMP	Water Management Protocols
WP	Water Plans
WRP	Water Resource Plan
WSAA	Water Services Association of Australia
WTP	Water Treatment Plant

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1. Introduction

1.1 Background

Investigations into the potential source of an additional urban water supply source for Stanthorpe to guarantee water security in dry years and to increase the amount of water available for high value irrigation and regional development in the region have been extensive and long running. Emu Swamp Dam was identified in these previous reports as the preferred option to address the long-term water needs of urban and agricultural consumers more than twenty years ago, leading to the development of an Environmental Impact Statement (EIS), supplementary EIS and environmental approvals (EA) for Emu Swamp Dam. No other options have been developed to this extent.

Despite several business cases and formal environmental approvals, the Emu Swamp Dam has failed to attract significant funding for construction and remains in the preliminary stages of development. In 2016, the Southern Downs Regional Council (SDRC) was awarded funding under the National Water Infrastructure Development Fund (NWIDF) to investigate further the feasibility of the Emu Swamp Dam.

There has been significant change in the years since the original investigations and recommendations. The past two decades have seen rapid changes in technology, patterns of urban and rural population growth and industrial development, on-farm water storage, improved irrigation technology and market demands.

Previous reports have indicated that the Emu Swamp Dam will require significant public investment if it is to proceed. Given the time since the original options analysis and business cases and the changes that have occurred since, SDRC has prudently and correctly determined that the first stage of the Emu Swamp Dam Feasibility Study should be to undertake a strategic assessment of the project, including comparison with alternative options with potential to meet the service need before proceeding. In doing so, the approach aligns with the Building Queensland Framework for major infrastructure development that identifies a Strategic Business Case as an initial requirement.

This report presents the outcomes of Stage 1 of the Feasibility Study of the Emu Swamp Dam and fulfils both the requirements of the brief from SDRC and the Building Queensland Strategic Business Case guidelines.

1.2 The strategic business case and strategic assessment development

The Building Queensland Business Case Development Framework guides a proposal from conceptualisation (Strategic Business Case), to options generation and analysis (Preliminary Business Case), and finally to the detailed analysis of the preferred option/s (Detailed Business Case). It is also closely aligned to the Queensland Treasury Performance Assessment Framework (PAF).

According to the Business Queensland Guidance Material, the Strategic Business Case is developed to determine whether further investigation of the identified service need is warranted. The Strategic Business Case should:

- Provide evidence for and clearly articulate the service need
- Document the benefits sought by responding to the service need and provide a minimum benefit against which any options generated in the Preliminary Business Case can be compared

- Identify a range of strategic initiatives that might respond to the service need and achieve some (or all) of the benefits sought
- Provide decision makers with the information needed to consider whether to progress further the proposal.

The brief provided by SDRC requires a broader scope of work than that required under the Building Queensland Framework and this is considered appropriate given the long history of the project, the amount of work and documentation that already exists. The scope of work that GHD has been engaged to undertake by SDRC as Stage 1 of this project includes several elements that typically form part of a Preliminary Business Case such as the identification and assessment of options. This report addresses the requirements of a Strategic Business Case and provides a strong information basis for the development of a Preliminary Business Case if it is decided by SDRC to move to Stage 2 of the Feasibility Study.

1.3 The strategic objectives of the project

The overall strategic objective for Stage 1 of this project is to identify a:

"… financially sustainable and reliable water supply to support population and regional growth."

The need to secure an efficient and reliable source of water for Stanthorpe has been acknowledged in reports dating back to the 1980s. This need encompasses both urban water users, who live with permanent water restrictions and producers reliant upon water for irrigation. Guaranteeing a secure and predicable supply of water is anticipated to stimulate horticultural production, improve crop yields and add value to the regional economy. It is also expected to make Stanthorpe a more attractive place to live and do business.

An Investment Logic Mapping workshop was held with key representatives from SDRC to help define the key problems and expected benefits that the project is intended to address[3]. The workshop identified three core problems, as well as several expected benefits and potential business changes or solutions that could be pursued to address the identified problems. The three key problems identified were:

1. Restrictions in urban water supply are reducing the attractiveness of the region to live and invest in
2. Lack of water security is a barrier to future investment in agriculture and horticulture
3. Not securing available water from Murray-Darling Basin may lead to loss of future competitive advantage.

The expected benefits of addressing the problems through the project include:

1. Increasing social amenity and liveability for residents of Stanthorpe
2. Servicing demand from anticipated future residential and commercial growth
3. Providing additional water capacity for spray irrigation to support high value horticulture crops
4. Securing the Murray Darling Basin water allocation for future use.

Several potential solutions or business changes were identified, including both capital infrastructure and non-infrastructure options. Potential options included for analysis in the Stage 1 Strategic

[3] The Investment Logic Map (ILM) is an evolving document that tells the story of an investment at any point in the investment lifecycle. Its strength is measured by its ability to be easily read by anyone who can then understand why an investment is being considered (or is underway). It is anticipated that the ILM may change over time, as the project progresses and in order to accommodate inputs from a wider range of stakeholders. A summary of the ILM is provided in Appendix A.

Analysis were categorised against the Queensland Government's Prioritisation framework identified in the State Infrastructure Plan. The key categories in order of preference are:

Table 1-1 Prioritisation framework categories

Category number	Category Type	Description
1	Reform	Improving service performance through an amendment of existing institutions and laws.
2	Better Use	Improving service performance by influencing demand.
3	Improve Existing	Improving service performance through relatively low cost capital works that augments existing infrastructure.
4	New Build	Construction of new infrastructure.

Source: (Building Queensland (2016) Strategic Business Case Template and Guide, p.5)

The potential options are described and assessed in detail in Sections 9 through 12 of this report.

A risk workshop held with same key representatives identified a number of high risks:

- **Financial -** arising from Council's current debt level and ability to fund a major infrastructure project
- **Strategic** - Council has been identified as the proponent for a major infrastructure project to serve urban and irrigation supply needs. However, it is not within Council's ambit to fund and develop irrigation infrastructure projects
- **Social** - Because of significant recent stakeholder consultation on this issue, there is concern of a low participation rate in consultation process, which results in insufficient data for a conclusion, and a low level of acceptance of the study by stakeholders.

1.4 The purpose of this report

The purpose of this Stage 1 report is to document a strategic analysis that will investigate the need for additional water to service both urban and irrigation users within SDRC region, and to identify and consider a range of possible options that could be pursued to address this service need. The report includes a preliminary assessment of these options, together with a recommended shortlist of options to be considered should the project proceed to a more detailed Preliminary Business Case.

1.5 Methodology

This Strategic Assessment and Business Case was guided by the Queensland Government's Project Assessment Framework, and seeks to analyse water demand needs and identify water supply options. The first stages of the project involved extensive stakeholder engagement, including public, business and irrigator consultation and a workshop with Council officers to articulate the need for the project. Subject matter specialists reviewed and summarised historical reports concerning water needs and supply options in the Stanthorpe region, identifying needs or risks and highlighting any gaps that required additional analysis. Water availability and water demand for urban users, water-dependent industries and irrigators were then assessed.

A long list of supply options identified in the document review that matched demand and availability were filtered according to infrastructure and non-infrastructure costs, risk and other qualitative factors, such as environmental and social impacts. Suitable options were shortlisted and compared at a higher level.

The key methodological steps taken to develop of this Stage 1 Strategic Business Case report were:

1. Reviewing previous reports and identifying gaps and options considered.
2. Analysing the social background and need.
3. Stakeholder consultation to drive an understanding of urban, industrial and irrigation needs.
4. Updating of urban (industrial and domestic) demand analysis and irrigation requirements.
5. Economic analysis of benefit of increased water availability to the irrigation sector.
6. Listing of options considered including demand side measures to address urban demand and, do nothing option.
7. Filtering of these based on certain criteria such as revised demand forecasts (Megalitres (ML) yield per annum requirements) based on most recent data on population size of Stanthorpe and consumption patterns (L/c/d) as well as an update to irrigation demand requirements to develop a short list of options including do nothing and non-government capital options.
8. Financial cost model producing capital cost/ML capacity, capital cost per ML yield (mean annual diversion), levelised cost per ML of water.
9. Undertaking a Multi Criteria Analysis (MCA) to identify options appropriate to take forward to Preliminary Business case to address identified need for different levels of Government capital support.
10. Developing recommendations of options to take forward.

A Project Risk Assessment was conducted in line with the principles described in the Building Queensland Business Case Development Framework[4]. Financial risks and opportunities were identified through consideration of cost consequences and benefits realisation, with modelling undertaken to determine capital cost uncertainty parameters and confidence intervals. This step also informed the supply options assessment costings and subsequent engineer design costing tasks.

1.6 Report outline

Following this introduction, Section 2 describes the strategic context of this problem and the service need. A summary of the findings of previous reports that investigated water security and supply in the region is presented in Section 3. Gaps in earlier work are also identified to ensure a comprehensive and robust analysis of the issue. Section 4 details the community engagement and

[4] The risk approach, criteria and risk management framework were applied as follows:

- Establishment of risk criteria (likelihood, consequence and risk matrix);
- Identification and documentation of project risks in a workshop setting involving Southern Downs Regional Council and subject matter specialists;
- Assessment of the materiality of the risks through analysis of likelihood and consequences of the risks occurring;
- Evaluation of the level of risk found during the analysis process by comparison with the risk criteria; and
- Treatment through the development of risk management strategies and contingency planning approaches to mitigate the risk.

These strategies were recorded in a risk register as part of the project management process (Appendix B).

stakeholder approach used. Population data and water usage figures are used in Section 5 to project the future demand for water, which is then contrasted against the capacity of Stanthorpe's existing water supply. Industrial and irrigation water demand are similarly assessed in Section 6, drawing on the information gained from engagement with irrigators and water intensive industries. The availability of water is analysed in Section 7 and, in conjunction with water demand, is then used to inform the filtering of all options identified and described in Section 8 to develop the short list supply options described in Section 9 and Section 10. Shortlisted build and non-build options are taken forward for more detailed analysis and assessment in Sections 11 and 12 respectively. GHD's overall conclusions and recommendations are presented in Section 13 and 14 respectively. Finally, references used in developing this report are tabled in Section 15.

1.7 Government stakeholders

The proponent for the project is SDRC. Other Government stakeholders include:

- Queensland Government Department of Energy and Water Supply (DEWS) with whom SDRC has a funding agreement for the development of a business case for Emu Swamp Dam through which this Emu Swamp Dam Final Feasibility Study is being undertaken
- Queensland Government Department of Natural Resources and Mines (DNRM) has an interest with respect to the Water Resources Plan and water resource modelling.
- Australian Government Department of Agriculture and Water Recourses (DAWR). DAWR administers the National Water Infrastructure Fund that has provided the funds to DEWS for the Emu Swamp Dam business case.

1.8 Scope and limitations of this report

This report has been prepared by GHD for Southern Downs Regional Council and may only be used and relied on by Southern Downs Regional Council for the purpose agreed between GHD and the Council as set out in Section 1.4 of this report. GHD otherwise disclaims responsibility to any person other than Southern Downs Regional Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible. The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

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

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect. GHD has prepared this report based on information provided by Southern Downs Regional Council and others who provided information to GHD (including Government authorities and information contained in third party reports), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared the preliminary cost estimates set out in various sections of this report ("Cost Estimate") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD. The Cost Estimates have been prepared for the purpose of assessing potential options and must not be used for any other purpose. The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the project can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

1.8.1 Qualifications

In developing this report, GHD has drawn on and augmented work detailed in previous studies in meeting the water supply needs for Stanthorpe region. GHD has developed cost estimates for dam infrastructure through escalating previous cost estimates to 2017 dollar terms. GHD has then compared this with current GHD cost estimates for recent comparable dam projects to derive a multiplying figure to bring these cost estimates in line with GHD's recent cost estimates developed for similar dam infrastructure. GHD has done this because of the lack of design and specification data for the different dam options. GHD has developed P50 cost estimates (50% probability of exceedance cost estimates, i.e. actual costs are as likely to exceed a given estimate as be below it) for water pumping and distribution systems using models that apply unit rates (e.g. $/km) for linear infrastructure.

GHD has developed these cost estimates used in this report to allow comparison between options on a like for like basis. They have not been developed as definitive stand-alone costs for individual options. As such, the cost estimates developed for this Strategic Business case should not be used in isolation as cost estimates for individual options.

2. Service Need and Context

2.1 Strategic context

The Southern Downs region is one of Queensland's most significant agricultural areas and the only place in Queensland that offers four distinctive seasons. Located at 1,000 metres above sea level, and under a three-hour drive from either Brisbane or the Gold Coast, the region is a major food bowl for Queensland, with a variety of seasonal produce grown all year.

In terms of future growth potential, there is available land for development, both agricultural and industrial, access to skilled workers, and good transport connections to Australia's major population centres. The Southern Downs region is strategically located at the junction of the New England and Cunningham Highways. From Warwick, there are fast, direct-road links to Brisbane (2 hours), Sydney (10 hours) and Melbourne (20 hours).

Growth prospects for the region have recently been boosted by the Federal Government's budget announcement committing a further $8.4 billion to deliver the inland rail project, although the final alignment is yet to be confirmed.

SDRC is targeting future growth and investment in the agribusiness, manufacturing, and tourism sectors. According to SDRC, there are opportunities to grow the following agribusiness areas[5] in the Southern Downs region:

Specialised horticulture & broadacre cropping - Investment in specialised horticulture cropping activities for targeted and niche markets. In addition, a number of experienced producers of fruit and vegetables have established businesses in the region to diversify and complement their existing operations in other horticulture areas, capitalising on the Southern Downs' climate and extending their growing season. Opportunities also exist for specialised broadacre cropping, particularly with higher value crops on quality soil types.

Chicken meat production- There are plans and approvals in place for the chicken meat sector to expand production in the region and there are further opportunities for more poultry operations. The Southern Downs region is considered a favoured location, as it meets the industry requirement of being within two hours of large-scale processing establishments located in or near the major urban centres of South-East Queensland.

Backgrounding for feedlots - Beef feedlotting is strong in the Southern Downs and neighbouring regions and a trend in the industry is for feedlots to access cattle that have been delivered from backgrounding operations.

Niche production and value adding - There is a current trend for markets to fragment, and producers are responding to the opportunities presented by an increasing array of niche food markets.'

The main commercial activities in the Granite Belt area around Stanthorpe are Horticulture (fruit and vegetable production) and tourism.

2.2 Addressing the problem of water security

While there are clear growth opportunities in the region, water security in the Stanthorpe and wider Granite Belt region has been identified by a range of stakeholders as a major constraint to future investment and economic growth.

As with most of the rest of South East Queensland, Stanthorpe residents have been subject to a number of years of water restrictions. At times, e.g. during the 2004-2008 drought, the highest level

[5] Southern Downs Regional Council. (n.d.).

of water restrictions (Extreme – target 140 litres per person per day (L/p/d)) were applied by Council, currently Permanent water restrictions are in place. A number of stakeholders, in particular the Stanthorpe and Granite Belt Chamber of Commerce and the Stanthorpe Community Reference Panel have indicated that ongoing water restrictions are a constraint to future urban growth, and have suggested they are reducing the attractiveness of the region as a place in which to live and invest. It is noted that water restrictions are rarely enforced by Council and the majority of residents and visitors to the Stanthorpe area would be unaware that restrictions are in place. Furthermore, the restrictions only apply to those people or businesses connected to the reticulated water infrastructure, not to areas beyond this.

Many of the existing high value horticultural and agricultural producers face periodic water shortages, which impacts negatively on crop yields and reduces the incentive to expand production. Stakeholder consultations with irrigators have indicated there is a demand for additional water, if only to consolidate existing crop yields.[6] The lack of access to a reliable water supply is also seen as a constraint on new entrants to the market, whether they be new industries or agribusiness. The producers are not impacted water restrictions established by Council.

In terms of demographic drivers, population growth in SDRC has been 0.7% over the past five years, which is far lower than for the rest of Queensland at 1.6% and has declined marginally in the last two years. The Stanthorpe Regional Statistical Level Area (SLA) grew at 0.7% and the Stanthorpe Urban SLA grew at 0.3% over the past five years. The population is also aging - 21.9% of SDRC is older than 65 compared to the rest of Queensland at 14.4%, while over a quarter (26.6%) of the population in the Stanthorpe SLA is older than 65.

Other key social and economic statistics indicate that:

- Agriculture is the major employer in the region.
- Unemployment rates are lower than the rest of Queensland.
- Levels of education across the population are lower than the rest of Queensland.
- The region has a low percentage of indigenous population (3.3%).
- 42.5% of SDRC population were considered to be in the most socially disadvantaged quintile compared to 20% of the population overall. Social disadvantage was greatest in the Stanthorpe Urban SLA.
- Crime in SDRC area was lower than the rest of Queensland. Crime rates in the Stanthorpe Urban SLA were higher than the rest of Queensland.
- Incomes in SDRC area were lower than the rest of Queensland. 42.5% of the population earned less than $20,000 per annum.
- The majority of housing stock is separate housing accommodating a single family.
- There were 133 housing development approvals in the entire SDRC area in the 12 months leading up to February 2017 with 15 in the Stanthorpe Urban SLA.
- The average house price across SDRC area was $258,000. The Stanthorpe Urban SLA had a slightly higher median house price than the Southern Downs Region as a whole.

Refer to Appendix C for a more detailed profile of social and demographic indicators.

2.3 Summary of key issues

The major implications of current demographic trends are that population growth in the Stanthorpe Urban area is slowing and the ability or capacity of residents to pay for an additional urban water supply is limited. While comparatively slow population growth has helped to moderate urban

[6] Refer to Appendix D Emu Swamp Dam - Agricultural and industrial water demand assessment

demands for water, according to most recent projections (Section 5.4) the current water supply for the Stanthorpe region is not sufficient to meet forecast urban water needs beyond 2036. Moreover, the high reliance on agriculture as a major source of employment suggests that the population is vulnerable to water insecurity, with any downturn in agricultural yields due to an extended drought likely to have flow on effects for incomes and employment. This suggests that identifying the best value for money solutions to meet future urban and irrigation needs for the region is critical to achieving the economic potential for the region.

3. Document review and gap analysis

3.1 Introduction

Subject matter specialists reviewed more than 100 documents relating to previous evaluations of water supply options, water security and economic studies in the Stanthorpe region, concentrating on reports prepared since circa 2005. Though previous work has been comprehensive, many of the assumptions underpinning earlier reports are now out of date, especially in terms of population growth and urban water demand growth.

GHD appraised the findings and recommendations of earlier work in the context of applicability to this study taking into account changes in assumptions such as:

- The population size of Stanthorpe
- Extent of water intensive industry
- Water consumption litres per capita per day (L/c/d) over that projected in earlier reports and in light of most recent forecasts, particularly for urban water supply
- Yield and reliability of yield for different water supply options.

GHD has also sought to identify gaps in the previous analysis of the water supply needs and options and sought to address those gaps, where possible, in this current stage of assessment (Strategic Business Case) in this report.

GHD has summarised the conclusions of the reports relied on in the following table (Table 3-1) and provided more detail of the assessment of previous reports by subject matter (e.g. dam engineering, pipeline engineering) in Sections 3.3 to 3.11. The identified gaps are discussed in Section 3.12

3.2 Previous report review summary

Full citations, as well as other relevant reports that informed this business case, are detailed in the Reference List in Section 15.1.

Table 3-1: Summary of review of previous studies and reports

Year	Document Title	Document Author	Relied on / not relied on	Document Conclusions
2017	Southern Downs Regional Council Contract 17/016 Design of Raw Water Pipeline from Storm King Dam to Mt Marley WTP – Stanthorpe, QLD. Route Selection and Options Analysis Report	R. Vosloo, Vosloo Consulting Engineers	Relied on	Several options were considered for the upgrade of the trunk main from Storm King to the water treatment plant. Option 1 was selected as preferred based on: • Follows existing easement and assumes the new pipeline will be constructed next to the existing pipeline and within the same easement. • Total length 8,940 m. • Hydraulic design – can gravitate from Storm King Dam. Diameter Nominal (DN)300 can supply by gravity for flow rates ○ Less than 48.65 L/s and dam at low water Less than 73.37 L/s when dam is full
2016	Initial (Pricing) Business Case for Emu Swamp Dam	Jacobs	Relied on	Jacobs considered three funding models for Emu Swamp Dam covering various combinations of urban and irrigation water needs. Scenario 2 (“5,000 ML Yield”) was identified as the preferred option, reflecting demand for high-priority urban water shares (99% reliable) of 750 ML and medium-priority irrigation water shares (88%) for 4,250 ML. The report estimates the prices that urban and irrigation users would have to pay over a 100-year period if the government provided a 65% capital contribution. The benefits and costs of proceeding with the project were also outlined, though the study did not investigate other options capable of meeting Stanthorpe’s urban and irrigation-related needs.
2015	Stanthorpe Regional Water Supply Security Assessment (RWSSA): Reticulation Network Water Demand Information Paper	Department of Energy and Water Supply	Relied on	This RWSSA report prepared by DEWS focuses primarily on updated resident population serviced by Stanthorpe’s reticulation network. Recommendation to use serviced population for future design and percentage of 0.95% growth as basis to develop other information.

2015	Stanthorpe Regional Water Supply Security Assessment (RWSSA): Population Growth Information Paper	Department of Energy and Water Supply	Relied on	This RWSSA report assumed that any future growth in this demand will be approximately proportionate to population growth and, as such, growth in water demand from industry will be reflected in the growth figures for urban water demand. Recommendation to use updated population and the following key data in future assessment: - Use average daily water demand 324 L/c/d - Average urban water demand to be 740 ML/a by 2036 Dry period demand to be 858 ML/a by 2036
2015	Stanthorpe Regional Water Supply Security Assessment (RWSSA): Water Supply Source Information Paper	Jo Carini / Miguel Wu, Southern Downs Regional Council	Relied on	The paper concludes that: - Storm King Dam has a small storage capacity and can be drawn down to low levels if there are extended periods of low or no-flow conditions, as has previously occurred during prolonged drought, such as the Millennium Drought (late 1996 to mid-2010); - Water restrictions have been introduced to reduce water consumption during dry periods and increase water efficiency; Without further inflows, Storm King Dam has a supply capacity of about 1-2 years and therefore relies heavily on seasonal inflows to replenish the dam.
2014	Emu Swamp Dam project: Coordinator General's Evaluation Report on the Environmental Impact Statement	Coordinator-General; Department of State Development, Infrastructure and Planning	Relied on	The key conclusions from the Coordinator-General's evaluation report for the proposed Emu Swamp Dam project are: - The environmental impact assessment requirements had been met; - Approval was granted in September 2014, and is valid until September 2017 unless an extension is requested ahead of the lapse date. The project has the potential to improve water security and support economic growth in Stanthorpe as well as surrounding areas.
2014	Department of the Environment Approval Decision for Construction of a dam and associated infrastructure at Emu Swamp, Stanthorpe,	Deb Callister; Department of Environment	Relied on	Approval for the Emu Swam Dam project is valid until 12 November 2074. If the Project has not 'commenced construction' within 5 years from the approval date (11/11/2014), construction cannot commence without written agreement from the Minister. There is a risk that the Minister will require additional information to support a 'proceed' decision or will require Project commitments (approval conditions) to be evidenced. Management and offset for Matters of national environmental significance (MNES) species (condition #5) requires rehabilitation to have been undertaken ahead of

	Queensland (2006/3201)			inundation – will need to be considered in terms of program and costs as early works are likely to be required. Alternatively, investigate and evidence that no impact on MNES species within inundation area – requires reporting and approval by the Minister.
2013	Emu Swamp Dam Project - Potential Offset Options	Alan Key; Earthtrade	Relied on	The document identifies six potential offset options. It is recommended that Southern Downs SDRC considers the following points: • Identification of potential offset areas on SDRC properties; • The protection of these areas with a Category X Property Map of Assessable Vegetation so that the areas are still classified as being able to be cleared under legislation; • Management of these areas to encourage natural regeneration of the Threatened Ecological Community (TEC) in the period prior to the construction of the Project. On utilisation of the areas as offsets, the Category X Property Map of Assessable Vegetation (PMAV) would be removed and the area would be protected by another instrument on the title of the property; and Investigate the willingness of private property owners upstream and downstream of the Project area, Connolly Dam and the three large stations identified in participating in a program to allow riparian and other areas of the TEC to naturally regenerate in the interim as for the properties controlled by SDRC
2013	Emu Swamp Dam Project - Potential Offset Options	Alan Key; Earthtrade	Relied on	The document identifies six potential offset options. It is recommended that Southern Downs SDRC considers the following points: • Identification of potential offset areas on SDRC properties; • The protection of these areas with a Category X Property Map of Assessable Vegetation so that the areas are still classified as being able to be cleared under legislation; • Management of these areas to encourage natural regeneration of the Threatened Ecological Community (TEC) in the period prior to the construction of the Project. On utilisation of the areas as offsets, the Category X Property Map of Assessable Vegetation (PMAV) would be removed and the area would be protected by another instrument on the title of the property; and Investigate the willingness of private property owners upstream and downstream of the Project area, Connolly Dam and the three large stations identified in participating in a program to allow riparian and other areas of the TEC to naturally regenerate in the interim as for the properties controlled by SDRC
2013	The Economic Impact of the Emu Swamp Dam	T Sargeant Services Pty Ltd	Not Relied on	The key conclusions from the report were as follows: - The majority of growers surveyed were supportive of the project (26 per cent of growers in the footprint were surveyed)

				- 83% of the growers surveyed were seeking access to additional volumes of irrigation water, either for water security of developmental purposes - The report estimated total demand for additional irrigation water at over 4,000 ML The report estimated that the development of the Emu Swamp Dam would have significant economic impacts on the regional economy.
2013	Report on Horticulture Production in the Proposed Footprint of the Emu Swamp Dam in Queensland's Southern Downs Region	J.S. Tancred & S. Organ; Orchard Services	Relied on	The report produced estimates for the total number of producers and area of crops grown (in ha) for both the Southern Downs region and the Emu Swamp Dam footprint. The report also identified the value of production by crop for each area. Estimates were developed for the following crops: - Tree fruit (disaggregated by apples, stone fruit, pears and other) - Grapes (disaggregated by wine grapes and table grapes) - Berries (strawberries and strawberry runners and other berries) - Vegetables (disaggregated by tomatoes, capsicums, brassicas, lettuce, baby-leaf, celery, peas and beans, cucurbits, heavy vegetables, parsley and herbs, other) Specialty crops (disaggregated by Euphorbia, mushrooms, turf).
2008	Emu Swamp Dam Environmental Impact Statement (and Supplementary EIS)	SKM	Relied on	In February 2007, the Coordinator General declared the Emu Swamp Dam project a 'Significant Project' for which an Environmental Impact Statement (EIS) was required. The EIS assessed two development options for the Emu Swamp Dam project: • An Urban Water Supply Dam with an Urban Pipeline linking the dam to the Mt Marlay Water Treatment Plan; and • A Combined Urban and Irrigation Dam. With the Urban Pipeline and an Irrigation Pipeline connected to a number of irrigators in the Stanthorpe Shire. The (then) Stanthorpe Shire Council released the EIS for public consultation in February 2008. Additional information was requested by the Coordinator-General and provided in April and May 2014. In September 2014, the Queensland Coordinator-General recommended that the project proceed, subject to conditions, recommendations and implementation of commitments. The Emu Swamp Dam project has four major components: 1. Emu Swamp Dam 2. Stalling Lane Access 3. Urban Pipeline 4. Irrigation Pipeline It was assumed that water supply capacity would need to increase a further 1,500 ML/a above then current levels to meet urban water needs. However, affordability considerations have led to Council pursuing an initial stage capacity of 750 ML. An 8% increase in irrigation entitlement is also assumed, taking the water entitlement to 1,740 ML/a.

				The project was assessed against the following Acts: • Environment Protection and Biodiversity Conservation Act 1999 • State Development and Public Works Organisation Act 1971 • Sustainable Planning Act 2009 • Environmental Protection Act 1994 • Fisheries Act 1994 • Vegetation Management Act 1999 • Water Act 2000 • Nature Conservation Act 1992 • Aboriginal Cultural Heritage Act 2003 • Queensland Heritage Act 1992 • Transport Infrastructure Act 1994 • Land Act 1994 • Environmental Offsets Act 2014 – this Act commenced in 2014, and so was not included in the EIS. However, the Coordinator-General's report includes offset requirements compliant with this Act, and an offset plan must be prepared and submitted for approval prior to construction on this project. IQQM simulation for a town water supply of 750 ML/a was undertaken (Supplementary EIS, SKM 2014). The storage volume for an "Urban (only) Water Supply Dam" was 5,000 ML for which the mean annual diversion is predicted to be 742 ML/a at a 99.9% monthly reliability. The storage volume for a combined urban and irrigation dam was 10,500 ML, and is predicted to yield 742 ML/a at 99.9% monthly reliability for urban supplies, and 1,676 ML/a at 96.6% monthly reliability for irrigation supplies. The performance of the dam (storage capacity of 10,500 ML at a Full supply Level (FSL) 738 m Australian Height Datum (AHD)) in terms of reliability was analysed in the supplementary EIS with an extended IQQM (hydrology model) developed by the Department of Science, Information Technology and Innovation and the Arts (DSITIA). The results show that in general that the proposed dam has a high reliability, greater than 99% for urban supplies and 96% for irrigation water supply. The results are based on an environmental release strategy to maintain the low flow regime for the Severn River such that the environmental release will pass flows through the dam of up to 30 ML/d when a flow is received into the dam.
2008	Stanthorpe Water Supply Off Stream Storages	Lex Appelgren, SKM	Relied on	The report concludes that: • The Severn River Off Stream Storage (OSS) options can provide the same water supply as the Emu Swamp Dam proposals (750 ML/a), potentially with

				fewer environmental impacts, but equal or higher initial capital costs. They will also be more expensive in the future. The Storm King Dam Off Stream Storage project can operate within the constraints of the existing water license and provide an additional 350 ML/a. However, it will have significant social impacts and carries a greater supply security risk than the Emu Swamp Dam site.
2008	Border Rivers Resource Operation Plan	Department of Energy & Minerals, Queensland Government	Relied on	The volume of unallocated water (3,000 ML for irrigation and associated industry) and 1,500 ML for town water supply) represent the average annual volume of water that may be taken. This effectively that the allowable nominal volumes of water allocations may be greater than this depending on their historical hydrologic performance as estimated using the department's hydrologic model.
2007	Stanthorpe Water Supply Strategy IQQM Modelling	SKM	Relied on	This preliminary assessment showed that Ballandean and Emu Swamp were the only viable options. The analysis concluded the storage needed to be 8,000 ML in capacity at Ballandean – this would provide a mean annual diversion of nearly 1,400 ML/a at a monthly reliability of about 90%. The Emu Swamp site provided marginally more water at a marginally higher reliability. The analysis also concludes an 18,000 ML storage at Ballandean (with an 8,000 ML town water reserve) would provide an adequate town water supply (mean annual diversion of nearly 1,400 ML/a at a monthly reliability of about 90%) and an irrigation supply with a mean annual diversion of about 1,000 ML/a at a monthly reliability of about 60%. The Emu Swamp site delivered a slightly higher irrigation diversion of 1,100 ML/a at a slightly higher reliability of 62%.
2006	Stanthorpe Shire Water Opportunities – Urban Water Needs Analysis	Scott Abbey, SKM	Relied on	Key recommendations were: <u>Urban Water Demand Results</u> • Results for Low Demand: – Almost certain are: 2005 915 ML/a and 2050 1,804 ML/a – All developments: 2005 915 ML/a and 2050 1,942 ML/a • Results for Medium Demand: – Almost certain are: 2005 915 ML/a and 2050 2,267 ML/a – All developments: 2005 915 ML/a and 2050 2,449 ML/a • Results for High Demand:

				– Almost certain are: 2005 915 ML/a and 2050 2,680 ML/a – All developments: 2005 915 ML/a and 2050 2,934 ML/a From the comparison of water demand and existing capacities, it is suggested that by 2010 the existing water supplies will be exceeded. Council needs to secure 1,500 ML/y urban water allocation and urgently develop the water supply infrastructure to deliver that allocation.
2005	Stanthorpe Water Supply Dam Options Review	SKM	Relied on	The purpose of this report was to review and update previous water supply investigations and determine a clear plan to provide increased water allocations provided by the Water Resource (Border Rivers) Plan 2003. The focus was mainly on options for satisfying town water supply requirements of Stanthorpe Shire, rather than providing water for irrigation expansion. The report considered: • An update of considerations for a new water supply, including planning, native title, environmental and social matters • Water consumption and demand • Ecological, cultural heritage and native title • Water supply options • Further investigations Of relevance, water supply options were: • Petries Crossing Weir • Raising Storm King Dam • Ballandean Dam Upper Emu Swamp Dam
2003	Water Plan (Border Rivers) 2003	Department of Natural Resources & Minerals, Queensland Government	Relied on	The plan provides for an allocation of unallocated water (from a watercourse, lake, spring or overland flow) as a strategic reserve of 3000 ML (average annual volume) for irrigation and associated industry in the Stanthorpe Water Management Area; plus 1,500 ML (average annual volume) for town water supply in the Stanthorpe Water Management Area. The plan sets out water allocation security objectives that must be met when making decisions in accordance with the plan. These are tested using the data and assumptions contained within DNRM's hydrologic model. For a water allocation group taking supplemented water, water allocation security objectives (WASOs) are specified in terms of an "annual volume probability". This is the average annual volume of water that may be taken by the group in the simulation period as a percentage of the total of the

<table>
<tr><td></td><td></td><td></td><td></td><td>nominal volumes for the group. A minimum target of 34% applies to supplemented water outside of the MacIntyre Brook Water Supply Scheme and a 45% annual volume probability (which must not reduce as a results of any decision). It is noted that the performance being sought from the new allocations from Emu Swamp Dam significantly exceed that required by the WASOs in the Water Plan.</td></tr>
<tr><td>2002</td><td>Comparison of Water Use Efficiencies of Stanthorpe Shire’s Horticultural Crops and Selected Field Crops</td><td>J.S. Tancred, Orchard Services</td><td>Relied on</td><td>Key findings of the report are summarised below:
<table>
<tr><th></th><th>Fruit</th><th>Veg</th><th>Cotton</th><th>Chickpeas</th></tr>
<tr><td>Water use – tonne per ML</td><td>4.79</td><td>4.45</td><td>0.27</td><td>1.67</td></tr>
<tr><td>Gross returns - $ per Ha</td><td>$32,173</td><td>$39,722</td><td>$3,183 - $3,800</td><td>$1,400</td></tr>
<tr><td>Water Use – ML per Ha</td><td>6-6. ML</td><td>6-12 ML</td><td>4.5-8 ML</td><td>1.5 ML</td></tr>
<tr><td>Gross Return - $ per ML</td><td>$4,950 - $5,362</td><td>$3,314 - $6,629</td><td>$398 - $844</td><td>$933</td></tr>
</table></td></tr>
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3.3 Urban water demand historic

The issue of urban water supply to Stanthorpe has been studied for many years. *The Report on Stanthorpe Water Supply Strategy Study* (Munro Johnson & Associates 1984) was the first to assess the potential future water demand for Stanthorpe including calculations for projected population, associated water supply forecast to 2044 and estimated costs of potential augmentation options. Although the report is dated and used a very high population growth rate, it does provide a good understanding about Stanthorpe's water system. It indicated that:

- The Storm King Dam had sufficient capacity to cater for Stanthorpe's water supply until 2013
- The trunk main from Storm King Dam had sufficient capacity to meet forecast increase in water demand
- The pump station was not capable of supplying the maximum demand of 7.09 ML/a
- The water treatment plant was not capable of supplying the water demand for forecast population of 6,300
- Another reservoir of 3.0 ML was required.

A more detailed and recent report of the projected urban demand was the *Stanthorpe Shire Water Opportunities - Urban Water Needs Analysis* (SKM 2006) which provided an assessment of the urban supply based on three growth scenarios (Low, Medium and High). The approach appeared very conservative (based on current knowledge), therefore the conclusions were unlikely to be realised. It was suggested that by 2010 the existing water supplies would be exceeded and recommended the need to secure an additional 1,500 ML/a. This has not transpired.

The most reliable report, based on robustness and current data, is the *Stanthorpe Regional Water Supply Security Assessment (RWSSA)* (DEWS 2016). The report updates the urban water needs to confirm water demand trends. The RWSSA assumed that any future growth in water demand will be approximately proportionate to population growth and, as such, growth in water demand from industry would be reflected in the growth figures for urban water demand. The recommended updated population forecast and the associated key data from this report has been used in the following sections of this report and are presented below:

- 2015 population of 6,168 which includes Applethorpe
- Projected Population (2036) of 7,540
- Projected Serviced Population (2036) of 6,259 (based on the assumptions: there will be no significant change in the proportion of the current population connected to the reticulation network, and an estimated 83% of new residents will be connected to the reticulation network)
- Based on the total volume of water sourced and the serviced population, the average water demand is 324 litres per capital per day (L/c/d) (residential and non-residential)
- The average residential water use was approximately 213 L/p/d
- Stanthorpe's wastewater treatment plant produced between approximately 270 ML and 400 ML of recycled water per year
- The combined industrial, commercial and municipal water use in Stanthorpe constituted on average about 30% of Stanthorpe's total water demand. The water use by these businesses is accounted for within the total water demand
- Average urban water demand is estimated to be 740 ML/a by 2036

- Recommendation to use serviced population for future design based on forecast population growth of 0.95% per annum to develop other information.

Litres per capital per day is the total urban water supply divided by the population and hence captures supplies to non-residential properties, parks and amenities etc. as well as residential properties. Litres per person per day is the actual average consumption per person. Hence L/c/d will always be greater than L/p/d.

3.4 Irrigation water demand

The demand for additional irrigation water in the Stanthorpe area has been subject to several previous assessments.

These demand studies have mostly applied survey-based approaches whereby producers were asked whether they required access to additional volumes of irrigation water; how they would use the water (i.e. application to new or existing crops); and their willingness to pay. These surveys have found that there is strong interest from producers of a wide range of crops in acquiring material volumes of additional irrigation water. The studies have reported that additional volumes of irrigation water would be used for both existing crops (increased yield and water security) and to expand crop production in the area.

The most recent irrigation demand study was conducted via an internet-based survey in December 2015. A total of 19 producers were surveyed with results showing that all would attempt to purchase additional water entitlements at a one-off purchase price of $5,979/ML and annual fixed charges of $241/ML and annual variable charges of $139/ML. In total, survey respondents indicated a total demand of 1,210 to 1,325 ML, with volume demand ranging from 5 ML/a to 300 ML/a[7].

In 2013, 90 interviews were undertaken, with the vast majority of producers indicating strong support for the project based on the growth it would enable. The study found that 40 of the 48 producers interviewed who would be able to access water from the project stated that they needed additional water[8].

Whilst surveys provide useful insights about demand, they also present limitations. Assessing irrigation water demand based solely on survey responses (or views expressed by stakeholders through other means), is not sufficiently robust to enable a decision to be made on the feasibility of a water supply augmentation. As such, whilst the survey results summarised above provide a useful starting point for GHD's assessment (e.g. irrigation water application rates, crop yields, intended uses of additional volumes of irrigation water), the outcomes from these past assessments cannot be relied upon in terms of drawing conclusions regarding the level of irrigation water demand in the region.

Other approaches can be applied to assess demand, including deriving estimates based on water market data, historical growth rates as a guide to future demand, and on-farm financial assessments.

3.5 Industrial water demand

Whilst less of a focus than irrigation demand, industrial water demand in relation to the proposed Emu Swamp Dam has also been subject to several past assessments. In 2006, SKM prepared a report for the Shire of Stanthorpe titled 'Stanthorpe Shire Water Opportunities – Urban Water Needs Analysis'. The report formed one of series of reports prepared by SKM on the status of water demand and supply in the region. In relation to industrial demand, the report

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[7] The total return to irrigation water is calculated by applying a discount rate commensurate with producers deriving a commercial return from irrigation water entitlements.
[8] Predominantly horticultural.

concluded that an improved water supply will provide opportunities to support and attract more diverse, value-adding businesses - primarily agrifood processing.

In 2008, an Environmental Impact Statement (EIS) was prepared by SKM for the proposed Emu Swamp Dam project, including a cost-benefit analysis of the project. This analysis assumed that, over time, industrial water demand would exceed residential demand due to the changing character of Stanthorpe, with the urban population being constrained (primarily by young people leaving for education and services sector employment opportunities), whilst growing tourism and agricultural value-adding are increasing water demand in these sectors.

The EIS forecast that industrial demand would outstrip residential demand by 2020 and that total urban demand would exceed 1,000 ML by 2024. This is considerably higher than that assumed by a more recent demand assessment conducted by DEWS as part of its Regional Water Supply Security Assessment (RWSSA) for Stanthorpe, which found that:

- Over a 7-year period (2008-2015), the Council has drawn down an average of 590 ML annually to supply urban users through the reticulated network;
- At present, the combined industrial, commercial and municipal water use in Stanthorpe constitutes, on average, about 30 per cent of the town's total water demand. All industrial water users in the region are currently serviced by the reticulated water network;
- Total urban demand (including industrial) is forecast to increase to between 740 ML and 858 ML per annum by 2036 (with the higher forecast based on extended dry periods).
- Importantly, DEWS assumed that industrial demand would grow in proportion to population growth and discounted the possibility of any major new industrial demand within the reticulated area.
- Based on these forecasts, the report concluded that between now and 2036 there is only a very low risk of Stanthorpe experiencing a supply shortfall (1 in 250 annual probability), provided water restrictions are applied as dam levels fall.

As detailed above, the DEWS assessment of industrial water demand in the Stanthorpe region is significantly different to that developed by SKM for the EIS. The key gap in the SKM's work, which identified significant growth potential in relation to industrial activity and water demand, is any assessment of the commercial viability of the industrial activity to which the forecasts relate and the extent to which access to reliable water supply is a constraint on this activity.

3.6 Social impact of water infrastructure

An examination of previous documentation regarding the Emu Swamp Dam and other water infrastructure investment in the Stanthorpe region rapidly identifies that the majority of investigations have taken a technical approach and focussed on supply side solutions. Social considerations have not been a major part of most reports.

Social considerations have been based on broad assumptions of the benefits of additional water supply in terms of population growth, employment and lifestyle. For example, the Emu Swamp Environmental Impact Statement identifies:

> *Stanthorpe Shire is a vibrant community with strong expectations and opportunities for growth. There is considerable development demand in Stanthorpe and the provision of a reliable urban water supply is necessary for the future growth and sustainability of the Shire. Stanthorpe would miss out on commercial and industrial opportunities with the No Project alternative*. (SKM (2008a) p.2-6).

Other reports have identified cultural heritage aspects of the proposed Emu Swamp Dam including the conduct of an Aboriginal Archaeological Survey of the Proposed Emu Swamp Dam.

The only major social impact analysis completed and available in the numerous reports on water supply solutions in the Stanthorpe area was commissioned as part of the Environmental Impact Statement for Emu Swamp Dam. Various other documents have summarised these as the key social implications of the Emu Swamp Dam project. Many of the social benefits and dis-benefits assigned to the Emu Swamp Dam are generic and applicable to many of the other options for increasing regional water supply.

The following table summarises the positive social impacts identified as part of the Emu Swamp Dam in the Environmental Impact Statement.

Table 3-2: Positive social impacts of Emu Swamp Dam

Positive Social Benefit	Description
Future Property Development	Provision of a reliable water supply would allow future residential development. Lack of additional water is a major constraint to future growth and development.
Additional Employment in Construction Phase	Additional 120-145 persons required for construction activities.
Housing and Accommodation	Increased demand for short-term and rental accommodation.
Community Facilities	Increased participation in sporting clubs and community organisations in construction phase.
Youth Employment	Employment and training associated with the project may help create opportunities and retain youth in area.
Tourist Accommodation	Additional urban water supply will support development of new tourism accommodation.
Agriculture and Horticulture	Additional water supply will support expansion of horticulture and agriculture.
Processing Facilities	Additional water supply will support development of processing facilities
Indirect Employment	Increased demand for goods and services will increase local employment opportunities.
Additional Visitors	Dam and proposed visitor and recreation facilities will increase number of regional tourists with flow on benefits to other industries such as food and accommodation.
Strengthening existing farm and rural uses	Viability of small farms will be increased through provision of additional water supply for irrigation.
Tourism	Additional workers during construction phase will increase numbers of tourist.
Manufacturing Industries	Benefit for local industries involved in manufacturing
Recreational Uses	Additional facilities at dam for picnic areas, motorised and non-motorised boating, water-skiing, swimming and fishing.

Source: Adapted from SKM (2008a) p 2.1 to 2.2

The following table summarises the negative social impacts identified as part of the Emu Swamp Dam in the Environmental Impact Statement.

Table 3-3: Negative social impacts of Emu Swamp Dam

Negative Social Dis-Benefit	Description
Property Acquisition	The inundation area of the dam would require the full or partial acquisition of 18 properties. The associated pipeline would impact on 2 properties (urban supply) and 9 properties (urban and irrigation).
Transport and Road disruption	Where possible the urban and irrigation pipelines would be located on the road reserves of the New England Highway and other local roads. The pipeline route crosses several railway lines. Local road closures. Increased volume of construction traffic. Road realignments.
Land Use within Buffer Area	Access to the 200 m buffer area around the dam will be restricted. All farming, livestock and similar intensity activities will be prohibited.
Impact on Property Values	Short term impacts on property values because of construction activities.
Housing and Accommodation	Increase cost in rental accommodation because of additional demand.
Community Facilities	Increased demand for health, education and childcare services in construction phase.
Business Enterprise	Construction phase of dam will impact on operation of existing wineries. Property acquisitions will impact on size of vineyards.
Increased Population	Dam may increase rate of population growth and impact on long term planning for community services and facilities.
Loss of Productive Land	Loss of up to 150 ha of land in inundation area currently used for horticultural, viticultural and agricultural uses.
Construction Impacts	Localised dust, noise and traffic.
Increased demand for skilled and unskilled labour	Competition for skilled and unskilled labour may impact on existing businesses.
Rural residential uses	Loss of rural residential land through acquisition. Impacts from construction on local rural residential amenity

Source: Adapted from SKM (2008a) p2.1 to 2.2

3.7 Water resource management and water products

GHD reviewed a suite of technical reports that include commentary about the hydrologic yield of water supply options in the Stanthorpe area. GHD considers that the assessments that were undertaken or reported within earlier studies to be less reliable than those of recent reports as the former were based on limited rainfall and/or streamflow information, and basic monthly time-step water balance assessment.

More recent reports and assessments have been prepared by the Department of Natural Resources and Mines and the Department of Energy and Water Supply to support the water resource planning, resource operations planning and water supply planning processes for the catchment. These contain hydrologic assessments and commentary that are based on daily time-step historical modelling and, more recently, stochastic analyses. These models use data inputs that have been collected or constructed using industry-standard modelling approaches and take into account current conditions such as the impact of the extent of private water infrastructure development upstream of proposed or existing dams on measured or assessed streamflow sequences. GHD notes that earlier reports generally acknowledged these shortcomings or assumptions when presenting results and included recommendations for additional studies to address such weaknesses).

Three key sources of hydrologic information therefore stand apart in terms of their currency, quality and utility:

- Modelling associated with the Border Rivers Water Resource Plan and Resource Operations Plan.

  This modelling resulted in 3,000 ML (average annual volume) being set aside by the Water Plan for irrigation and associated industry, plus a further 1,500 ML (average annual volume) for town water supply, in the Stanthorpe Water Management Area.

  GHD notes that the minimum water allocation security objectives (which are defined in the Water Resource Plan and are a modelled statistical measure of the minimum reliability to be achieved when developing water infrastructure to create these water allocations) are quite low for supplemented water allocations. For example, the “annual volume probability” which is the average annual volume of water that may be taken by the group in the simulation period as a percentage of the total of the nominal volumes for the group must be greater than a minimum target of just 34%.

- Historical and stochastic modelling[9] associated with the Stanthorpe regional water supply security assessment. This modelling examined the security of Stanthorpe’s existing urban water supply system (based on water being supplied from Storm King Dam) and its capacity to support current demands and future growth. It found that:
  - There are only a few licences that authorise the take of water from the catchment area of Storm King Dam, each of which is for a relatively small volume of water for agricultural or irrigation purposes. These are not considered to have a significant impact on Stanthorpe’s water supply security.
  - Information from the State-wide Water Information Management database shows that the total volume of water sourced from Storm King Dam for the reticulation network over the 7 years from 2008–09 to 2014–15 averaged 590 ML/a (ranging from 530 ML/a to 696 ML/a).
  - Stanthorpe’s wastewater treatment plant produced between approximately 270 ML and 400 ML of recycled water per year from 2010–11 to 2014–15 meaning that, on average, more than half of the water supplied to meet Stanthorpe’s urban demands is subsequently recycled. All of the recycled water produced is allocated for irrigation of sporting fields, parks, gardens and local horticulture, which reduces the potential demand on Storm King Dam.
  - Historical modelling undertaken (for the period 1890 to 2015) indicated that Storm King Dam would have been capable of meeting a demand of 600 ML/a without experiencing any periods of water supply shortfall (with or without water restrictions). Extended IQQM simulation(Supplementary EIS, SKM 2014) showed that Storm King Dam would have been capable of meeting a demand of 742 ML/a at 99.9% monthly reliability (99.2% annual reliability). This is equivalent to Stanthorpe’s projected 2036 average water demand) that the modelling indicates will be met without experiencing any periods of water supply shortfall (with Council’s water restriction regime in place and assuming that the targeted water consumption reductions are met). Under both of

[9] Stochastic modelling involves the statistical analysis of random probability distributions that can’t be predicted precisely and is considered to be more reliable than purely historical analysis.

these scenarios, Storm King Dam would historically have fallen to quite low levels on a number of occasions, with only a few months of supply remaining at times.

– Stochastic modelling extends the underlying characteristics of the historical record and allows assessment of the statistical probability of more extreme events than those observed in history. This modelling indicated that, at Stanthorpe's projected 2036 water demand (740 ML/a) and with restrictions in place, Stanthorpe would experience a water supply shortfall once in 350 years on average over a 10,000 year period. In addition, during that period 1,000 occurrences of 'high' water restrictions lasting longer than 1 month might be expected (of which 600 could be expected to last longer than 3 months and 330 last longer than 6 months).

Historical hydrologic modelling was undertaken as part of the Environmental Impact Assessment. This involved analysis of the yield-related hydrologic performance of the dam using the Department of Natural Resources and Mines' (DNRM's) IQQM and associated parameters and assumptions and presented against the Environmental flow objective (EFOs) and Water Allocation Security Objectives (WASOs) defined in the WRP.

The EIS outlined hydrologic analyses for two key scenarios. The first scenario was a storage volume for an "Urban (only) Water Supply Dam" of 5,000 ML (734.5 m AHD) for which the mean annual diversion is predicted to be 696 ML/a at a monthly reliability of 93%.

The second was a "Combined Urban and Irrigation Dam" with a volume of 10,500 ML (738 m AHD) for which the existing entitlements IQQM was modified to include the dam, a town water supply annual allocation of 750 ML/a and an annual allocation of 1,740 ML/a for irrigation. The required storage volume for a Combined Urban and Irrigation Dam was determined to be 10,500 ML for which the mean annual diversion for the urban component of Combined Urban and Irrigation Dam was predicted to be 698 ML at a monthly reliability of 93%. The mean annual diversion for the irrigation component of the combined urban and irrigation dam was predicted to be 1,302 ML at a monthly reliability of 75%.

3.8 Supply options analysed

There are seven different dam sites assessed by previous studies. These include:

- Petries crossing weir
- Raising Storm King Dam
- Ballandean Dam
- Emu Swamp Dam
- Quart Pot Creek Dam

Other options that had previously been assessed and discarded were:

- The Broadwater, which having a number of small on-farm dams built in the catchment is no longer considered viable
- Kia Ora, which is located in New South Wales. SDRC has no jurisdiction to develop the site.

The key report which made a comparative assessment (SKM 2005a), concluded that Ballandean Dam and Emu Swamp Dam should be considered for further investigation.

Overall, the reports, other than the EIS, relating to proposed dam options have been undertaken at a pre-feasibility level and are limited in scope with the exception of Emu Swamp Dam, which was subject to updated cost analysis in later SKM (2007b; 2015) reports. The SKM (2005a) report undertook comparable estimates, but did not consider a variety of dam wall heights. The cost estimates and short description of impacts relate to a 1,500 ML/a yield, or a maximum potential construction height in the case of Petries Crossing Weir and raising Storm King Dam by 4 m. There is little information on other potential storage capacity options. Subsequently, the capital cost per ML yield, is not optimised making comparison of each site for one or two dam sizes difficult. This limits decision-making when relying on previous studies as the implications of staging of construction as emerging demand is realised, is not transparent.

There is very limited engineering information at each site. GHD has not sighed the Water Resources Commission report relating to each dam site, which is likely to contain such information for this study. Engineering data has been progressed for Emu Swamp Dam, including a geotechnical investigation and a concept design but not for the other sites.

The reports stating costs and yield were completed with a robust methodology at the time, but are no longer reliable. This is primarily due to the limited nature of design information used to derive comparative costings in the 2005a SKM report and due to the work undertaken by DNRM/DEWS/DSITIA in order to update the IQQM to include on-farm storages that affect yield.

Further, the comparative yield estimates, documented in the IQQM (2007d) report by SKM, did not include environmental flows for Storm King Dam. These have the potential to impact significantly on the yield results, given, once a raising of the dam is undertaken, infrastructure to accommodate environmental flows will have to be constructed to gain legislative approvals.

In short, it is not possible to revisit the evaluation of different options through analysis of previous reports given the change in assumptions, urban demand, yield, environmental considerations and the difference in the level of analysis in the different reports.

3.9 Environmental and planning approvals

The existing environmental and approval documents reviewed all relate to the proposed Emu Swamp Dam (and pipelines) project and include:

- Emu Swamp Dam EIS (and accompanying technical reports) prepared for Stanthorpe Shire Council (SKM 2008a)
- Emu Swamp Dam Supplementary Report prepared for SDRC (SKM 2014)
- Emu Swamp Dam project: Coordinator General's Evaluation Report on the environmental impact statement (Department of State Development, Infrastructure and Planning (CGER 2014)
- Commonwealth Department of Environment (2014) approval and conditions under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) for the proposed Emu Swamp Dam.

Reports considered as precursors to the Emu Swamp Dam EIS, such as the EPBC Act Referral and Initial Advice Statement, or instruction/contractual/commercial documents, are superseded by the EIS and were not reviewed.

3.9.1 Emu Swamp Dam project environmental impact statement

The Emu Swamp Dam project as described in the EIS (SKM 2008a) and Supplementary EIS (SKM 2014) and approved by the Commonwealth and the State allows for the development of an urban only water supply dam or a combined urban and irrigation water supply dam. Key characteristics for the respective proposed developments are provided in Table 3-4.

Table 3-4 Emu Swamp Dam key characteristics

Parameter	Urban water supply	Combined urban and irrigation water supply

Storage capacity (ML)	5,000	10,500
Full supply level (m AHD)	734.5	738
Inundation (surface) area (ha)	110	196
Allocation volume (ML/a)	1,500	1,740
Annual extraction volume (ML/a)	750	1,740
Mean annual diversion (yield) (ML)	696[1]	742 urban[2] 1,696 irrigation[2]
Monthly reliability (%)	93[1]	99.9 urban[2] 96.6 irrigation[2]
Annual reliability (%)	89[1]	99.2 urban[2] 93.5 irrigation[2]
Environmental flow objectives (EFOs)	EFO targets were not available as DNRW was developing them for the final Resource Operations Plans (ROP). An environmental release strategy to pass flows up to 30 ML/d when a flow is received into the dam was adopted	
Water allocation security objectives (WASOs)	Not able to be assessed[3] The majority of the water allocations downstream of the dam have passing flow conditions of 0-25 ML/day before they can take water. The environmental release strategy (up to 30 ML/d of passing flow) is designed to preserve access to existing water allocations	
Regulation	Water Resources (Border River) Plan 2003 Draft Border Rivers Resource Operation Plan (consultation draft, January 2007)	
Buffer area (m)	200	200
Aquatic fauna passage	Lock-style Fishway Secondary Fishway at existing weir on Severn River Turtle and other aquatic fauna passage	
Pipeline infrastructure (km) and associated pump stations	23.2	102

Notes:

1 IQQM simulation period 1890 to 1996 (SKM 2008a)

2 Extended IQQM simulation period 1 January 1890 to 31 December 2011 (SKM 2014)

3 WASOs for the downstream water allocations can only be assessed using the final ROP IQQM. At the time of writing the EIS (SKM 2008a) the WASOs were not available as DNRW was finalising the WASOs to support the final ROP. The Supplementary EIS (SKM 2014) reports that DSITIA advised that the extended IQQM was not suitable for assessing compliance with EFOs and WASOs, as a predevelopment model had not been developed for the extended and upgraded IQQM (SKM 2008a; SKM 2014)

Associated infrastructure components comprise the following for either development scenario:

- Recreation area and facilities on the left abutment including a picnic area, toilets, boat ramp and accesses
- Stalling Lane access and closure of Emu Swamp Road
- The workforce will be accommodated locally within Stanthorpe or utilise existing accommodation in the area.
- SDRC is the project proponent.

The EIS and Supplementary EIS are considered to adequately address environmental values as required under the *State Development Public Works Organisation Act 1971* (Qld) and the EPBC Act and relative to the regulatory requirements at the time of writing (2008 for the EIS and updated to 2014 in the Supplementary EIS).

The EIS reports are relatively old in terms of currency, having been developed between 2008 and 2010. Consequently, additional investigations and reports were prepared in 2014 as a Supplementary Report to the EIS to inform the State and Commonwealth's decisions to approve the proposed Emu Swamp Dam project.

The EIS and Supplementary EIS development follows a rigorous, robust and public process to identify, assess, mitigate and manage a project's impacts and benefits on environmental, social, cultural and economic values. Opportunities for review and engagement with local, State and Commonwealth regulatory agencies and the wider community are provided through an extensive consultation programme.

The conditions of approval (including proponent commitments) are reliable and address the environmental (socio-economic and cultural) requirements of the Emu Swamp Dam project as described in this section.

The EIS and Supplementary EIS (including conditions of approval and proponent comments) can be used to inform the development approvals in the next phase should the Emu Swamp Dam project proceed as described. Due to the currency of the reports (2008 to 2014), some elements will need to be revised to inform programme and costs. These may include but are not limited to:

- Vegetation offsets
- Mitigation and management commitments such as fish passage (including as turtle passage provision
- Land acquisition.

The CGER will lapse three years from the date of grant of the approval (29 September 2014) – that is in September 2017. An extension can be requested of, and granted by, the Coordinator-General ahead of the lapse date. Given the active development of a business case for the proposed Emu Swamp Dam project, GHD considers it likely that, if requested, the Coordinator-General would grant an extension.

The currency period extension granted for EIS evaluation reports is at the discretion of the Coordinator-General and differs between projects. Recent extensions[10] have ranged between one and two years, for example:

- SunWater Limited's proposed Connors River Dam and Pipelines project was granted an 18 month extension December 2015
- The Gladstone-Fitzroy Pipeline project proposed by the Gladstone Area Water Board was granted two periods of extension; two years in the first instance followed by a further two years in November 2015
- Eaton Place Pty Ltd.'s proposed Hummock Hill Island Development was granted a one-year extension in May 2016.

GHD has not sighted documentation to indicate that an extension to the CGER has been requested by SDRC.

The Commonwealth's approval of the Emu Swamp Dam project is valid until 12 November 2024. Condition 17 however states that 'If, at any time after five years from the date of this approval [11 November 2014], the approval holder has not commenced construction, then the approval holder must not have commenced construction without the written agreement of the Minister'. **If construction of Emu Swamp Dam is not commenced by 10 November 2019, construction cannot commence without written agreement from the Minister**. 'Commence construction' is defined as site preparation and clearing of vegetation, earthworks, civil works and associated infrastructure and does not include minor physical disturbances for monitoring programs or activities associated with mobilisation of plant and equipment, materials etc. prior to the start of development or construction.

Requests for extension are at the discretion of the Coordinator-General and Commonwealth Minister for the Environment and Energy. Conditions can be imposed on extensions granted and/or additional information may be requested to inform decision making, for example updated data, new field investigations and surveys, etc.

3.9.2 Emu Swamp Dam environmental and approvals costs

Capital costs identified in the EIS economic analysis (Chapter 14) are reported at approximately $44.5 million for the urban water supply dam and $82 million for the combined urban and irrigation supply dam. GHD has compared these capital cost estimates reported in the EIS with capital cost estimates recently developed for a comparable dam and considers the EIS reported cost estimates to be low. GHD's estimates for capital costs are approximately $106 million for an urban supply dam and $162 million for a combined urban and irrigation supply dam in 2017 dollars (see Section 11.5). The estimate of capital cost includes:

- Dam construction
- Pipeline construction
- Construction of Stalling Lane Access
- Land acquisition
- Environmental works and investigation.

Annual operation and maintenance costs are estimated in the EIS to be $175,000 for the Urban Water Supply Dam and $610,000 for the Combined Urban and Irrigation Dam.

Detail on how costs are attributed to each element are not provided in the documentation reviewed. There is no information regarding costs attributed to mitigation, management and

[10] Source: http://statedevelopment.qld.gov.au/assessments-and-approvals/completed-eis-projects.html

offsets and proponent commitments as a result of the Coordinator-General and Commonwealth Minister's assessment and approval. The latter for example require additional investigations, surveys and studies to be undertaken, additional fish passage to be designed and installed on a weir elsewhere in the catchment, additional land assessed, acquired and managed for vegetation offsets, etc.

3.9.3 Emu Swamp Dam project departures

Changes to the proposed Emu Swamp Dam project from that described in the EIS and Supplementary EIS will require assessment.

Where the change is determined to be material additional approvals and amendments to approvals will need to be sought.

3.10 Dam engineering and design

The key reports considering dam engineering and design are:

- Water Resources Commission (1980), Water Resources Development Potential; Granite Belt Area (describes Quart Pot Creek Dam)
- SKM (2005a) Stanthorpe Water Supply Dam Options Review
- SKM (2007c) Emu Swamp Dam Design Report
- GHD (2010) Report for Petries Crossing Weir
- GHD (2011) Report for Storm King Dam Upgrade; Design Report

This section summarises the engineering considerations with respect to each dam site (Petries Crossing Weir, Raising Storm King Dam, Ballandean Dam, Emu Swamp Dam and Quart Pot Creek Dam).

3.10.1 Petries Crossing Weir

Petries Crossing Weir is proposed to be located on the Severn River and a 370 ML capacity storage was considered in SKM (2005a). The report by SKM concluded that, although this option was favourable in terms of the multi-criteria analysis, it was expensive per ML of yield. GHD (2012) considered a 4 m high weir and a 60 ML (5 m high weir) at crest level to facilitate the pumped harvesting of Severn River catchment stormwater runoff into an off-stream holding storage (not included in that project scope) which was intended to be used to supplement Stanthorpe's urban water supply.

A geotechnical investigation was undertaken (GHD, 2012) and boreholes located immediately below the existing Unolds weir revealed a fresh coarse-grained granite with tight subvertical to vertical joints, quartz veins and open subhorizontal to horizontal joints. Test pits were performed on the right bank of the Severn River in exposed medium to coarse grained sand (residual soils) overlying an extremely weathered granite. The depth to the extremely weathered granite within the three test pits varied from 0.3 to 1.3 m. Groundwater was not encountered. Geological mapping and scan line surveys, coupled with the joints encountered during the borehole drilling, is interpreted as three main joints (dominant horizontal to subhorizontal and two subordinate subvertical to vertical) plus a random set exist within the area. The geological features controlling weir stability and seepage are mainly the sub horizontal joints. Grouting will be required to reduce seepage rates under the weir.

GHD recommends that the upper slabs of rock be tied together with dowel bars to minimise the chance for slabs of rock to be plucked from the toe of the dam during floods and destabilising the structure.

Both SKM (2005a) and GHD (2012) considered a mass concrete weir at the site. This is appropriate based on the information reviewed.

3.10.2 Raising Storm King Dam

Raising Storm King Dam by 4 m was considered in the report by SKM (2005a). The existing dam is located on Quart Pot Creek east of Stanthorpe. A report by GHD (2011) assessed the stability of the dam for acceptable flood capacity. The study identified that to maintain stability during floods, 5 m to 6 m anchors would need to be installed and these were constructed in 2012.

A raising of Storm King Dam could be achieved by either a downstream raise of the existing dam with concrete or a new dam immediately downstream of the existing (SKM, 2005a).

As referenced in the GHD (2011) report, a report by SMEC (December 2009) recommends an acceptable flood capacity (AFC) of the 1 in 100,000 Annual Exceedance Probability (AEP) event based on a Population at Risk (PAR) of 98. According to Australian National Committee on Large Dams (ANCOLD) guidelines, the dam is assessed as having a Hazard Category of HIGH C. Consequently, the AFC has an inflow of 1,117 cumecs (cubic metres per second) and an outflow of 1,059 cumecs, with a reservoir level of 881.00 m. If the dam is raised, however, the PAR would increase, and it is likely that the AFC design flood would increase in magnitude. This would also require the increased use of anchors if a raising were to be achieved by a downstream concrete raise. In addition, an increase in the spillway width, or an auxiliary spillway, or a higher abutment (and therefore flood rise and additional land impacts) would likely be required to pass safely an increased design flood for compliance to AFC.

Geotechnically, the existing dam is located on granite. Test pits were excavated by GHD in July 2010 and mapped by an experienced engineering geologist. Measured foundation discontinuities were found to be generally very favourably orientated and that the granite foundations are very unlikely to fail through shearing or sliding on unfavourable joints.

An erodability assessment was also completed as part of GHD’s study (2011). This concluded that, while there is presently erosion on the upper right flank, it is unlikely to advance beyond the present depth of 1 to 2 m in the massive moderately weathered rock. Further, it was concluded that there was negligible likelihood of erosion of the Storm King Dam foundation undercutting the dam and compromising its stability. During the AFC upgrade design, no additional erosion protection was proposed.

GHD considers it likely that this conclusion would also remain true for a 4 m high raise, but the stream power increase, may result in a need for minor erosion protection, potentially in areas of rock joints.

Storm King Dam does not currently have a requirement nor infrastructure to release environmental flows. Given a Waterway Barrier Works approval would be required if the dam were to be raised, new outlet works and potentially new intake works would need to be constructed. This does make the construction complicated and likely to contain underwater work, which leads to both high risk and increased cost. A new dam downstream, removes the risk of underwater work.

3.10.3 Ballandean Dam

There is limited engineering information regarding Ballandean dam. Located on the Severn River, the SKM (2005a) report discussed a 3,750 ML capacity dam, 9.25 m high.

The site is narrow, located between two closely, spaced bluffs, described as granite in SKM (2005a). This is a distinct advantage of this site over others, because the risk cost of dam construction is in the foundations, either by excavation quantities and methods, or by grouting and securing water tightness. In addition, a much larger dam could be constructed at this site, and therefore cost per ML of yield could be economic, but SKM (2005a) nominated 1,500 ML/a yield as the project objective.

The dam is proposed to be a gravity concrete dam. No investigations have been undertaken to assess foundations nor construction materials for the site. No information is available regarding spillway sizing nor flood hydrology/hydraulics. No information is available regarding PAR, although a review of aerial imagery indicates this is likely to be low. Consequently, the hazard rating of the dam is likely to be High A, B or C in accordance with ANCOLD guidelines.

One of the disadvantages of this site is impacts on the New England Highway during extreme flood events. Earlier reports have also highlighted that a main fibre optic cable would also be impacted, but there is insufficient information regarding where and how this is impacted.

Engineering assessment of Ballandean dam site was not progressed as it was decided that Emu Swamp Dam, being closer to Stanthorpe, would be more economic. Previous reports also raise concerns about Ballandean Dam impacting on other infrastructure (i.e. the New England Highway and a fibre optic trunk main). Consequently, comparative statements regarding the suitability of Ballandean Dam are not available for dam sizes other than the 3,750 ML storage.

3.10.4 Emu Swamp Dam

The engineering aspects of Emu Swamp Dam are described in SKM (2007c). Two sized dams were assessed:

- Option 1: Full Supply Level of 738 m AHD[11], which provides 8,000 ML storage (described in the report as urban water only)
- Option 2: Full Supply Level of 740.5 m AHD, which provides 18,000 ML storage (described in the report as the combined urban and irrigation water)[12]

Emu Swamp Dam, located on the Severn River some 20 km south of Stanthorpe is proposed as a gravity dam using roller compacted concrete with a central overflow spillway.

The report noted that the geotechnical investigation found that '*while the quartz monzonite foundation was competent, the bedrock is jointed and will require foundation grouting to reduce foundation seepage*'. It was noted in the Emu Swamp Dam Site Preliminary Geotechnical Investigation Report (URS 2006) that quartz monzonite is suitable for rip-rap, concrete aggregate and filter material but the rock strength results does not indicate that this is the case. This may be a key deficiency.

The Emu Swamp Dam Flood Hydrology and Failure Impact Assessment – Hydrologic Modelling Report (Rev 1) (SKM, 2007e) was undertaken with sound methodology of the day, however a further 10 years of flood data has been added to the historic record including significant floods of record, which can influence the calibration of the hydrological model and impact on flood frequency estimates. Further, the Australian Rainfall and Runoff (the principal flood guideline in Australia) has recently undergone a major upgrade and may influence results (Ball et al., 2016). Estimates of population at risk may also have changed, although a review of aerial imagery indicates this is unlikely.

The design report (SKM 2007c) does not describe the methodology of the design and therefore comment on the adequacy of the design is not possible. However, GHD considers that the design generally aligns with standard practice.

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[11] AHD = Australian Height Datum
[12] Note: These FSLs are different to those specified in the EIS (SKM 2008a)

Three options were considered in the design report for the design of fish passage infrastructure; however, no option was designed specifically for the site. A fish lock was recommended, but this infrastructure does not operate well over a headwater or tailwater range above about 6 m. Given the headwater will be greater than 6 m, either a complicated system or a number of fishlocks would be required. This remains an issue to be resolved.

3.10.5 Quart Pot Creek Dam

Quart Pot Creek Dam is described in Water Resources Commission (1980). The dam site is located on Quart Pot Creek and is proposed as an earth and rockfill dam with a central overflow spillway. Two sized dams were considered:

- Full supply level of 856.0 m (datum not defined) some 21 m above the stream bed level with a capacity of 2,900 ML
- Full supply level of 860.4 m (datum not defined) some 25.4 m above the stream bed level with a capacity of 8,060 ML

In the report, it was decided at the time that The Broadwater was a better dam site and as such, the engineering for Quart Pot Creek was not progressed.

3.11 Pipeline system engineering and design

There is little information regarding the distribution system (pipelines) for the proposed dams in previous reports and almost no information at all regarding pump stations and storage tanks required for the proposed system.

The two main documents with robust information are:

- Sustainable Development Investment Portfolio (SDIP) (2014) provided a schematic for the Emu Swamp Dam option with the proposed pipeline routes designed for urban and irrigation demand. Pipelines routes were based on pre-concept design alignments associated with the Emu Swamp Dam proposal.
  - The proposed urban pipeline would extend 23 km to connect with the Mount Marley Water Treatment Plant and would traverse along Fletcher Road, the New England Highway, several other existing road reserves and short sections of private land.
  - The proposed irrigation pipeline would be supplied by the urban pipeline and would extend 102 km along existing road reserves with some short sections crossing through private land.
- R. Vosloo (2017) prepared a desktop route analysis for the upgrade of the trunk main from Storm King Dam to the Mount Marley Water Treatment Plant. The preferred option No. 1 follows an existing easement and assumes the new pipeline will be constructed next to the existing pipeline and within the same easement with a total length 8,940 m. The hydraulic calculations were based on a flow rate of 62.67 L/s (based on a very high population growth forecast). The alignment is considered appropriate and will be taken into next phases of assessment.

GHD recommends using both alignments to create relevant geographic information system (GIS) files and digital data associated with both pipeline routes in refining and consideration of the Emu Swamp Dam and Storm King Dam options.

3.12 Major gaps in previous works

The water needs for the Stanthorpe (Granite Belt) region and options to supply those needs have been studied for many years. However, from the analysis of previous reports it is apparent that many of the reports have been developed with an emphasis on one potential solution, Emu

Swamp Dam, and only this option has been analysed in any detail, including with respect to design concepts. All other options were considered at a superficial level.

There are also significant inconsistencies between the different reports in terms of assessment criteria, such as potential yield from different options, making it again difficult to compare options directly as described and analysed in previous reports and to draw definitive conclusions as to a preferred option. In particular, GHD finds that the yield analysis and assessment, in general, has not been consistent in terms of the modelling method used as well of the yield definition applied. This makes it difficult to compare yield assessment for different options between and within earlier reports. For example a term 'safe yield' has often been applied in the reports reviewed, whereas the Water Services Association of Australia (WSAA) has, since circa 2005, recommended that yield be specified for a given monthly and annual reliability figure to allow direct comparison between estimates.

Equally, GHD considers that the basis and techniques used for development of cost estimates in many of the reports has not been consistent and rigorous (given the high-level nature of the reports). For example, GHD would have expected to see concept designs for different dam wall heights, capacity and yields for a given average monthly reliability (say 96%) to have been developed such that the optimum dam height could be determined on a cost per ML of yield basis.

GHD also notes that many of the underlying assumptions and basis of earlier analysis have changed. In particular:

- Population growth in Stanthorpe has been significantly less than predicted in the mid-2000s, with current population being approximately half of what was predicted to eventuate at that time
- Average water consumption per capita is materially less now than was assumed to be the case in the mid-2000s. At that time an average consumption of 500 L/c/d was assumed whereas the current consumption is running at 324 L/c/d.
- GHD and DEWS demand forecasts project a shortfall of 250 ML/a by 2050, whereas earlier reports forecasts a projected shortfall in excess of 500 ML/a by 2050.

This is also the case for a number of the key assumptions underpinning the EIS and approvals for Emu Swamp Dam. In addition to the assumptions described above, GHD notes that assumptions around cost of demand side measures considered an avoided cost if Emu Swamp Dam was constructed underpinning the benefit cost ratio calculation in the EIS are materially higher than is the case now. If this analysis were undertaken now with current data, the benefit cost ratio for urban supplies would likely be less than "one."

Because of this, there has been an emphasis on Emu Swamp Dam as a solution at the expense of other options that, potentially, could meet the urban and irrigation need. For example, it is not clear to GHD why the Ballandean dam site was ruled out in earlier reports when, arguably, it is a better dam site than Emu Swamp Dam:

- It is lower in the catchment, but not sufficiently lower as to make distribution costs prohibitive over Emu Swamp Dam;
- Terrain is more conducive for dam construction with steeper side walls, particularly at the dam wall site (which infers less fractured base rock), that would result in a deeper dam with less surface area for a given capacity (leading to lower evaporation loss over Emu Swamp Dam);
- The costs of this dam are likely to be significantly lower than Emu Swamp Dam given the superior terrain and shorter dam wall.

In addition, GHD considers that lower cost options such as raising Storm King Dam coupled with integrated water supply management (water distribution leakage reduction coupled with demand side measures) have not been adequately considered.

The average consumption levels in Stanthorpe are materially higher than for other regions in South East Queensland and it is noted that water consumption bounced back significantly after the removal of Stage 6 (Stage 7 most severe for Brisbane) water restrictions. In the Brisbane and surrounding areas this bounce back did not occur, partly as a result of the water conservation measures (rain water tanks, efficient shower heads, changes in gardening practices) put in place that have resulted in permanent reductions in water consumption per capita. SDRC has advised that water conservation has not been promoted in the Southern Downs, nor is there a high awareness of water restrictions.

With respect to irrigation supplies, GHD considers that the option of auctioning water allocation to irrigators to enable greater surface water harvesting through increased on-farm storages has not been adequately considered in previous studies. On-farm storages provides the bulk of the water needs of irrigators, with the mean annual diversion for existing entitlements estimated at 20,700 ML. By comparison, the unallocated reserve nominated for irrigation supplies from the proposed Emu Swamp Dam is 1,750 ML i.e. less than a 10% increase (albeit at higher levels of reliability that from surface water harvesting).

3.12.1 Urban water demand and needs analysis

GHD has not identified any major gaps in any urban water demand and needs analysis, as the issue of urban water supply has been studied for many years by different sources.

Population projections, undertaken in previous reports, have been overly optimistic in comparison to the actual growth that has occurred causing overdesigning the forecast urban water demand for Stanthorpe.

Other than the Stanthorpe Regional Water Supply Security Assessment (DEWS 2015b), previous reports are now out of date in terms of population growth and urban water demand growth.

3.12.2 Irrigation water demand and needs analysis

Several previous studies have assessed demand for irrigation water for agricultural production in the region. Whilst these studies have found that agricultural producers in the region have an appetite for additional irrigation water, the studies have not been sufficiently robust to enable a decision to be made on whether to proceed with the construction of the dam, or an alternative option. This is largely due to the absence of any detailed assessment of the on-farm financial return from the use of additional irrigation water.

In contrast to the previous approach used to inform previous reports on projected irrigation demand and ability to pay, GHD's sub-consultant's (Synergies) approach is based on assessing the level of demand for additional irrigation water by conducting farm-level financial modelling for individual crops. Whilst stakeholder consultation is important in order to identify key inputs for the farm-level financial modelling, this approach enables a more robust assessment of the level of demand for irrigation water compared to methodologies that are solely reliant on stakeholder input.

The principle underpinning this methodology is as follows: For those crops that are identified as likely sources of demand for additional volumes of irrigation water, GHD estimates the net financial return from the use of additional volumes of irrigation water ($ per ML). This differs from previous assessments, which have derived estimates of demand for additional irrigation water based solely on producer responses.

3.12.3 Regional economic development potential (Industrial water demand)

As outlined above, there have been a number of past reports that have sought to forecast industrial water demand growth for the Stanthorpe region:

- the 2016 *Regional Water Supply Security Assessment* for Stanthorpe, prepared by Department of Energy and Water Supply (DEWS)
- a 2006 report by Sinclair Knight Mertz (SKM) titled “Stanthorpe Shire Water Opportunities - Urban Water Needs Analysis;
- the 2008 Environmental Impact Statement (EIS) prepared by SKM for Emu Swamp Dam

The reports by DEWS in 2016 arrived at a significantly different conclusions as to the likely demand from water intensive industry in the region from the earlier reports by SKM. Whilst SKM in 2006 projected strong growth with a number of water intensive industries identified as planning to establish in the region, the DEWS report forecast little if any growth in water intensive industry.

The key gap in the analysis to date is an assessment of whether growth in water intensive industries, forecast in the 2006 SKM report has not eventuated primarily because of a perceived lack of available water available to Stanthorpe or whether there are other market factors that have inhibited the growth of water intensive industries in the area.

3.12.4 Social Impact of water infrastructure investment

The majority of work done on potential water supply options for Stanthorpe have focussed more on the economic benefits and environmental impacts of various options than on the social impacts of any additional water sources identified. Adherence with the Building Queensland framework if the project moves the Preliminary Business Case phase will require a greater focus on the social impacts of any options under analysis.

Work done to date highlights that water supply has a significant social impact and that all options under consideration will have varying degrees of social benefit and dis-benefit. Significant assumptions have been made on the social benefits of an increase in the volume of urban water supply.

Previous works have failed to use benchmarking as a point of comparison. Comparing the degree of water stress and vulnerability in Stanthorpe to other areas in the Southern Downs Region, Queensland and Australia may enhance understanding of business case needs.

No analysis has been undertaken to date on the real and perceived impacts of permanent water restrictions on population growth and industrial development in Stanthorpe. Future population projections typically relied upon 5 and 10 year averages, which do not adequately reflect Stanthorpe’s ageing population and the potential for the death rate to exceed the birth rate (as has been the case in the last two years. Nor have forecasts taken into account that most new developments are on acreage that is not connected to the reticulated urban water system.

Additionally, assessments of regional development have not considered the impact of water restrictions on tourism and the tourist experience. However, in GHD’s forecast demand, GHD has assumed a conservative 0.95% growth rate per annum (Section 5).

The success of earlier water efficiency programs is absent in previous reports, and there is insufficient data detailing current patterns of household water use by category (i.e. shower, garden) and by age and income, which are useful in approximating approximate the success of demand reduction measures or the impact of water restrictions.

Whilst irrigator interest in obtaining additional and reliable water supplies has been studied extensively, (Tancred 1996, 2001a, 2001b, 2013, Unidel 2010, T Sargent 2013) the interest of urban users in obtaining additional water supplies has been overlooked. Earlier reports have also neglected to investigate the social acceptability of urban, industrial and irrigation options.

Finally, no alternative water supply options for gardening have been considered until recently, despite gardening constituting some 20-25% of domestic water use in Stanthorpe since 'Extreme' water restrictions have been lifted (MWH 2010)[13]. SDRC has advised that following Council's adoption of minutes of Council's Water and Advisory Committee of 17 February 2017, Council in the approaching financial year will seek to encourage water efficiency through providing homeowners who are on town water with a financial incentive to install a water tank. GHD understands that this is being listed in Council's revenue statement that is currently in the draft 2017-18 budget.

3.12.5 Water resource management and water products

The assessments of hydrologic yield and performance undertaken for the proposed Emu Swamp Dam utilised robust IQQM simulation and associated data inputs, and were assessed against water allocation security objectives and environmental flow objectives that are specified within the Water Plan. Similarly, the performance of the existing water supply system (utilising Storm King Dam) has been extensively examined using robust IQQM simulation and stochastic modelling.

The results of a similar standard of analyses for other potential water infrastructure supply options in the Stanthorpe region have not been undertaken. This means that it is potentially misleading to compare directly the recent hydrologic assessments relating to Storm King Dam and Emu Swamp Dam with earlier hydrologic assessments reported for other sites or proposals.

To address this gap, modelling of the hydrologic yield and performance of alternative water infrastructure proposals using a similar IQQM-based simulation and data inputs would be desirable.

In addition, it would be desirable to undertake a stochastic analysis to assess the underlying level of service that might be expected from the proposed Emu Swamp Dam infrastructure at the current and future levels of water demand.

3.12.6 Dams engineering and design

Broadly speaking, engineering designs have been progressed in an ad-hoc manner. Other than Emu Swamp Dam, where two full supply levels have been considered, there is limited information that enables an understanding of engineering issues, risk and limitations or an analysis of cost comparativeness, not only across sites, but also over a variety of dam heights.

The history of the assessments to date have defined a target yield, which has altered over time, for the associated dam capacity. It is normal practice in dams engineering, for options studies, that several full supply levels are studied, up to a limiting height of dam and yield applied such that a cost per ML per annum be derived for a true comparison of the capacity of a dam storage to provide a yield.

Further, no target reliability for yield has been set in the assessments in the form of a WASO or project objective to date, nor has EFO compliance been established. As such, decision making for cost per ML per annum yield on the basis of pervious analysis is not comparative between options because differences in reliability are also part of the equation.

The lack of consistent application of methodology to each site is also a gap in information.

[13] An assumption of 25% of domestic water consumption being for external use is typically quoted by the Water Services Association of Australia; derived from data published by the ABS (50% external use) and adjusted for changes in water consumption patterns post the 2006-9 drought.

Assessments have been completed over a number of years and some information, for example, flood hydrology assessments, becoming outdated with new technological and industry standards. The only dam engineering information that remains consistent is the survey and factual geotechnical/geological data.

For most of the dam sites, geological information is too high level to allow assessment or comparison of sites. As such, risks associated with potential excavation depths, failure planes, water tightness, erosion potential, and construction materials, all of which can significantly affect the cost of a dam, are not sufficiently defined.

3.12.7 Pipeline system engineering and design

Distribution systems (pipelines) have only been designed for the proposed Emu Swamp Dam (urban and irrigation) at pre-concept design configuration. None of the other proposed dams has information of pipeline routes, pump stations and storage tanks required for the proposed system. This will require a review and update of any options identified as part of the earlier studies to provide an up-to-date reflection of the costing, as well as the pre-concept design estimates of the Emu Swamp Dam, for the associated pump stations and pipeline infrastructure.

4. Stakeholder consultation approach and metrics

4.1 Overview of community engagement

4.1.1 Community engagement approach

Community and Stakeholder Engagement on the Emu Swamp Dam Business Case Feasibility Study aimed to ensure that stakeholders and the broader community were informed about project activities and were given opportunities to be actively involved in the assessment process. Undertaking this engagement process demonstrated the commitment to:

- Transparent communication of the assessment process and engagement opportunities to stakeholders and the community, building strong relationships and providing realistic expectations
- Identify and manage risks and opportunities through effective stakeholder management activities
- Identify and engage with stakeholders that will inform the feasibility analysis in a way that provides rigour and validity to the assessment process
- Provide stakeholders and community members with an equal opportunity to be informed and engage in the project
- Provide confidence to all interested and affected stakeholders, including those that disagree with the final decision, that the business case has been independently developed by rigorous and robust analysis and is thoroughly substantiated.

This project has previously been a sensitive and contentious issue for Council, as the reliability of water supply for both urban and rural use demands is critical. Testing the feasibility of Emu Swamp Dam required the understanding of a complex mix of community attitudes, perceptions of capital providers (Government, private investors and banks), Government policy frameworks and other commercial interests

Community and Stakeholder Engagement was broken down into two components:

1. Communication and stakeholder management

Communication and Stakeholder Management aimed to inform stakeholders and the community about the project and the processes involved in the assessment, to publicise and encourage participation in the stakeholder consultation activities, and to manage stakeholder issues and media enquiries.

2. Stakeholder consultation

The community consultation component for this project aimed to engage stakeholders and community members on the process involved in the analysis of the Emu Swamp Business Case, as well as gathering feedback from key stakeholders to inform a robust and substantiated analysis.

4.1.2 Stakeholder identification

The scope of this study included the residents, landowners, stakeholders, and industry and agriculture businesses within the Southern Downs region, which have potential or interest to be serviced by water supply from the Emu Swamp Dam. The study focused on the key town centres of Stanthorpe and Warwick and the surrounding regional areas.

GHD identified key stakeholders that were in positions of providing feedback that will assist in informing a robust and substantiated analysis. This included local businesses, irrigation-farmers and water intensive industry stakeholders.

4.1.3 Community engagement activities

Community and stakeholder management

GHD undertook the following activities as part of the communication and stakeholder management component of this project. In undertaking these activities, GHD has endeavoured to avoid bias and sought a broad cross section of input.

Website

A project website was established and managed from the initiation of this project. It provided information on project updates, engagement opportunities, details on project events, and project contact details. The website was publicised through social media, the community service announcements on radio and in local radio.

Social Media

GHD established the Facebook page "Emu Swamp Dam Business Case Feasibility Study" and used to encourage participation in engagement activities, such as the Irrigator Focus Groups, and publicise the Information Sessions.

Several posts and the two events created for the Information Sessions were boosted to reach a wider audience, targeting people aged 18 – 65+ within a 40 km radius of both Stanthorpe and Warwick.

Community Service Announcements

GHD employed Community Service Announcements over radio to encourage participation in engagement activities, such as the Irrigator Focus Groups, and publicise the Information Sessions. Both Rainbow FM and Ten FM had 30-second announcements on rotation throughout the week leading up to the Information Sessions and Irrigator Focus Groups.

Local Newspaper

GHD used local newspaper editorials to encourage participation in engagement activities, such as the Irrigator Focus Groups, and publicise the Information Sessions. Two editorial pieces were included in the Stanthorpe Border Post and Warwick Daily News leading up to the Information Sessions and Irrigator Focus Groups.

Information Sessions

GHD held information sessions in Stanthorpe on 26 April 2017 and Warwick on 27 April 2017. It provided a chance for stakeholders and community members to learn about business case feasibility study process and an opportunity to discuss any issues and concerns with the project team and Council. Stakeholders and local residents were informed through social media, community service announcements, local newspaper pieces and email updates.

Email Updates

GHD used email updates as a communication channel to inform stakeholders about engagement opportunities. Council provided the project team with a contact database of over 100 local farmers that use irrigation water. Forty-three people registered their email addresses website and through the online survey and a further 35 people registered their email addresses at the Information Sessions.

Stakeholder consultation

Water Irrigation Online Survey

GHD developed and used an online survey to seek interest in the focus groups, as well as gathering data to be used during the irrigation water demand analysis. The surveys were distributed to the contact database provided by Council with over 100 local farmers that use irrigation water.

Focus Groups

GHD held two focus groups on 19 April 2017 with local farmers who use irrigation water. These focus groups gathered in depth feedback used to assist in the irrigation water demand assessment. Over 100 local farmers were invited to attend, with information about the focus groups distributed to the contact database provided by Council.

One on One Interviews

GHD interviewed local farmers and water intensive industry stakeholders by telephone or through face-to-face meetings as part of the regional water demand assessment.

Telephone Surveys

Local businesses in Stanthorpe were interviewed to gather in depth feedback used to assist the water demand assessment, local sentiment towards water restrictions and any potential opportunities for regional growth with greater access to a reliable water source and 150 local businesses were surveyed over the phone.

Information Sessions

GHD held information sessions were held in Stanthorpe on 26 April 2017 and Warwick on 27 April 2017. These a chance for a broad group of stakeholders and community members to learn about business case feasibility study process and an opportunity to discuss any issues and concerns with the project team and Council.

Stakeholders and local residents were informed through social media, community service announcements, local newspaper pieces, direct email and telephone using contact lists provided by SDRC and the Stanthorpe Community Reference Panel.

In addition, the irrigator and industry consultation process was promoted with the support of the Stanthorpe and Granite Belt Chamber of Commerce. GHD used contact lists for irrigation and industry stakeholders provided by both SDRC and the Stanthorpe and Granite Belt Chamber of Commerce to identify affected and interested members of this stakeholder group.

4.2 Community engagement metrics

GHD used feedback from stakeholders and community members gathered during community engagement activities to provide input into the analysis as part of the Emu Swamp Dam Business Case Feasibility Study. Metrics and the level of engagement for each activity can be found below in Table 4-1. The feedback and input assisted in ensuring a robust and substantiated analysis. Details from the feedback and input received from key stakeholders can be found in the Urban Water Demand Assessment and the Industrial and Irrigation Water Demand Assessment.

Table 4-1 Engagement metrics

Activity	Level of engagement

Social media	2,551 people were reached by project update posts and events for the Information Sessions on Facebook 86 people engaged with the project update posts and events for the Information Sessions on Facebook
Community Service Announcements	30 second announcements on rotation throughout the week leading up to the Information Sessions and Irrigator Focus Groups
Local Newspapers	Two editorial pieces in local newspapers leading up to the Information Sessions and Irrigator Focus Groups
Information Sessions	40 people attended the Information Session in Stanthorpe on 26 April 2017 7 people attended the Information Session in Warwick on 27 April 2017
Email updates	123 people were emailed project updates, encouraging them to participate in the engagement activities and publicizing the Information Sessions
Irrigator and water intensive industry approaches	137 irrigators and other water intensive industry and representatives were approached directly either by email or via telephone calls and invited to take part in an online survey, attend focus group discussions and or engage in one-on-one interviews
Online Irrigation Survey	12 people participated in the survey
Focus Groups	8 people attended the focus groups
One on One Interviews	8 people were interviewed
Telephone Surveys	150 local businesses completed telephone surveys

GHD considers that the number of contacts made with stakeholders and the process of holding in-depth focus groups and on-to-one discussions together with the level of representation are such as to make the resulting responses and detailed data gathered to be robust, valid and representative. Equally, the sample size of the telephone survey is statistically valid.

GHD has used the information gathered through the consultation process, together with data drawn from previous surveys and reports and public domain information to inform the urban water demand assessment and industrial and irrigation water demand assessments (Section 5 and Section 6 respectively).

5. Urban water demand assessment

5.1 Introduction

The issue of urban water supply to Stanthorpe has been critical to all the previous planning, economic and approval documents. Within the historical documents reviewed, there is a significant variation in both the necessity and timing of the need for a supplementary water supply for Stanthorpe. Expected population growth has been a critical dependency identified in previous studies. A Strategic Review of Stanthorpe's historical population and urban water demand forecasts is included in Appendix E. The ensuing section provides a broad overview.

5.2 Background

Stanthorpe's sole source of water supply is Storm King Dam, which is at times at risk of depletion, requiring the imposition of restrictions on water use for significant periods. Any further growth in demand will result in increased periods of restrictions unless the supply is augmented. Refer to Section 10.1 regarding the effectiveness of past water restrictions.

GHD presents analysis of water demand from urban water users connected to the reticulated system and water dependent industries in the following sections.

The intent of the assessment is to identify urban water use and forecast future water demand over the next 50 years for the Stanthorpe area.

5.3 Current water supply system to Stanthorpe

SDRC operates water supply schemes for the towns of Stanthorpe and Wallangarra. Water supply for Stanthorpe is obtained from Storm King Dam (approximately 8 km southeast of Stanthorpe) and Wallangarra obtains its water from two council water storages, the Beehive Dam and The Soak.

SDRC holds a water licence with a volumetric limit of 1,150 ML/a for extracting water from Storm King Dam, and uses this to supply Stanthorpe's urban water demand.

Water extracted from Storm King Dam is transferred by pipeline approximately 7 km for treatment at the Mount Marley Water Treatment Plant, located on the eastern outskirts of Stanthorpe. From there, treated water is delivered to the town's reservoirs and distributed to customers via the reticulation system.

The current water supply system to Stanthorpe consists of (Munro Johnson & Associates. 1984):

- Storm King Dam. The dam is an un-reinforced mass concrete gravity structure. The dam has a storage capacity of 2,180 ML with a catchment area of about 91 km^2. Under normal conditions, water can be extracted from this storage down to a minimum operating volume of 200 ML, providing a useable storage volume of 1,980 ML. There is 21.9 m available head between the FSL of the dam and the top water level (TWL) of the water treatment plan inlet level. The dam wall height is 9.5 m.
- Trunk main (constructed 1954) from Storm King Dam consists of approximately 3,660 m of DN300 ductile iron pipe (DICL) pipe and 5,095 m DN250 DICL pipe. Flow in the pipeline is normally by gravity. Flows through the pipeline at times of high demand are boosted by pumps at Storm King Dam. The pipeline has experienced a number of pipe breaks resulting in interruptions in supply. Vosloo Consulting Engineers prepared a planning report (R. Vosloo 2017) based on a DN300, 8,940 m long pipeline following the existing easement, that could be supplied by gravity for flow rates:

- Less than 48.65 L/s and dam at low level (reduced level (RL) 872.685)
- Less than 73.37 L/s when dam is full (RL 878.78)

- Booster pump station located at Storm King Dam (approx. 72 L/s and max. demand 7.09 ML/a), which deliver the raw water to the water treatment plant.
- Series of reservoirs: Sentimental Rocks (0.9 ML), Showground (0.9 ML), Mayfair Lane (0.045 ML), Mount Marley Water Treatment Reservoir (2.275 ML).
- Mount Marley Water Treatment Plant. The water treatment process comprises flocculation, clarification, filtration and disinfection. The plant produced between approximately 270 ML and 400 ML of recycled water per year from 2010–11 to 2014–15, and in 2015 produced an average of about 1.08 ML/day (DEWS 2016).
- Reticulation (not part of the scope). Areas of low flow and/or pressure have been recognised by Council as reticulation problems to be addressed in future developments (MWH 2010).

5.4 Population

5.4.1 Previous studies

Expected population growth has been a critical water demand dependency identified in previous studies. The purpose of this section is to review issues regarding expected population growth in Stanthorpe and subsequent urban water demand.

Population demographics in the time-period since 2006 are presented in the following table.

Table 5-1 Population of Stanthorpe by year (Actual)

Year	Population	Annual Population Change
2006	4770	-
2007	4845	+75
2008	4888	+43
2009	4946	+58
2010	5002	+56
2011	5086	+84
2012	5125	+39
2013	5135	+10
2014	5186	+51
2015	5174	-12
2016	5159	-15

Source: Queensland Government Statisticians Office. (2016).

From the above table, the population growth has been relatively minor over the past ten years and exhibited a negative trend in last two years.

The 1997 Water Headworks Strategy Study for Stanthorpe (SKM 1997) presented the following population projections, which are shown for comparative purposes below.

Table 5-2 SKM 1997 Stanthorpe population projections

Year	Projected Population
1996	5,085
2005	5,845
2015	6,824
2025	7,996

The projected population of 6,824 in 2015 was 32% greater the actual population figures.

The initial advice statement prepared by SKM in 2006 (based on three growth scenarios) is presented in the following table.

Table 5-3 SKM 2006 initial advice population projections

Year	Low Growth Scenario	Medium Growth Scenario	High Growth Scenario
2005	5,485	5,484	6,160
2010	5,692	5,956	6,727
2020	6,105	6,642	7,583
2030	6,521	7,455	8,566
2040	6,938	8,361	9,642
2050	7,359	9,390	10,841

The medium and high growth population scenarios were considered conservative (on the low side p.35) on the basis that they were constructed on a declining growth rate rather than the higher annual growth rate that was occurring at the time the report was delivered. The high population growth projection for 2010 was 34% higher than the actual population in that year (SKM 2006).

Projections of population growth by the Queensland Government Statisticians Office for the Stanthorpe Statistical Area Level 2 (SA2), which takes in an area slightly larger than the town boundaries indicates that as of the 30 June 2016 the estimated resident population was 5,596 persons and that projected population of the area is expected to be 6,064 persons in 2036. This population estimate was based on an increase of 0.4% per year over 25 years (Queensland Government Statisticians Office, 2017b).

The Department of Energy and Water Supply completed a Regional Water Supply Security Assessment (RWSSA) for Stanthorpe in 2016 (DEWS 2016) that is considered the most robust and reliable data in comparison with previous reports mentioned above. Data from this report has been used for the water consumption assessment in the following sections.

5.4.2 Population growth

DEWS (2016) presented the updated population statistics for Stanthorpe, including Applethorpe, which is summarised in Table 5-4.

Table 5-4 Stanthorpe and Applethorpe historical total population

Town	2011	2012	2013	2014	2015
Stanthorpe	5,523	5,565	5,579	5,626	5,703
Applethorpe	476	469	465	461	465
Total	**5,999**	**6,034**	**6,044**	**6,087**	**6,168**

The RWSSA assumed that any future growth in water demand will be approximately proportionate to population growth and, as such, growth in water demand from industry will be reflected in the growth figures for urban water demand.

It has been assumed that the population will increase 0.95% per annum in the future for the larger Stanthorpe area based on the DEWS (2016) report.

The projected population by 2050 for Stanthorpe has been based on the above growth rate and population shown in Table 5-4 with forecast presented in Table 5-5 (end of June data).

Table 5-5 Forecast population

	Total projected population	Total projected serviced population
2015	6,168	**5,119**
2016	6,249	**5,187**
2021	6,549	**5,436**
2026	6,864	**5,697**
2031	7,194	**5,971**
2036	7,540	**6,258**
2041	7,902	**6,558**
2046	8,281	**6,874**
2050	8,600	**7,138**

There is no indication that there will be an increase in the proportion of the population connected to the reticulation network in coming years, as some of the growth that is occurring is in areas not connected to the reticulation network, such as ‘lifestyle blocks’.

GHD has therefore estimated that the total projected future population by 2050 will be 7,138.

5.5 Historical water consumption in Stanthorpe

Population growth, average water use per person and the yield from the existing Storm King Dam have been central to the various business cases and planning documents assembled in relation to the urban water supply.

The SKM (1997) report for Stanthorpe presented the following table of historical water consumption in Stanthorpe from 1966 to 1992.

Table 5-6 Stanthorpe historical water consumption

Year	Annual Consumption (ML)	Average Day – AD (kL^)	Population	AD (L/p/d)
Pre-metered				
1966	664	1,820	3,641	500
1971	718	1,970	3,602	547
1976	717	1,960	3,927	500
Metered				
1981	556	1,520	3,966	383
1986	797	2,180	4,408	495
1988	695	1,900	4,493	423
1992	705	1,930	5,150	375

^ Kilolitre

The DEWS (2016) report presented a more updated historical water consumption from 2008 to 2015 shown in the table below.

Table 5-7 Recorded water consumption

Year	Recorded Water Consumption (ML/a)	Average daily demand (L/p/d)
2008-2009	530	299
2009-2010	530	320
2010-2011	530	292
2011-2012	586	321
2012-2013	599	327
2013-2014	696	377
2014-2015	620	332

5.6 Water restrictions and annual daily usage

Water restrictions are central to the security of supply to Stanthorpe. The following table shows the level of water restrictions imposed at various dam levels based on the DEWS (2016) report.

Table 5-8 Stanthorpe's water restriction levels

Restriction level	Supply trigger levels (% of full supply volume)	Targeted maximum daily residential consumption (L/p/d)
Permanent	75% and above	230

Medium	70% (or below) Relaxed when volume increases to 75%	200
High	50% (or below) Relaxed when volume increases to 55%	170
Extreme	30%(or below) Relaxed when volume increases to 35%	140

According to DEWS (2016), average water demand per person was 324 .L/p/d. This includes residential, commercial, municipal and industrial water supplied from the reticulation network, plus any system losses.

The average residential water use over the period 2008-09 to 2014-15 was approximately 213 L/p/d (DEWS 2016). The 213 L/p/d is relatively high in comparison to South East Queensland. The following table shows the residential water consumption in various zones in South East Queensland[14].

Table 5-9 Residential water consumption in SEQ

Zone	SEQ	Central SEQ	Gold Coast	Redland	Scenic Rim	Sunshine Coast
Average daily residential consumption (l/p/d) April 2016	172	168	185	189	119	177
Average daily residential consumption (l/p/d) April 2017	167	157	192	177	100	188

Guidelines on SDRC website outline allowable activities under each level of restriction and provide a series of fact sheets on water savings. Given the differential between average individual daily water use in Stanthorpe with permanent water restrictions and other comparable areas within South East Queensland with no water restrictions there appears scope to further reduce individual consumption (through demand management initiatives) to maintain storage levels in Storm King Dam and extend supply. It is noted that whilst water restrictions are in place SDRC has advised that there is little knowledge or enforcement of the restrictions in the community.

5.7 Projected urban water demand

The Statewide Water Information Management database (SWIM) database contains the most up to date water demand data., Based on this data DEWS proposes that the derived population for the period 2008–09 to 2014–15 of 324 L/c/d be adopted to project the urban water demand for Stanthorpe's reticulation system. GHD supports this approach and has used this data to forecast future urban water consumption.

Projections for each of the ten-year design horizons from the year 2016 to the year 2050 are detailed in Table 5-10 and figures are based on the following assumptions:

[14] Seqwater: www.seqwater.com.au/

- Forecast future water demand over the next 50 years (agreed 2050) – DEWS (2016) report only covers until 2036

- Any future growth in water demand will be approximately proportionate to population growth

- The average per capita water use adopted is 324 L/c/d base on recorded total water consumption (residential and non-residential) and population during the period – DEWS (2016)

- The water use by businesses/industrial is accounted for within the total urban water demand.

Table 5-10 Urban water demand projection

	2016	2026	2036	2046	2050
Population	5,187	5,697	6,258	6,874	7,138
Consumption (@324 L/c/d) (L/d)*^	1,681000	1,846,000	2,028,000	2,227,000	2,313,000
Urban Water demand AD (ML/a)	613	674	740	813	**844**
Urban Water demand AD (L/s)#	20	21	23	26	27

*Based on findings from DEWS 2016
^Numbers rounded to nearest thousand.
Numbers rounded to two significant figures

The main industries in Stanthorpe are in the areas of: agricultural support industries; health care and social assistance; financial and insurance services; construction; retail; rental; hiring and real estate services. These businesses are generally of a smaller scale, consistent with most urban areas, and there are no major industrial users of water in Stanthorpe.

Over the period 2008–09 to 2014–15, the combined industrial, commercial and municipal water use in Stanthorpe constituted on average about 30% of Stanthorpe's total water demand. The water use by these businesses is accounted for within the total urban water demand.

5.7.1 Small business and domestic consultation

A telephone survey of local businesses in the Stanthorpe region was conducted to develop an understanding as to whether increased water supply would contribute to economic growth that is more businesses attracted to the region, and hence increase urban demand[15].

The survey shows that only 44% of Stanthorpe respondents and only 19% of respondents in surrounding areas indicated that if water restrictions did not exist or if more water was available then they would anticipate economic growth in the region. When asked about the impact of water restrictions, some 49% of Stanthorpe respondents indicated that they considered that business in Stanthorpe was impacted by water restrictions.

Given that there is a five percent error in the survey, these results indicate that the current level of water supply is not seen as the primary inhibitor to business growth and that an increase in water supply would not necessarily support business growth or attracting new businesses to the area.

[15] See Appendix C

When asked would they like to see population growth to support economic growth in the area 87% responded that 'yes' they would. This result indicates that business owners support growth in the area but, when coupled with the less than 50% response indicating that water availability is an inhibiting factor, GHD concludes that business owners consider that there other factors, and potentially more important than water, that influence economic growth.

Conclusion

These results indicate that business owners in the region do not consider that economic growth primarily depends on an increased availability of water. Given this, GHD considers that greater availability of water will not result in material rises in water consumption amongst the small business and domestic sector and hence an urban water demand forecast based on trend growth patterns is appropriate.

5.8 Storm King Dam

Storm King Dam was constructed in 1954 with a storage capacity of 2,180 ML and has been the major source of water supply for Stanthorpe. The total average volume of water sourced from Storm King Dam to supply Stanthorpe over the 7 years from 2008-09 to 2014-15 averaged 590 ML/a (ranging from 530 ML/a to 696 ML/a) which is 47% of the 2015 demand predicted in the 1997 SKM (1997) study. Average usage over the same period was 324 litres per person (L/p/d) which is 65% of the average demand used in the 1997 study.

The reliability of Storm King Dam and water security for Stanthorpe has been highlighted in many of the planning and approval documents. SDRC holds a water licence with a volumetric extraction limit of 1,150 ML per annum (ML/a) (DEWS 2016). The relatively small storage capacity of Storm King Dam means it is vulnerable to extended dry periods, although Storm King Dam has never run out of water and hence has always been unable to supply Stanthorpe.

There are only a few licences that authorise the take of water from the catchment area of Storm King Dam, each of which is for a relatively small volume of water for agricultural or irrigation purposes. GHD does not consider these to have a significant impact on Stanthorpe's water supply security (DEWS).

Yield estimates were determined in 1997 by SKM for the Storm King Dam indicated that 990 ML/a is reliably available. It also estimated a reduction in reliable yield based on existing drought conditions (at the time) to 792 ML/a as shown in Table 5-11 below.

Table 5-11 Storm King Dam yield

Storm King Dam	ML/a
Water licence - Urban	**1,150**
Yield estimates 1997	990
Yield estimates 1997 (reduction for current drought)	792
Average Volume of water sourced 2008–09 to 2014–15	590

The Queensland Coordinator General's evaluation report (SDIP 2014) identified that Stanthorpe's projected water demand would exceed the existing Storm King Dam water allocation (reported at 700 ML per annum) by 2016 and continue to increase to 952 ML per annum by 2056.

Table 5-11 shows that the volume of water sourced from Storm King Dam for the reticulation network over the 7 years from 2008–09 to 2014–15 averaged 590 ML/a (ranging from 530 ML/a to 696 ML/a) (DEWS 2016).

The following Table 5-12 shows the IQQM data included in the SKM 2007 report regarding the reliable percentage per annum.

Table 5-12 Storm King Dam IQQM results*

Storm King Dam	Dead storage ML	IQQM Mean Annual Diversion ML/a	IQQM Monthly Reliability %
9.5 m wall height (storage volume 2,300 ML)	730	654	94
13.5 m wall height (storage volume 7,300 ML)	730	846	94

Based on the assessment presented in sections above, GHD has estimated the proposed forecast urban water consumption by 2050 to be 844 ML/a (26.77 L/s) refer Table 5-10. Based on the IQQM simulation results this demand could be met by Storm King Dam by raising the wall 4 m with a 94% reliability.

The most recent water supply security assessment for Stanthorpe completed by the Department of Energy and Water Supply (DEWS 2016) presents a divergent position on both the reliability of Storm King Dam and the demand for urban water in Stanthorpe. Key findings from the report are summarised in the dot points below:

- There has been no supply failure to date from Storm King Dam, however there have been frequent water restrictions in place
- Urban water demand is expected to increase to 740 ML/a by 2036
- Historic modelling also indicated that Storm King Dam would have been capable of meeting a demand of 740 ML/a without experiencing a shortfall with water restrictions in place. Without restrictions the storage would have fallen below its minimum storage level on at least three occasions
- As water demand increases in line with population the occurrence of high level water restrictions will increase in frequency. At current levels of demand, high levels of water restrictions are expected to occur approximately once every 10 years. At predicted 2036 levels of demand the frequency of restrictions increases to once every 6.4 years on average.

5.9 Conclusions

Based on the information presented in this chapter GHD concludes that:

- Population growth in urban areas of Stanthorpe has been limited over the past ten years. Population growth has been slightly negative over the past two years
- Projections of population growth in Stanthorpe undertaken in previous planning and business cases have been significantly higher in comparison to the actual growth that has occurred
- Rates of population growth used in previous planning studies (1.5%) have been far greater than actual population growth (0.4%). Recommended 0.95% has been used to update the projected population growth
- Rates of water usage used to determine future demand (500 L/p/d) are far greater than recent historical averages (324 L/c/d). The 324 L/c/d has been used to update the water urban demand forecast

- As population increases the occurrence of water restrictions will also increase
- Current per person daily usage is higher in Stanthorpe than in other comparable areas in Southeast Queensland
- Overall water demand for Stanthorpe has been far less than predicted in previous studies (1,246 ML/a predicted for 2015 versus 590 ML/a actual). GHD's forecast of water demand by 2050 is 844 ML/a. This is consistent with the most recent forecast by DEWS. On this basis, and using a supply capacity of 600 ML/a from Storm King Dam (at circa 98% average monthly reliability), an additional circa 250 ML/a supply capacity is required by 2050 to meet demand and avoid the need for water restrictions.
- There are significant variations in the planning and business case documents regarding the reliable long-term supply baseline of the existing Storm King Dam. The current assessment is that 654 ML/a can be supplied at a reliability of 94%
- Storm King Dam is capable of meeting a demand of 600 ML/a (at 98% reliability) without experiencing any periods of water supply shortfall (with or without water restrictions)
- Water restrictions are central to meeting supply objectives over the longer term for the sustained supply from Storm King Dam

Section 10.1 of this report examines in detail options including water restrictions and other water consumption reduction/demand management options.

6. Industrial and irrigation water demand assessment

6.1 Introduction

In this section, GHD summarises its assessment of the agricultural and industrial water demand that could potentially be met by the proposed Emu Swamp Dam. This work was undertaken by GHD's sub-consultants, Synergies, a firm of economic consultants specialising in the water and irrigation sector. The dam has a storage capacity of approximately 10,500 ML, with an estimated combined (urban and irrigation) yield (96% monthly reliability) of 2,418 ML per annum of which approximately 1,700 ML per annum high priority water is reserved for irrigation supplies. The purpose of this section is to provide a robust assessment of agricultural and industrial demand for water within the proposed irrigation distribution system coverage area (dam supply footprint) to inform the Strategic Assessment of the project.

6.2 Agricultural water demand

The principle underpinning GHD's sub-consultant, Synergies', methodology for assessing demand for irrigation water is as follows:

For those crops that are identified as likely sources of demand for additional volumes of irrigation water, Synergies has estimated the financial return from the use of additional volumes of irrigation water ($ per ML) net of all costs incurred in the expansion of production (including crop production costs and on-farm capital infrastructure costs).[16]

This represents the upper bound of what producers would be able to pay (in total) for additional irrigation water entitlements. It is important to note that this estimate does not necessarily represent the upper bound of what irrigators are willing to pay. The latter is likely to be lower than the derived estimates due to the other factors that producers take into account when determining what they are willing to pay for water entitlements (e.g. irrigation prices in other jurisdictions).

This is also supported by the review of previous studies and reports relevant to the project.

The key steps for the agricultural demand assessment are as follows:

- Establish the current irrigation water supply-demand situation within the dam supply footprint
- Review financial crop production information
- Consult with producers[17] in the dam supply footprint
- Develop farm-level financial models for individual crops and estimate the total returns to additional irrigation water for each crop.

In relation to current irrigation water supply and use in the Southern Downs, GHD and Synergies make the following observations:

- Producers are currently reliant upon on-farm storages and the harvesting of overland flows and the intersection of near-surface groundwater resources for irrigation water supply

[16] The total return to irrigation water is calculated by applying a discount rate commensurate with producers deriving a commercial return from irrigation water entitlements.
[17] Predominantly horticultural.

- The volume of irrigation water to be made available by the construction of the proposed Emu Swamp Dam would represent a relatively marginal increase (estimated at less than 10%) in total irrigation water use in the region and as such is more likely to supplement water supplies of established producers as opposed to being used by greenfield producers to meet base water requirements. In short, the additional water will be predominantly used for ‘stand by and top up’ purposes to cover periods of drought and for the incremental expansion of crop production by established producers
- The thinness of water trading markets in the region, including in the Stanthorpe Water Management Area, means there is little price information for water that would otherwise reveal how much producers are prepared to pay for water
- There is significant variability in irrigation application rates across crops produced in the region (3 to 12 ML per ha)
- Access to suitable land is unlikely to represent a constraint on the expansion of crop production in the region.

GHD, together with its sub-consultant, Synergies, conducted consultation with producers in the Southern Downs region through three streams –

- Focus groups,
- An internet-based survey,
- One-on-one telephone interviews.

The key outcomes from the consultation were as follows:

- Water availability is a significant constraint on crop production in the region, particularly in relation to tomatoes, strawberry runners and strawberries;
- Market factors (e.g. insufficient demand, competition from other regions) are the other major constraint on production, particularly for apples, other tree fruits, wine grapes and a range of vegetable crops;
- Consistent with the results of the 2013 agricultural land audit, producers confirmed that they have access to significant areas of additional land (at minimal cost) for the expansion of crop production;
- Additional volumes of irrigation water, either from a dam or other means would be used to supplement existing irrigation water supply sources in the region (i.e. on-farm storages) rather than to underpin new greenfield developments (as opposed to existing farm expansion/use of currently uncultivated farming land);
- There is a significant desire for additional volumes of irrigation water from producers of a wide range of crops, including apples, tomatoes and capsicums, strawberries, wine grapes, strawberry runners, green vegetables and specialty crops (e.g. vegetable seedlings, mushrooms); and
- Water shortages resulting in the reduced application of water has a significant negative impact on yield and/or product quality for several crops.

Based on the documentation reviewed and consultation conducted, the following sources of demand for additional irrigation water within the dam supply footprint were identified:

- Apple producers, predominantly for increased water security for existing crops in addition to small scale incremental expansion of cropping area;
- Tomato and capsicum producers, for the expansion of crop production, predominantly for tomatoes;

- Strawberry producers, for the expansion of crop production;
- Wine grape producers, predominantly for application to existing crops, but also to facilitate small scale expansion of crop production; and
- Strawberry runner producers, for the expansion of crop production.

Limited consultation was undertaken with producers of green vegetables, due to the unavailability of green vegetable producers to engage during the consultation period. Whilst farm-level analysis has been undertaken for this crop, it has not been included in the base demand assessment.

There are two potential uses of additional volumes of irrigation water for producers within the dam supply footprint – application to existing crops and the expansion of production.

The table below summarises the extent to which additional irrigation water is likely to be applied for these two purposes by crop type.

Table 6-1 Uses of additional volumes of irrigation water by crop type

Crop	Likelihood of application to existing crops	Potential for expansion of area of production
Apples	**HIGH** – Producers expressed a strong interest in securing additional volumes of irrigation water to avoid yield and product quality losses in 'dry' years.	**LOW** – Market factors are the primary constraint on apple production in the region.
Tomatoes and capsicums	**LOW** – Due to the significant planting costs and the need to maintain product yield and quality, tomato and capsicum producers normally scale production in accordance with their water availability.	**HIGH** – Water availability is the key constraint on the expansion of tomato production in the region. Producers estimated that production could increase 20-30 per cent without price reductions.
Strawberries	**LOW** – Strawberry producers ensure they have sufficient water to maintain existing production levels in order to meet quality and yield requirements.	**MEDIUM** – Whilst water is a constraint, market factors also constraint production. Expansion would therefore be incremental.
Wine grapes	**HIGH** – Whilst there is significant variability in crop yields and irrigation application rates across producers, several producers stated that their primary use of additional irrigation water would be for established crops.	**LOW** – Market factors are the key constraint on wine grape production in the region. An increase in irrigation water supply may facilitate the small-scale expansion of some producers, in particular the planting of new varietals.
Strawberry runners	**LOW** – Producers of strawberry runners scale production based on their water availability due to the need to meet crop yield and quality requirements.	**HIGH** – Water is the primary constraint on production. Subject to this constraint being addressed, producers advised that production could expand by 20-30 per cent.
Green vegetables	**MEDIUM** – It is understood that some green vegetable producers are likely to benefit from application of additional water during dry periods.	**LOW** – Based on anecdotal information from other crop producers, any expansion in production of green vegetable crops is likely to involve incremental expansion by existing producers.

The following table presents the results of the crop-by-crop analysis of the returns from increased availability of irrigation water within the dam supply footprint.

Table 6-2 Summary of modelling results

Crop	Approx. area of production within dam footprint (ha)	Total return for existing crops (Present Value per ML)	Total return for new crop production (Present Value per ML)
Apples (lower water security)	1,202	$43,800	$33,900
Apples (higher water security)		$26,300	
Tomatoes	65		$38,400
Strawberries	160		$55,400
Wine grapes	170	$20,900	$25,400
Strawberry runners	170		$12,600
Green vegetables	500	$25,600	$30,700

Note: Total returns calculated based on a real discount rate of 10 per cent. Areas are approximations only. Estimates are rounded to the nearest $100.

Source: Synergies modelling. Areas of production are based on the assessment undertaken by Orchard Services in 2013, informed by an updated assessment undertaken by Orchard Services in April 2017.

The table below sets out the potential demand for additional irrigation water by crop type and use, based on an assessment of the likelihood of additional volumes of water being applied to existing crops and used for new crop production.

Demand for additional irrigation water by crop type and use

Crop	Area within dam footprint (ha)	Demand for existing crop production		Demand for new crop production			
		Demand per ha	Total demand	% expansion in area	Additional area of crop production (ha)	ML/ha required for expansion	Total demand
Apples (lower water security)	1,202	0.55 ML	330.5 ML	5	60	6.05	363.5 ML
Apples (higher water security)		0.55 ML	330.5 ML				
Tomatoes	65			60	39	6.05	236 ML
Strawberries	160			15	24	8.80	211 ML
Wine grapes	170	0.53 ML (to 50% of ha)	45 ML	5	8.5	1.93	16.5 ML
Strawberry runners	170			25	42.5	11.00	467.5 ML
Green vegetables	500	0.5 ML (to 50% of ha)	125 ML	5	25	5.50	137.5 ML

Notes: Assumed that 50 per cent of apple producers have lower water security and 50 per cent have higher water security.

The percentage expansions of areas were estimated by Synergies, based on a review of recent production trends in the region and consultation with producers.

For wine grapes and green vegetables, it has been assumed that only 50 per cent of producers will demand access to additional irrigation water for application to existing crops (based on consultation with stakeholders and past reports and studies).

Source: Synergies modelling.

Based on the above table, the estimates of demand for additional irrigation water within the dam supply footprint are as follows:

- 2,000 ML (for all crops without green vegetables)
- 2,263 ML (for all crops including green vegetables).

As noted above, the proposed Emu Swamp Dam has an indicative yield of approximately 1,700 ML per annum for irrigation use. The following table provides a breakdown of the take-up of these additional volumes by crop type and use, based on the outcomes of this assessment.

Table 6-3 Illustrative demand take-up for additional volumes of irrigation water (without green vegetables)

Use	ML used	Cumulative ML supplied by crop[a]	Total returns (Present Value)	Cumulative returns (Present Value)
Strawberries – new crops	211.2	211.2	$11.71 million	$11.71 million
Apples – existing crops (producers with lower levels of water security)	330.6	541.8	$14.46 million	$26.17 million
Tomatoes – new crops	236.0	777.7	$9.07 million	$35.24 million
Apples – new crops	363.6	1,141.3	$12.32 million	$47.56 million
Apples – existing crops (producers with higher levels of water security)	330.6	1,471.9	$8.67 million	$56.24 million
Wine grapes – new crops	16.4	1,488.2	$0.41 million	$56.65 million
Wine grapes – existing crops	44.6	1,532.8	$0.93 million	$57.58 million
Strawberry runners – new crops	167.2	1,700.0	$2.11 million	$59.69 million

a These estimates refer to total use of water to be supplied by the proposed Emu Swamp Dam (or an alternative supply source). For example, total water supplied for new strawberry crop production, existing apple production for producers with lower levels of water security and new tomato crop production is estimated at 777.7 ML.

Note: Green vegetable crops were excluded based on the level of consultation that was able to be undertaken with producers due to lack of availability.

Source: Synergies modelling.

It is acknowledged that in practice, different producers of the same crop will derive different returns from additional irrigation water, subject to a range of factors associated with their current production practices, levels of water security, etc. The merit order presented above is therefore intended to provide an illustration of the likely take-up of additional volumes of irrigation water and hence the on-farm return from additional irrigation water use.

It is important to note that the estimates contained in the above table do not take into account annual water infrastructure and supply charges or up-front costs that would need to be incurred for producers to make use of additional irrigation water delivered to the farm gate (e.g. additional pipe infrastructure).

In order to compare the return to additional irrigation water to the capital cost of a proposed supply augmentation, such as the Emu Swamp Dam or an alternative option, it is necessary to make an allowance for these costs. This is because the estimates of total return per ML do not take into account future costs to be incurred by the producer in securing access to the irrigation water. To the extent that the producer is to incur additional costs, such as annual water infrastructure charges, the total return to the irrigation water will be reduced.

For example, if annual water infrastructure and supply charges are expected to total $500/ML, and producers needed to invest, on average, $2,500/ML in on-farm infrastructure improvements in order to access their additional water entitlements (e.g. additional pipeline connections to existing on-farm storages), it would be necessary to reduce the estimates for the total return by $7,500/ML.[18]

Based on an estimated yield for the proposed Emu Swamp Dam of approximately 1,700 ML, this equates to a total reduction of $15.0 million, lowering the average return per ML from $35,100/ML to $27,600/ML (for the scenario excluding green vegetable crops). It is this value that should be assessed against estimates for the capital cost per ML for any supply augmentation options.

18 Based on a discount rate of 10 per cent. It is important to note that these are indicative estimates intended to demonstrate the impact of these costs on the value of additional water entitlements.

It is important to note that the above estimates have been derived based on the assumption that entitlements are 'high reliability' (i.e. >95%). The value of additional irrigation water to producers is for application to existing crops during periods of water shortage to avoid crop yield and product quality losses and for application to newly established crops. Both of these uses require producers to be confident in the reliability of supply.

If the water entitlements to be made available from the proposed Emu Swamp Dam, or any other supply augmentation, were to be of a lower level of reliability, an adjustment would need to be made to the estimated returns to additional irrigation water.

Finally, it is important to note that this assessment is not intended to provide a recommendation as to the price at which additional irrigation water should be supplied to producers (or the prices that producers would actually agree to pay). Rather, the purpose of the assessment is to estimate the financial return to additional irrigation water at the farm level (i.e. the most that producers would be willing (or have capacity) to pay for additional irrigation water) to enable the cost of supply augmentation options to be compared to the farm-level return to additional volumes of irrigation water. There are a range of factors that impact on the price that producers will actually pay for irrigation water, several of which are unrelated to the farm-level return to irrigation water, including irrigation prices in other areas.

Sensitivity analysis was conducted on three key variables – discount rate; crop prices; and incidence of 'dry' years. Whilst all variables had a significant impact on the average per ML return to irrigation water, the impact was most significant for crop prices, with a 10 per cent reduction in future crop prices resulting in a reduction in the average per ML return from $35,100/ML to $20,400/ML (in Present Value terms). This is significant and demonstrates the extent to which producers' expectations regarding future crop price fluctuations will impact on the price that producers are prepared to pay for additional irrigation water entitlements.

The overall projected total net return (in present value terms based on a real discount rate of 10%) arising from increased crop production from the 1,700 ML available from Emu Swamp Dam is circa $60 million. The total net return from the use of the reserved 2,263 ML of additional irrigation water for which demand has been identified is circa $71 million. This is broken down into revenue by crop type below:

Table 6-4 Total return from additional irrigation water

Crop	Total ML of additional water	Per ML return for existing crops	Per ML return for new crops	Total return from additional water
Apples	1,024.5 ML	$44,000 (low security) $26,000 (high security)	$34,000	$35.46 million
Tomatoes	236 ML	-	$38,000	$9.07 million
Strawberries	211 ML	-	$55,000	$11.71 million
Wine grapes	61.5 ML	$21,000	$25,000	$1.35 million
Strawberry runners	467.5 ML	-	$13,000	$5.90 million
Green vegetables	262.5 ML	$26,000	$31,000	$7.41 million
Totals	**2,263 ML**			**$70.90 million**

Note: Totals may not add due to rounding. Per ML estimates have been rounded

6.3 Industrial water demand

Several past studies have projected future industrial demand for water in Stanthorpe. The demand projections from these studies are widely divergent. Synergies therefore sought to understand the basis for the differences and come to an informed view about whether water is indeed a constraint to future industrial activity in the region. Synergies did not attempt to forecast actual volumes of industrial water demand as this was not within project scope.

The assessment involved the following steps:

- Review of relevant, previous studies containing demand projections including:
  - The 2016 *Regional Water Supply Security Assessment* for Stanthorpe, prepared by Department of Energy and Water Supply (DEWS);
  - A report by Sinclair Knight Mertz (SKM) titled "*Stanthorpe Shire Water Opportunities - Urban Water Needs Analysis;*
  - The 2008 Environmental Impact Statement (EIS) prepared by SKM for Emu Swamp Dam;
- Consultation with DEWS to confirm assumptions underpinning their 2016 demand assessment; and
- Consultations with the Stanthorpe and Granite Belt Chamber of Commerce, SDRC and horticultural producers in the region to gain perspectives around the potential for an agrifood processing industry to become established in Stanthorpe should a new, reliable supply of water become available.

DEWS examined Stanthorpe's urban water needs over the next 30 years. At present, Stanthorpe is supplying, on average, 590 ML per year, of which about 30 per cent (177 ML) is for non-residential use (i.e. industrial, commercial and municipal). By 2036, total urban demand is projected to grow to between 740 ML and 858 ML per year. DEWS assumed that there would be no change to the proportion of non-residential use (i.e. 30%) as it had no strong evidence to indicate that major, new industrial/commercial projects would develop in Stanthorpe.

SKM, in its previous forecasting, arrived at a significantly different conclusion and assumed that industrial demand would outstrip residential demand by 2020, reaching about 500 ML in that year. Synergies notes that in 2017, just three years short of 2020, actual industrial water use (as estimated by DEWS) is just 177 ML.

The Granite Belt Chamber of Commerce (GBCC) identified Emu Swamp Dam as its number one priority for promoting economic development in the Stanthorpe region. It believes that there is considerable scope to attract agrifood processors to Stanthorpe if a reliable source of treated water could be made available. By way of example, the GBCC pointed to the trend towards pre-packaging of fruit and vegetables and preparation of "ready to cook" sliced and diced vegetables prior to supply to supermarkets. It was said that this activity could be done more efficiently and at a larger scale in town if a reliable source of treated, reticulated water was available for washing and hygiene purposes.

Discussions with horticultural producers in the region found that not all share GBCC's optimism for locally based value adding. Even if an additional reticulated water source became available, few producers GHD or its sub-consultant, Synergies, spoke to raised any interest in shifting to food processing, as they are currently securing good returns from supplying fresh produce to Brisbane and northern Queensland markets.

6.4 Conclusion

In GHD's assessment, it is unlikely that an agrifood processing industry will become a major new demand driver for additional water in Stanthorpe. The reason for this is twofold:

- the volumes of additional water capable of being supplied by the proposed Emu Swamp Dam are relatively small, so would only allow a marginal increase in horticultural output and unlikely to be of sufficient scale to underpin a major, local food processing hub; and

- Stanthorpe producers currently have the option of transporting their produce to nearby Warwick for processing, where there is no water constraint and better access to major transport routes and labour. However, there is little evidence of this occurring, so GHD is cautious of claims that a new water source for Stanthorpe would attract more local processing.

While non-residential water demand is expected to increase over time, it is GHD's view that there is insufficient evidence to support a forecast that would have industrial demand outstripping residential demand in the foreseeable future or exhibiting a 'step change' in economic development if a new bulk water supply was developed.

7. Water planning and availability

7.1 Existing water plan

Surface water and groundwater management and allocations are governed and guided by the following legislation and regulations:

- *Water Act 2000* (Qld) (Water Act)
- **Water Regulation 2016**
- Water Plans (WP) (previously Water Resource Plans WRPs[19])
- Water Management Protocols (WMPs) (previously Resource Operations Plans (ROPs)).

Water resource planning in Queensland is prescribed under the Water Act to meet the challenges of maintaining river health and groundwater reserves. A catchment specific WP and WMP set out the strategic framework for the allocation and sustainable management of water. Each WP is reviewed after 10-years. As subordinate legislation, WPs are the legal means by which the outcomes and strategies are established to address the full range of social, economic and environmental goals for each plan area.

The current water plan for the Border Rivers catchment came into effect in 2003 (Queensland Government 2003a). The Stanthorpe region is at the upper end of the Border Rivers Water Plan area, which is shown in Figure 7-1 below.

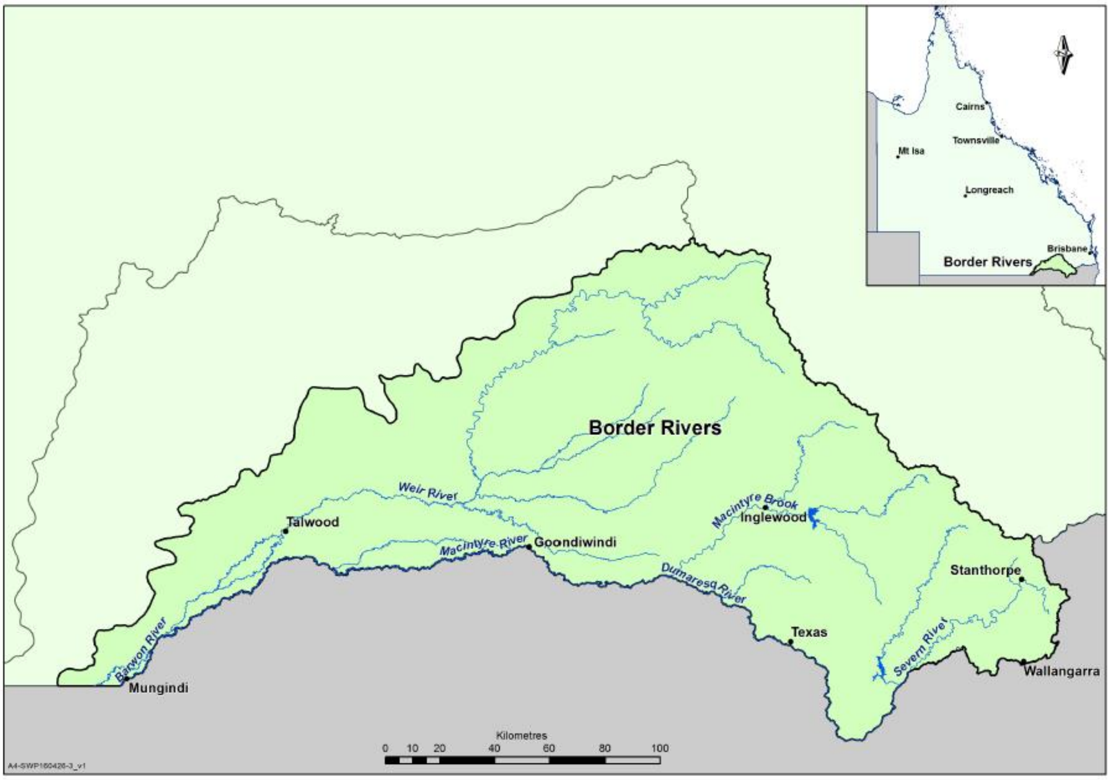

Figure 7-1: Current Border Rivers Water Plan area

Source: Department of Natural Resources and Mines

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[19] Under the Water Reform and Other Legislation Amendment Act 2014, water resource plans and resource operation plans have been replaced by new planning instruments. Water planning outcomes for the Border Rivers catchment are now provided by the Water Plan (Border Rivers) 2002, Border Rivers Water Management Protocol, a Resource Operations Licence and respective operations manual (Department of Natural Resources & Mines, 2017).

The Border Rivers Water Plan includes management of overland flows in the catchment. There is a range of specific provisions in relation to overland flow, but the effect of the Plan is to limit additional overland flow capture, for example in farm dams, unless it meets particular criteria.

The Plan provides for unallocated water reserves in the Stanthorpe Water Management Area (refer to Figure 7-2 below) as shown in Table 7-1 below. Unallocated water reserves are reservations of water within a catchment area that can be made available for consumptive use in the future without affecting the security of other users within a catchment. In this particular case, the uses of the reservations are defined and any future release must be in accordance with the defined use.

Figure 7-2 Stanthorpe water management area

Source: Department of Environment and Resource Management (2011)

Table 7-1 : Unallocated strategic (surface) water reserves

Area	Average Annual Volume (ML)	Use
Stanthorpe Water Management Area	3,000	Irrigation and associated industry
Stanthorpe Water Management Area	1,500	Town water supply

Source: Queensland Government (2003a) Schedule 4

Section 41 of the Border Rivers Water Plan provides for unallocated water (surface and groundwater) reserves to be allocated/released through the process specified in the *Water Regulation 2016* (Queensland Government (2003a). The Strategic Water Reserve applies to water from a watercourse, lake or spring. However, the Chief Executive may allow an equivalent volume of water to be taken as overland flow water determined based on an equivalent impact on the end of system flow[20]. The process for releasing/allocating unallocated water (including unallocated water reserves) is defined in the Water Regulation and could involve:

[20] Ibid

- Public auction
- Tender
- Fixed price sale
- Grant for a particular purpose[21].

More recently the Strategic Water Reserve has been linked with a specific infrastructure option i.e. Emu Swamp Dam. However, GHD understands that this link could be amended as part of the current WP review process discussed below.

Recent releases of un-supplemented water allocations in the Gilbert, Flinders and Nicolson catchments and the Great Artesian Basin have involved tender processes. The 2017 Gulf water tender report indicates that successful bid prices ranged from $45.01 to $200.00/ML[22].

7.2 Proposed water plan

The Border Rivers water plan is scheduled to expire in 2019 and must be replaced under the Water Act. Replacing the plan aims to ensure that the needs of water users, the environment and the general community continue to be met. There is also a proposal to amalgamate the Border Rivers Water Plan and the Moonie Water Plan (Queensland Government, 2003b) covering the catchment immediately to the west in order to achieve greater administrative efficiencies. The new plan will also be consistent with the requirements of the Murray-Darling Basin Plan 2012 (Department of Natural Resources & Mines, 2017).

The proposed area for the new amalgamated plan is shown below in Figure 7-3.

Figure 7-3 – Proposed Border Rivers and Moonie Water Plan area

Source: Department of Natural Resources and Mines (2016)

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[21] Water Regulation 2016, Part 2 Water rights and planning, DNRM, 2016, pp 14-17

[22] *Water Plan (Gulf) 2007, Sale of general reserve unallocated water, Tender assessment report*, DNRM, April 2017, P i

The proposed matters to be addressed in the new plan are outlined in the "Statement of Proposals to prepare a draft Water Resource (Border Rivers and Moonie) Plan" (Department of Natural Resources & Mines, 2016). This notes that:

> "*In the Border Rivers catchment, the Dumaresq and MacIntyre rivers form part of the Queensland-New South Wales border. The New South Wales-Queensland Border Rivers Intergovernmental Agreement 2008 (IGA) provides direction on groundwater and surface water sharing and access, interstate trading, and managing the flows of streams shared by both states as well as water for the Murray-Darling Basin.*
>
> *The Border Rivers catchment includes the highly productive Granite Belt region where high value horticultural crops are grown such as permanent plantings of grapes for wine, and seasonal fruit and vegetables. In addition to irrigated agriculture in the catchments, there are numerous businesses dependent on irrigators for their livelihood. This is particularly the case in the Stanthorpe area, which relies on water to support its high value irrigation industry and tourism. Providing long term certainty for water users will be a key matter to deal with in this plan review.*"

In preparing the new plan, the state government has:

- Signalled that new science and knowledge will be used to inform improved plans for managing water in the catchment. This includes using updated hydrologic models (using extended hydrological data incorporating the Millennium drought and recent significant flood events) and data from new stream gauges providing for better understanding of the hydrology including in the Stanthorpe area.
- Established a moratorium on new works that intercept groundwater (including near-surface groundwater) and surface water (including new farm dams, trenches or bores) to manage these resources and ensure security of existing entitlements whilst the planning review is undertaken. This is in response to a recent trend in the development of near-surface groundwater interception drains and dams and the view that the shallow groundwater that is being extracted is directly influencing stream flows (with base flows in the streams around Stanthorpe having a reliance on these flows). The notice has the effect of temporarily prohibiting any works that take groundwater (including near surface groundwater) in the defined area (shown in below). The Granite Belt Area covers most of the area under consideration in this investigation.
- Proposed to review the suitability of converting area-based surface water licences to tradeable water allocations as a means of providing opportunities for businesses to purchase or sell entitlements to suit business needs whilst preventing growth in take of water in the Stanthorpe area.
- Indicated that no changes are proposed for unallocated water (surface and groundwater) available for future consumptive use in the Border Rivers catchment (including the strategic reserves from the Stanthorpe Water Management Area available for irrigation and related industrial purposes, and for town water)[23]. Unallocated water will continue to be available for release/allocation through processes specified in a Water Regulation[24].

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[23] The new plan is also expected to continue to make small amounts of groundwater available as general reserve water from two groundwater units in the Stanthorpe area: the Border Rivers Fractured Rock and the sediments above the Great Artesian Basin.

[24] Department of Natural Resources & Mines (2016)

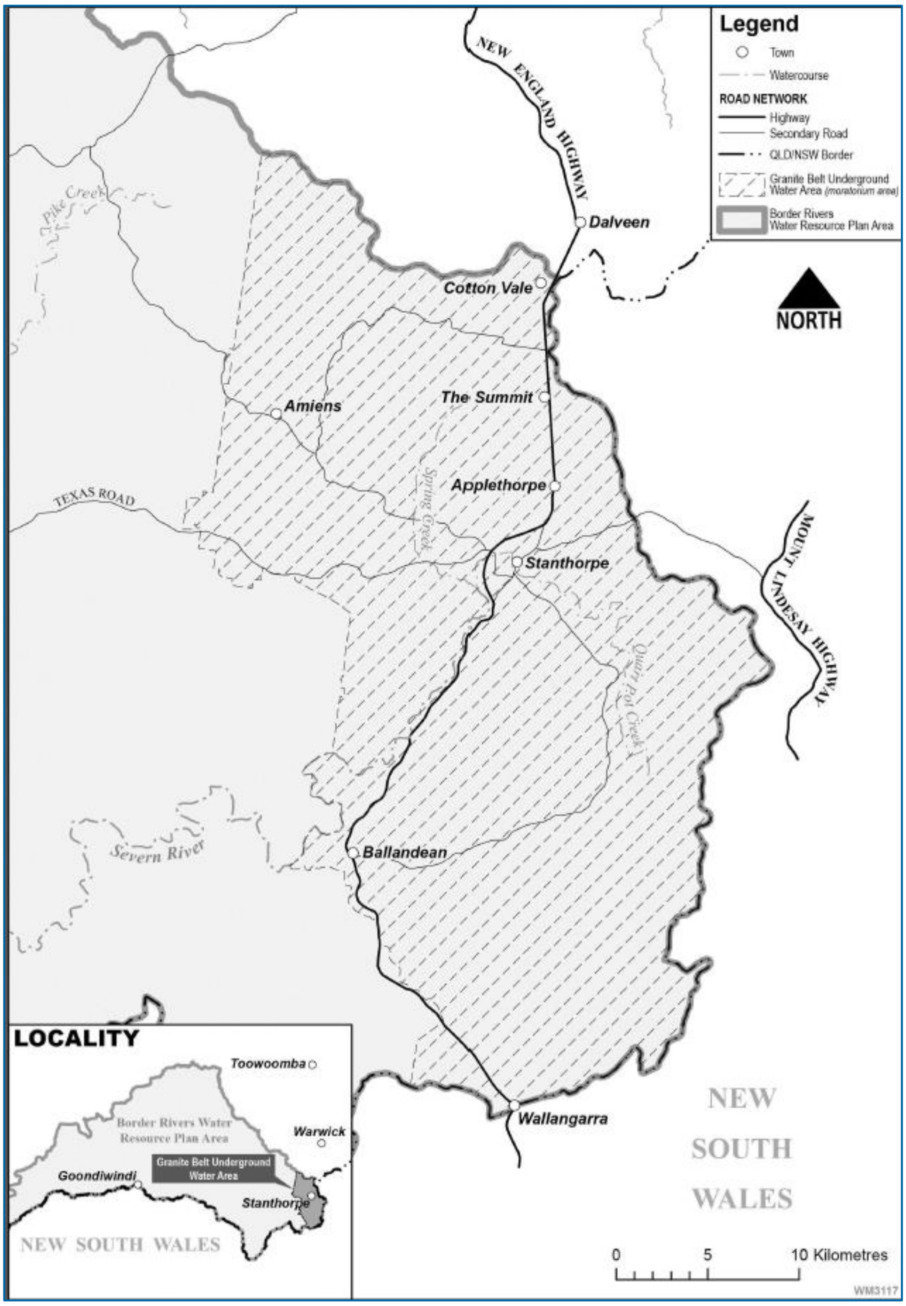

Figure 7-4 Granite Belt groundwater moratorium area

Source: Department of Natural Resources and Mines (2016b)

GHD understands that a revised Draft Water Plan for the combined catchments is planned for release for comment in January 2018 with the Final Plan released in December 2018 and accredited (consistent with the Murray Darling Basin Plan) in June 2019 (verbal advice, DNRM).

7.3 Conclusions

The revised Water Plan for the Border Rivers and Moonie systems is likely to retain Strategic (Surface) Water Reserves within the Stanthorpe Water Management Area i.e. 3,000 ML/a for irrigation and associated industry and 1,500 ML/a for town water supply. These are the only remaining additional water allocation volumes that are available under the Water Plan to support future consumptive water development and use in the local district. A moratorium on water development remains in place in advance of the Water Plan being updated and finalized through a structured review process.

The Strategic (Surface) Water Reserve is currently linked to the Emu Swamp Dam development proposal. However, the outcomes from this feasibility study could provide guidance to Government and the community with regard to retaining or forgoing this link as part of the Water Plan review and potentially enabling either through another infrastructure solution or by permitting its allocation through an open tender process.

8. Supply options description

8.1 Background

The primary water use in the Southern Downs region is irrigated agriculture. The project objectives focus on meeting future water demands i.e.:

- Urban – to increase water supply security for Stanthorpe for urban and the industrial community to promote business investment consistent with revised forecasting and identified drivers
- Irrigation – to increase the reliable water supply to farmers and substantially increase the production of high-value agricultural food products.

The water augmentation options captured in this assessment have largely been identified by earlier studies and associated documentation. Options have focused on the provision of urban and rural water supplies with rural water supplies generally targeting a multi-user irrigation scheme.

8.2 Introduction

The schemes put forward by earlier studies are typically infrastructure solutions, such as building new dams or improving existing water infrastructure. Generally, these schemes are considered to be at a pre-feasibility stage, lacking detail, and are now becoming quite dated in regards to subsequent changes in Government's regulatory environment, general knowledge gained over the past few decades and construction costs.

The options identified in previous works are described in the Option Long List (Table 8-1). Capacity, yields and capital costs vary significantly between different options, and are influenced by factors such as distance from service population, reliability of the water supply, and the intended use of water (urban or irrigation).

The list is by no means comprehensive in terms of potential opportunities. GHD recognises that:

- Some of the key underlying assumptions (particularly population growth projections) have changed since original investigations were undertaken i.e. resulting in a number of water augmentations being ruled out in earlier studies due to their inability to meet the projected annual water demand at the time. Refer to Section 5.7.
- Urban demand management strategies have not been fully explored by Council. Typically, these strategies would be considered prior to any decision to make a major capital investment in augmenting water supplies. Refer to Section 10.1 for further discussion.
- During stakeholder and community engagement activities, other potential options emerged, such as Braeside storage. SDRC also recently advised of discussions with Tenterfield Shire Council with regard to the potential development of dam options on tributaries of the Clarence River. However, it is noted that:
  - These options appear to be at a very early concept stage
  - Potential dam sites (and pipeline routes) impact heavily vegetated areas and would involve transferring water from easterly flowing rivers to westerly draining systems. The environmental impacts associated with such developments could be expected to be significant / extremely challenging to advance.
  - Reaching agreement on the interstate transfer of water could be expected to further impact the project approvals pathway and overall viability.

The Options Long List was filtered via consideration of yield, ability to meet future demand, costs, and environmental and social impact. This filtering process is summarised in Section 8.4, while Section 8.5 confirms the shortlisted options to be taken forward for further analysis.

8.3 Options identification: long list

Table 8-1 Options description

OPTIONS GENERATION			
Option	**Option Category**	**Key Data**	**Option Description**
Base Case	Maintain existing	**Capacity:** 2,180 ML **Yield:** 700 ML/a **Capital Cost:** nil	Storm King Dam is Stanthorpe's major water supply. A limited number of licenses permit the taking of small volumes of water from the catchment area for irrigation and agricultural use.
Raise Storm King Dam	Improve existing	**Capacity**: raising walls would create 7,300 ML capacity. **Yield:** raising walls would create 620 ML/a additional yield. **Capital Cost** 8.84 million (to raise dam) + $0.66 million (pipeline)	This option is based on raising Storm King Dam by 4 m (from 9.5 m to 13.5 m in height) by constructing a new concrete dam over the top of existing dam structure. The raised dam would have an increased capacity at fully supply level of up to 7,300 ML from its existing capacity of 2,180 ML. The dam will be connected to Stanthorpe's water supply system at Mount Marley Water Treatment Plant. GHD assumes that the new pipeline will be constructed next to the existing trunk main along approx. 8 km of existing road reserves.
Storm King Dam – Off Stream Storage at Diamondvale Rd	New build	**Capacity:** 800 ML **Yield:** 350 ML/a **Capital Cost:** $14.41 million (dam)	This option includes a site for an OSS along Diamondvale Road, near the existing trunk main from Storm King Dam.
Emu Swamp Dam (ESD)	New build	**Town Water Supply (TWS)** **Capacity:** 5,000 ML **Yield:** 742 ML/a **Capital Cost:** $33.73 million (dam) + $10.87 million (pipeline)	The proposed dam is located on the Severn River with up to about 10,500 ML capacity and a wall height of 19.8 Mm, almost same location as upper ESD. A pump station would be required at the dam site because of the large difference in elevation between the dam site and Stanthorpe. The urban pipeline would extend approx. 23 km to connect with the Mount Marley Water Treatment Plant and would traverse along Fletcher Road, the New England Highway, several other existing road reserves and short sections of private land. The proposed irrigation pipeline

		TWS & Irrigation **Capacity:** 10,500 ML **Yield:** 742 + 1,676 ML/a **Capital Cost:** $39.26 million (dam) + $42.74 million (pipeline)	is to be supplied by the urban pipeline and would extend approx. 96 km along existing road reserves with some short sections crossing through private land. Please note that "Upper Emu Swamp Dam", which is investigated in earlier reports, has been superseded by Emu Swamp Dam (same location).
Lane Weir with pump to Emu Swamp Dam off-stream storage facility	New build	**Capacity:** not determined **Yield:** not determined **Capital Cost:** nil	No available data for this option.
Ballandean Dam	New build	**Capacity:** up to 18,927 ML **Yield:** up to 6,370 ML/a **Capital Cost:** $7.32 million (dam) + $8.58 million (pipeline)	This option is based on a new dam located on the Severn River in a narrow pass between two ridges. A dam up to 19,000 ML capacity could be constructed at this site. A pump station would be required at the dam site because of the large difference in elevation between the dam site and Stanthorpe; a booster pump will also be required along the pipeline between the dam and the town. The pipeline route would follow the New England Highway and be approx. 25 km in length. A distribution pipeline would be required to distribute irrigation supplies, this pipeline would be approx. 90 km in length.
Connolly Dam Pipeline	Improve existing	**Capacity:** 2,590 ML **Yield:** Unknown DEWS undertaking modelling **Capital Cost:** $8.84 million (dam) + $12.5 million (pipeline)	Connolly Dam is a small dam that is owned by SDRC. The proposed pipeline would be designed from Connolly Dam to Mount Marley Water Treatment Plant. This option is based on a yield of 750 ML/a. The exact route of the pipeline has not yet been determined. This would require an intake pump station at Connolly Dam to pump the urban water along a 35 km long (approx.) pipeline against a static pumping head of approximately 323 m. A booster pump and balancing tank would be required at The Summit. Recent modelling by DEWS has indicated that Connolly dam has sufficient yield to meet the short fall from Storm King Dam to supply Stanthorpe at

			least to 2036 (DEWS has advised that this is work in progress as current modelling does not extend beyond 2036).
Leslie Dam	Improve existing	**Capacity:** 106,200 ML **Yield:** SDRC holds two water allocations from Leslie Dam totalling 3207 ML. **Capital Cost:** $10.94 million (dam) + $16.79 million (pipeline)	Leslie Dam is owned and operated by SunWater. Leslie Dam is essentially fully committed to existing irrigation and urban consumers. There is a small urban allocation that SDRC released for a development project (that did not proceed) and SDRC is endeavouring to recover this for Warwick's town water supply needs. DEWS has advised that Leslie Dam is fully committed and hence there is no available yield to supplement Stanthorpe's supplies.
Petries Crossing Weir and Off-Stream Storage	New build	**Capacity:** 370 ML **Yield:** 230 ML/a **Capital Cost:** $4.94 million (dam) + $2.46 million (pipeline)	This option requires a small weir on the Severn River adjacent to Petries Crossing to create a 30 ML pumping pool, during periods of high stream flows water would be pumped into an 800 ML Off-Stream Storage (OSS). The water would then be pumped to the Mount Marley Water Treatment Plan along 7 km pipeline (approx.) against a static pumping head of 75 m. Water will be sourced whenever available, in preference to Storm King Dam.
Quart Pot Creek Dam (Kyoomba)	New build	**Capacity:** up to 20,450 ML **Yield:** 2,200 ML/a **Capital Cost:** $36.35 million (dam) + $1.35 million (pipeline)	This option is located on Quart Pot Creek approximately 5 km southeast of Stanthorpe. A dam of up to 40,000 ML capacity could be constructed on the site, upstream of the Storm King Dam. A new pump station and pipeline will be constructed to connect with the existing water supply pipeline from Storm King Dam to Stanthorpe's Mount Marley Water Treatment.
Kia Ora Dam	New build	**Capacity:** 20,000-30,000 ML **Yield:** not determined **Capital Cost:** not determined	The proposed dam is located on the Maryland River (in New South Wales (NSW)). Very little data exists on this option.
Bookookoorara Dam	New build	**Capacity:** not determined **Yield:** not determined **Capital Cost:** not determined	This option includes a new Bookookoorara Dam at a FSL of 840 m. The site is in NSW. As this is a concept only, there is no data work.

The Broadwater	New build	**Capacity:** 8,650 ML **Yield:** 3,460 ML/a **Capital Cost:** $9.7 million (dam) + unknown (pipeline)	Details unknown. It is assumed that this is a new dam on the Broadwater.
Severn River Off-Stream Storage – Booth and Somme Lane	New build	**TWS 100% reliability** **Capacity:** 5,400 ML at each site **Yield:** 748 ML/a at each site **Capital Cost (Booth Lane):** $78.66 million (dam) + $10.14 million (pipeline) **Capital Cost (Somme Lane):** $83.10 million (dam) + $11.30 million (pipeline) / **TWS + Irrigation** **Capacity:** 4,300 ML at each site **Yield:** 708 ML/a (urban) + 1,331 ML/a (irrigation) at each site **Capital Cost (Booth Lane):** $74.32 million (dam) + $41.88 million (pipeline) **Capital Cost (Somme Lane):** $83.10 million (dam) + $11.30 million (pipeline) /	This option includes OSS on the Severn River adjacent to Emu Swamp Dam, with potential sites identified at both Booth and Somme Lanes. A weir would be constructed on the Severn River at Emu Swamp with a full storage capacity of 630 ML. The water would be pumped to a 1,600 ML OSS and pumped from the OSS to the Mount Marley Water Treatment Plant along a 25 km pipeline (approx.) against a static pumping head of approximately 125 m.
Individual on-farm storages	New build	**Capacity:** Unknown **Yield:** 1,700 ML/a **Capital Cost:** $6 million	This option is based on freeing up water reserves and auctioning allocations to farmers to enable an increase in on-farm water storage to provide additional yield for surface water harvesting from the estimated 20,700 ML/a to achieve, at least the additional yield for irrigation that would be available from building Emu Swamp Dam for urban irrigation use and a dedicated irrigation water distribution system

Recycled water beneficial reuse	Better use	**Capacity:** N/A **Yield:** approx. additional 200 ML p.a. **Capital Cost:** nil	Treated sewage effluent is currently used by farmers in a relatively small but highly reliable irrigation supply scheme (300-400 ML/a). However, due to a lack of storage, much of the water is used only to augment existing on-farm storages and is often not used during periods of wet weather resulting in potential environmental discharge breaches for SDRC (source: discussions with SDRC). As such, additional yield may be achieved from the recycled water scheme through the increase in storage capacity for the scheme. However, the increase will be insufficient to meet the irrigator demand as determined from the stakeholder consultation. As such, GHD has captured this option as a part of the on-farm storage (market led) option.
Demand management water saving measures	Reform	**Capacity:** N/A **Yield:** Up to 30% water savings (250 ML/a by 2050) **Capital Cost:** $5 million over 30 years	Stanthorpe has largely managed its water supply by imposing water restriction and by pricing of water tariffs. There is significant opportunity to replicate the successful water conservation measures implemented in other parts of South East Queensland that have achieved a sustained reduction in water consumption, close to the levels achieved during the imposition of Stage 6 water restrictions. This can be achieved by both demand side measures (subsidised rain water tanks, low flow shower heads etc.) and supply side measures, leakage reduction in water reticulation systems.

The following map provides a summary description of the source and associated water conveyance infrastructure for each of the options.

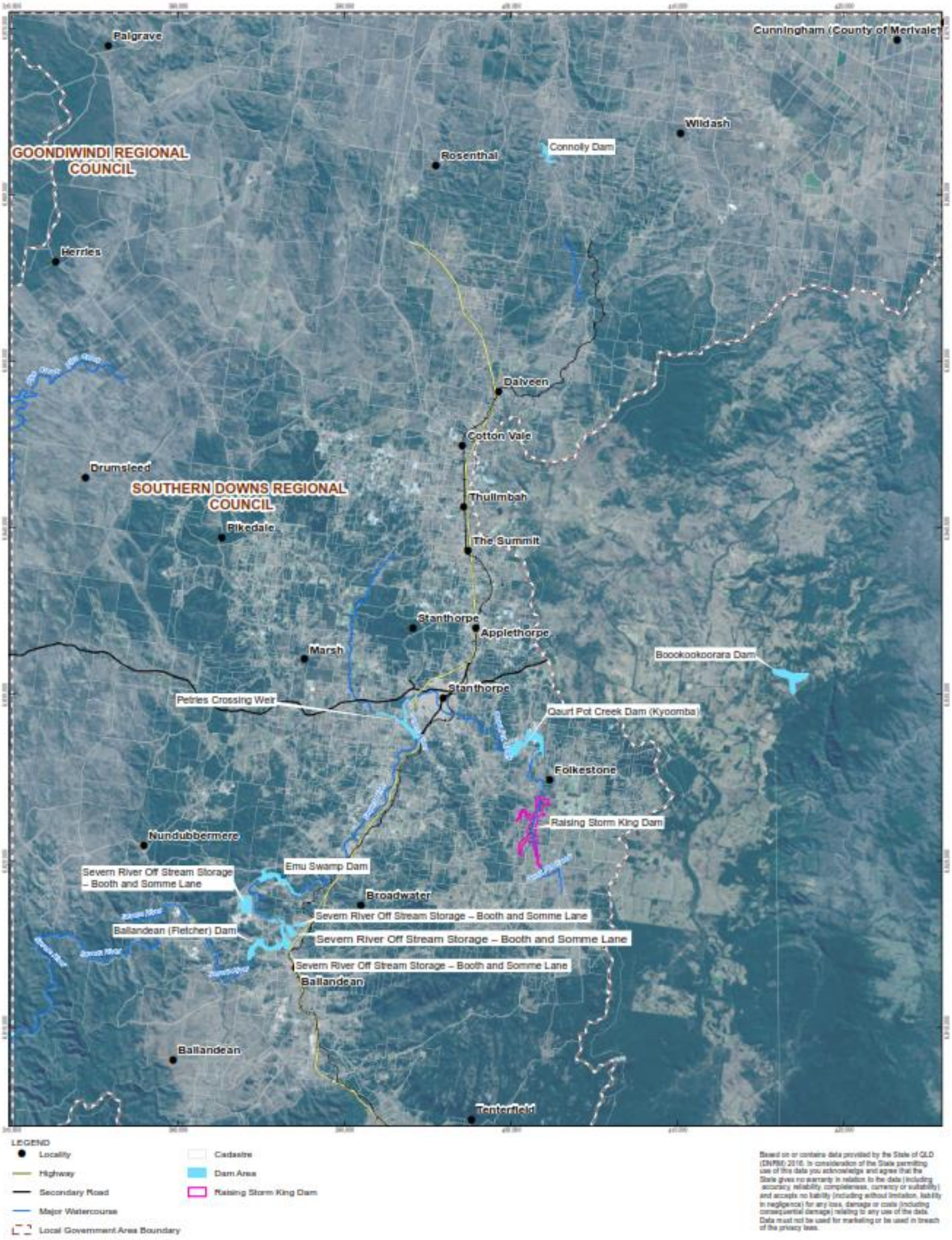

Figure 8-1 Water supply to Stanthorpe options

8.4 Options filter: short list

GHD developed a process to filter the catalogue of potential water augmentation and supply options to meet the water needs of high value irrigated cropping and future urban and industrial needs of Stanthorpe. The options filter assesses the proposed projects identified in Section 8.3 in terms of their potential yield and ability to meet future needs, cost viability, project risks and environmental and social factors. Evaluations of each option are presented in Appendix G. Figure 8-2 below summarises the outcomes of those evaluations via a “traffic light” system, assigning a green (yes), amber (potentially) or red (no) marker to each option, according to the project’s overall viability and ability to meet yield requirements.

OPTION	Meets Yield	Project Viability	Shortlisted
Storm King Dam (urban only)	Green	Green	Green
Storm King Dam (Off Stream Storage)	Red	Red	Red
Emu Swamp Dam (urban and irrigation)	Green	Green	Green
Ballandean Dam	Green	Green	Green
Connolly Dam and Pipeline	Green	Amber	Green
Leslie Dam and Pipeline	Amber	Amber	Green
Demand Management Water Saving Measures	Amber	Green	Green
Individual on-farm storage	Green	Green	Green
Petries Crossing	Red	Red	Red
Quart Pot Creek Dam	Green	Red	Red
The Broadwater	Red	Red	Red
Kia Ora	Red	Red	Red
Severn River Off Stream Storage	Red	Red	Red
Bookookoorara Dam	Red	Red	Red
Lane Weir (with pump to Emu Swamp Dam Off-Stream Storage Facility)	Red	Red	Red

Figure 8-2 Traffic light representation of option filtering

8.5 Selected options for further analysis in this stage

Table 8-2 lists the options to be taken forwards for further analysis in this Stage 1 (Strategic Business Case) following the filtering process. Each of these options is considered in detail in Sections 11 and 12.

Table 8-2 Selected options

Option Type	Selected Options
Urban Only	Storm King Dam Upgrade
	Emu Swamp Dam (small)
	Ballandean Dam (small)
	Connolly Dam Pipeline
	Leslie Dam Pipeline
	Demand management water saving measures Integrated Water Supply Management (IWSM)
Urban and Irrigation	Storm King Dam Upgrade – urban only + on-farm storage
	Emu Swamp Dam (large) – urban and irrigation pipeline
	Emu Swamp Dam (small) – urban only + on-farm storage
	Ballandean Dam (large) – urban and irrigation pipeline
	Ballandean Dam (small) – urban only + on-farm storage
	Connolly Dam Pipeline – urban only + on-farm storage
	Leslie Dam Pipeline – urban only + on-farm storage
	IWSM + on-farm storage

9. Base case

The following section outlines the assumptions underpinning the base case. The base case provides the benchmark against which other options will be assessed. It also describes the expected future situation and impacts that are likely to result in the absence of any major new investment in water supply options in the region

9.1 Existing infrastructure and supply

The base case assumes that urban water supply for Stanthorpe will continue to be provided by Storm King Dam, with no major capital investment or expansion of urban water storage facilities.

The unallocated water reserves available for the region under the Border Rivers Water Resources Plan would remain unallocated.

No additional water allocation would be available for irrigators. Irrigators would continue to draw on their existing water allocations, with irrigation water obtained by harvesting overland flow run-off and by extracting water at pre-determined thresholds from the tributaries of the Severn Rivers, or via off-stream and on-farm storage. A limited number of existing licences, authorising the taking of small volumes of water for irrigation use from the catchment area of Storm King Dam, would continue[25].

Annual irrigation diversions by producers in the region are estimated at approximately 20,700 ML per annum[26]. As such, the proposed additional 1,700 ML of reserves assigned to irrigation supplies from Emu Swamp Dam represent less than an addition 10% of existing urban irrigation supplies, albeit at a higher level of reliability.

9.2 Future population and forecast urban demand

Population and demand forecast is set out in detail in Section 5.4 and summarised here for convenience. Population growth in Stanthorpe has been limited over the past ten years, in part due to changing demographics associated with an aging population.

As previous forecasts of future urban water demand have been based on overly optimistic projections of population, the base case assumes that the population of Stanthorpe will continue to grow at the more conservative rate of 0.95% per annum. The 2050 population is therefore projected to be 8,600, comprising 7,138 urban users. This also presumes that the reticulated network is not extended.

It is also assumed that permanent water restrictions in Stanthorpe will be maintained, and higher level restrictions (ranging from Medium to Extreme) may be invoked during prolonged drought conditions and enforced.

If the average water demand per person per day remains at its current level (324 L/c/d), then based on the above assumptions, forecast demand for urban water is expected to be 844 ML per annum by 2050, exceeding current supply capacity. It will be sensible for a water conservation education campaign to be undertaken to assist in reducing the average water demand per person per day.

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[25] DEWS (2016).
[26] SKM (2007). Emu Swamp Dam Project – Planning Report.

9.3 Irrigation demand

According to a study undertaken in 2013[27], the Southern Downs region currently produces between 5-8% of the State's horticultural production. Worth around $300 million per annum, this mostly summer-based produce contributes double the value of the traditional 'salad bowl' areas, such as the Lockyer Valley and Stanthorpe.

The area's significant horticultural base periodically experiences water resource difficulties during times of drought. Most growers highlight a considerable need for greater certainty to sustain current levels of production and to justify planned growth opportunities. Around 83% of surveyed growers were seeking additional water –several desperately – for either security or development purposes.

GHD notes that none of the options considered will yield more than 10% of what is currently available to irrigators from surface water flow harvesting (e.g. 1,700 ML/a from Emu Swamp Dam compared to an estimated 20,700 ML/a from existing entitlements for surface water harvesting

9.4 Summary of expected future impacts

Under the base case, the following future scenario and impacts are expected:

- Storm King Dam is expected to have sufficient capacity to meet urban water needs until 2036 without material supply restrictions and in absence of a strategy if implementing Integrated Water Supply Management initiatives.
- Storm King Dam is a relatively small storage highly reliant on seasonal in-flows and an extended drought may see it drop below operational supply levels. Therefore, the reliability of urban water supply may be impacted.
- Water restrictions will remain central to meeting supply objectives over the longer term. As population increases, water restrictions will further tighten.
- Without access to additional water for irrigation, future growth in agricultural output will be constrained, although this is being and will be somewhat mitigated through improved farming methods and irrigation technologies that improve the efficiency of water use and minimise water loss, through e.g. covers on on-farm storages to reduce evaporation loss.
- Irrigators will continue to experience negative impacts on crop yields during extended drought periods, when on-farm storage facilities run dry. The last extended drought period being approximately 10 years ago. However, it is not possible to predict with any certainty the frequency and severity of any future drought periods. Water shortages resulting in the reduced application of water has a significant negative impact on yield and/or product quality for several crops, particularly tomatoes, strawberry runners and strawberries.

In short, GHD considers that 'do nothing' is not a viable option for addressing either urban or irrigation water supply needs.

[27] The survey canvassed the views of around 26% of all growers operating the region.

10. Non major infrastructure options

In this section, non-capital options are discussed and analysed.

10.1 Integrated water supply management

10.1.1 Introduction

This section examines the current approach to minimising water use in the urban area of Stanthorpe and the potential role of water efficiency measures in meeting enabling future demand requirements to be met. The approach is consistent with the principles of least cost planning (LCP) which seeks to determine the most cost effective means of providing water services or alternatively the cheapest forms of water conservation (White and Fane 2007). It contrasts to other approaches identified across the range of planning studies reviewed in relation to Emu Swamp Dam and meeting projected water demands for the Stanthorpe area that have focussed mainly on increasing supply to Stanthorpe. Consideration of water efficiency measures is consistent with the Queensland Government Infrastructure Plan and the Building Queensland Guidelines that state a preference for better use of existing resources through demand management rather than constructing new infrastructure. Further information on urban water conservation measures is provided in Appendix F.

10.1.2 Water restrictions

Water restriction levels

Water restrictions are recognised as a key component of managing demand in the Stanthorpe urban supply area. The vulnerability of the township to decreasing supply levels is recognised is the range of restrictions that are presented in the following table.

Table 10-1 Stanthorpe's water restriction levels

Restriction level	Supply trigger levels (% of full supply volume)	Targeted maximum daily residential consumption (L/p/d)	Summary of Restricted Activities
Permanent	75% and above	230	Outdoor water use on 3 allocated days except between 10 a.m. and 4 p.m. No other restrictions
Medium	70% (or below) Relaxed when volume increases to 75%	200	Restrictions on hours of outdoor water on allocated days (morning and evening only) Topping up of existing pools only Minimal cleaning of paved areas.

High	50% (or below) Relaxed when volume increases to 55%	170	Restrictions on hours of outdoor water on allocated days (evening only) Outdoor sprinkler and irrigation systems not allowed No hose washing of vehicles No topping up of pools Minimal cleaning of paved areas No cleaning of buildings
Extreme	30%(or below) Relaxed when volume increases to 35%	140	Further restrictions on hours of outdoor water on allocated days (evening only) No hand-held hosing of gardens and lawns Outdoor sprinkler and irrigation systems not allowed No hose washing of vehicles No topping up of pools Minimal cleaning of paved areas. No cleaning of buildings

Source: Southern Downs Regional Council (2017) Water Restrictions

MWH (2010) reported that outdoor use of reticulated water in Stanthorpe was minimal during drought restrictions. Level 4 (one hour of outdoor watering per week) and Level 5 (Extreme) restrictions (no outdoor water use) were in force for much of the period of study (2003-2008). Whilst historic consumption patterns demonstrate a reduction in demand during this period (see Figure 10-1 below), SDRC has advised that most of the Stanthorpe Community is unaware that 'Permanent' restrictions are currently in place and that there is minimal enforcement or education with respect to these restrictions undertaken by Council officers.

During that period, the external water use in Stanthorpe was commonly supplemented by alternative water sources such as rainwater tanks, bores and recycled greywater.

Water restrictions and water efficiency

The focus of the approach in relation to water supply has been on water restrictions backed by enforcement measures rather than a voluntary program of water efficiency, the latter having which had success in other parts of Queensland and Australia. Managing water demand is central to water efficiency. According to the Queensland Water Directorate (2017), a permanent reduction in water demand is identical to an increase in supply.

Reducing demand can correspondingly reduce the capital and operational costs of providing water to a community. This will potentially result in lower long-term water costs for consumers. Lower water use is correlated with lower energy use and other environmental benefits such as reduced greenhouse gas emissions and reduced extraction from aquifers and rivers leading to improved river health.

Demand management is defined as the proactive management of end use water consumption. Critically it can contribute to the following outcomes:

- Delaying the need for new bulk water supply infrastructure
- Reducing peak demand therefore delaying operational and infrastructure investment costs
- Extending the period before drought response triggers are reached
- Reducing water business operational costs and pump maintenance
- Providing customers with greater understanding of their water use and the ability to make informed choices about how they use water

10.1.3 Current urban water use in Stanthorpe

Water consumption trend

Consumption in Stanthorpe has decreased significantly from 1979 to date (SKM 1997, DEWS 2016), falling from approximately 700 L/c/d in 1979 to approximately 332 L/c/d in 2014-15. However, GHD notes that, whilst projected population growth is slow any increase in population benefiting from reticulated water supplies will result in an increase in availability of recycled water for irrigation use.

SDRC advised that Stanthorpe was under drought restrictions from 2002 to 2006 that caused a temporary fall in consumption to under 300 L/c/d. The reason of the difference between the observed and predicted water consumption trends following the 2006-2008 drought demonstrates the impact of drought restrictions on water use in Stanthorpe and general change in attitude to water consumption (MWH 2010). Figure 10-1 below shows residential water consumption trend during drought restrictions (L/p/d).

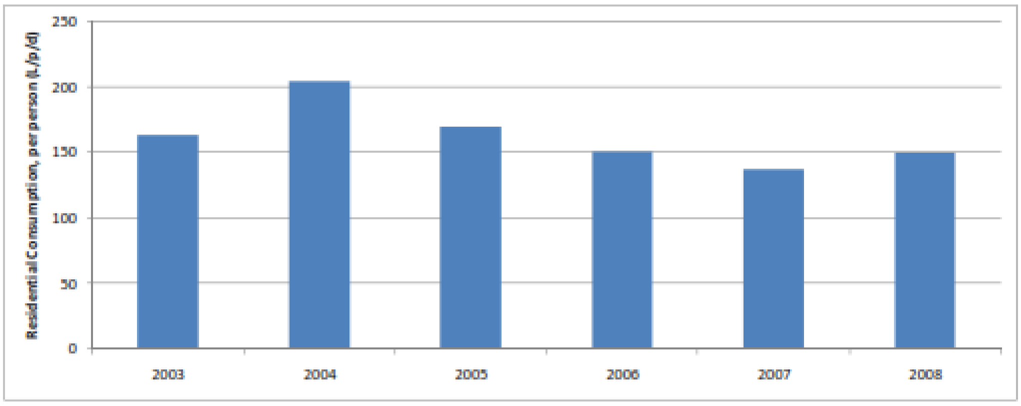


Figure 10-1 Residential average daily consumption (L/p/d)

Source: MWH 2010

Target Consumption Comparison

Permanent restriction levels are based on a target consumption of an average of 230 L/p/d for Stanthorpe. The actual average residential water use over the period 2008-09 to 2014-15 in Stanthorpe was approximately 213 L/p/d (DEWS 2016). This average water usage of 213 L/p/d is relatively high in comparison to South East Queensland. In 2015, the average use per person per day in South East Queensland was 159 litres per person per day (Seqwater 2016). Melbourne Water reports that the average per person per day water use over 2016 was 166 litres (Melbourne Water 2016). In the United Kingdom, average water consumption is 150 L/p/d (Fidar et al 2016).

Water system metered

All connections in Stanthorpe are metered with the only exception of hydrants. A water meter replacement program started in 2007, under which approximately 1,000 meters are replaced each year (MWH 2010). Sectoral water use for Stanthorpe is shown in Figure 10-2 (source MWH 2010) below. It represents percentage for each sector as follow: 50% urban residential and 5% rural residential, 25% non-residential (hydrants, flushing programs, illegal water connections, inaccurate water meters), 11% business in the central business district (CBD), 6% non-rateable (army quarters, council buildings).

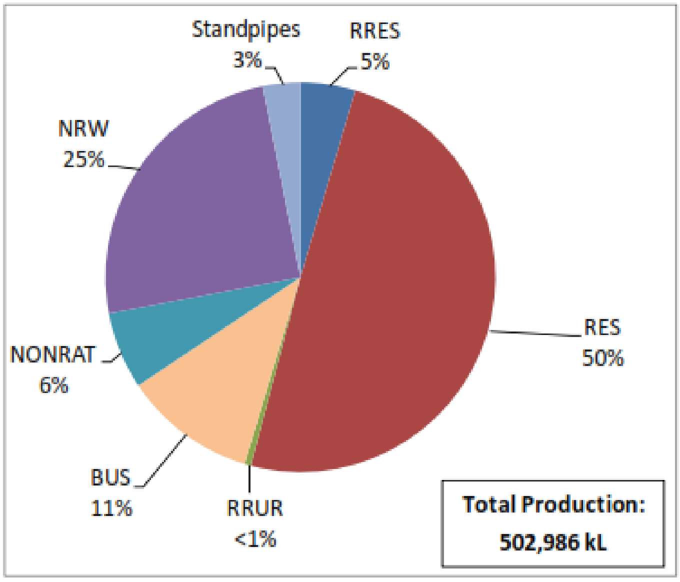


Figure 10-2 Sectoral water use breakdown (% total water use per sector - 2008)

10.1.4 Demand management measures

Demand management measures can be categorised into the following categories; outlined in the table below:

Table 10-2 Demand management measure categorisation

Category	Description	Example
Increase system efficiency	No change to resource usage by consumers but less system losses.	Leakage detection and repair; change in system operation such as pressure reduction, installing peak balancing capacity.
Increase end use efficiency	Less resource used by the consumer to provide the same service.	Regulating water efficiency in new buildings, financial incentives for water efficient purchase and retrofit efficient equipment.
Promoting distributed sources of supply	Provide services via a locally sourced resource not currently being used.	Household rainwater tanks and greywater reuse systems.

Substitute resource use	Provide same service without use of the resource in question	Planting indigenous plants adapted to local rainfall
Improve the market in resource usage	Inform the consumer about the full costs of their resource use.	Full cost recovery, greater feedback on consumer usage and costs, smart metering, education campaigns, water use audits.

Source: Adapted from White & Fane (2007).

The effectiveness of demand reduction strategies was evidenced in South East Queensland during the millennium drought. A study by the Urban Water Security Research Alliance examining residential end use in South East Queensland identified that showering (29%) tap (19%) and clothes washing (21%) comprised the bulk of water consumption. The study identified that in South East Queensland replacing low efficiency showerheads with high efficiency reduced usage by 20% and that from front loading washing machines used 7% less water than front top loaders (Urban Water Security Research Alliance (UWSRA) 2010).

The cost effectiveness of various demand reduction strategies available for implementation within South West Queensland, including Stanthorpe was investigated by MWH in 2010 and selected measure are identified in the following table:

Table 10-3 Cost effectiveness of individual demand management measures

	Average Water Savings (ML/a)
Residential Education Program	$0.07 to $0.44 per kL
Non-residential education	$2.45 to $13.16 per kL
Permanent Conservation Measures	$0.03 to $0.67 per kL
Rebate – Pool covers	$33.46 to $37.29 per kL
Rebate – Washing Machine	$23.41 to $25.86 per kL
Rebate – Shower Head	$0.47 to 0.54 per kL
Rebate – Dual Flush toilet	$8.70 to $9.89 per kL
Rebate – Internally Plumbed Rain Water Tank	$8.38 to $9.13 per kL
System Water Loss Management	$0.54 to $1.71 per kL
Residential Retrofit Program	$1.58 to $5.73 per kL
Tourist Based Education	$0.79 to $2.14 per kL
Water Efficiency Management Plans	$1.54 to $4.04 per kL
Home Leakage Programs	$11.05 to $20.92 per kL
Installation of Smart Meters	$3.13 to $7.47 per kL

Source: MWH (2010) South West Queensland Water Demand Analysis

The same MWH study identified the effectiveness of demand measures based on their individual economic performance for each individual region including Stanthorpe. Selection only of measures with a total annualised cost equivalent to or less than anticipated marginal supply cost of water (2.00 per kilolitre (kL)) was modelled to result in a 9% decrease in water demand per person per day from the baseline.

In broad terms a 9% reduction in average per person water usage in Stanthorpe (213 L/p/d) translates to a 19.2 litres per person per day saving or a change to 193.8 per person per day usage (L/p/d). Across the current population of 5,159 this translates to a potential reduction in water usage of 35.2 ML per year or the equivalent supply demand for an additional 524 residents (based on average daily use of 193.8 L/p/d).

10.1.5 Conclusion

Permanent water restrictions have been effective in reducing overall demand in Stanthorpe. **However, despite restrictions being in place for some time, water consumption is over 50 l/p/d higher than the average l/p/d water consumption level experienced more broadly in the rest of South East Queensland**. This, coupled with no history of Council implementing or actively promoting water conservation measures in Stanthorpe indicates there is significant and realisable potential to implement cost effective measures to further reduce water demand and consideration should be given to this 'better use' approach as part of a future options analysis. Demand reduction in this instance can potentially delay the need new infrastructure and the triggering of drought restrictions. Further Stanthorpe specific investigation may identify additional demand reduction measures or supply substitution options.

The previous report shows that rainwater tanks contribute considerably to the cost of demand management programs, however also demonstrate considerable savings in water demand. GHD understands that Council recognises the potential for reducing urban demand through water conversation measures and has been advised by Council (email of 17 May 2017) that an initiative to promote and subsidise the installation of rainwater tanks at domestic properties is being listed in Council's revenue statement that is currently in the draft 2017/18 budget

Central to an understanding of the potential benefits to be gained from implementing water efficiency measures and the type of measures that would be most effective within Stanthorpe is a detailed investigation of end usage. This would provide a basis for estimating the cost effectiveness of the option in comparison to other solutions.

10.2 On-farm water storage

The development of Emu Swamp Dam would deliver an incremental increase in available irrigation water supplies to the local area (SKM, 2007b, p.21). Current water supplies supporting irrigation enterprises are largely met by on-farm water storage, interception of near surface groundwater resources in decomposed granites and bores accessing deeper groundwater resources.

A moratorium on the development of on-farm storages accompanied the development of the Water Resource Plan in the early 2000s and remains in place as the Water Plan is reviewed.

On-farm storages take multiple forms i.e.:

- Gully dams and weirs
- Hillside storages
- Ring tanks/turkeys nest.

Storage yields reflect catchment areas (including diverted catchments and overland flows) and potential base flows, near surface groundwater interception trenches and water harvesting pump facilities (and any associated threshold flows).

These on-farm storages are generally relatively small in nature compared to community dams and weirs.

By way of example, one local irrigation-farmer, canvassed at recent Focus Group meetings, has an average annual irrigation usage of approximately 800 ML, which is largely met by a 350 ML on-farm storage. However, expanding existing on-farm storages may affect downstream/downslope landholders' water allocation reliabilities. These would need to be specifically assessed if this water augmentation option was to be pursued.

10.2.1 Indicative cost

The cost associated with enhancing existing water storages would generally be a function of the type of structure and construction material (e.g. concrete, compacted earth etc.), site conditions (e.g. rockiness etc.) and topography i.e. the earthworks volume required to store a ML of water (reflected in the storage ratio).

The cost of construction (per cubic metre of earthworks) for on-farm storages is generally significantly lower than that associated with bigger community dams and weirs. This largely reflects lower specifications and compliance systems.

Generally, the storage type with the lowest earthworks to storage ratio is the ring tank/turkeys nest. This storage type will generally reflect the highest cost per ML of increasing an existing on-farm water storage and has been used for indicative purposes. By way of example a 100 ML ring tank with a diameter of 250 m, an embankment height of 2.8 metres with 3: 1 embankment batters and allowing 5% for settlement would comprise approximately 20,000 cubic metres of compacted fill (it is assumed that suitable compacted fill is sourced from within the storage).

Earthworks associated with the construction of on-farm storages are expected to cost in the order of $7 per cubic metre (depending on site conditions e.g. rockiness etc.) i.e. approximately $140,000 for a 100 ML storage. Mobilisation, demobilisation, site clearing and works area preparation is expected to cost a further $30,000, equating to approximately $1,700/ML of storage. These costs are indicative only for developing a concept level comparison. Clearly actual costs will vary widely depending on site conditions and the ability to enhance existing embankments and associated structures.

In addition, yield will vary significantly ranging from the example shown above where 1 ML of storage equates to approximately 2.2 ML of average annual yield to 1 ML of storage providing less than 0.5 ML of average annual yield. For comparative purposes, the on-farm development option cost would range from approximately $780/ML of yield to $3,400/ML of yield. However as previously noted, on-farm storages could be expected to provide lower water allocation reliabilities as compared to the Emu Swamp Dam proposal.

Conversely, the enhancement of on-farm storages could reasonably expect to utilise existing pump and water distribution systems minimising costs associated with water distribution systems.

10.2.2 Potential release of unallocated water

As noted previously:

- The only unallocated surface water resources exists in the Strategic Reserve and is currently linked to the development of Emu Swamp Dam
- The release of unallocated water is guided by the Water Regulation with some flexibility for the Chief Executive Officer to adopt one of the following mechanisms:

– Public auction
– Tender
– Fixed price sale
– Grant for a particular purpose.

Notwithstanding this, most recent water allocation tenders in the Gilbert, Flinders and Nicolson catchments and the Great Artesian Basin have all involved tender processes. The 2017 Gulf water tender report (DNRM) indicates that successful bid prices ranged from $45.01 to $200.00 per ML.

GHD expects that a similar tender held in the Stanthorpe Water Management Area will attract significantly higher prices and translate into near term development based on current water demand and existing levels of irrigation development.

10.3 Offsetting Storm King Dam yield for enhancing urban supply

An option for meeting future urban water demand could involve the staging of a number of smaller storages similar to those discussed above for on-farm irrigation supplies. Given the lower reliability of water allocations from this style of water storage, they can be integrated into the broader Stanthorpe Water Supply Management strategy. This would involve water being utilised when it is available from these smaller water storages and thereby offsetting supply from Storm King Dam i.e. use water from smaller storages first (when available) and reducing or delaying supply from Storm King Dam.

The costs can be expected to attract higher construction and related standards than those for on-farm dams. This will translate through to cost which are estimated to range from $1,500/ML to $6,800/ML of yield.

11. Further technical evaluation of short list capital options

11.1 Overview

This section outlines GHD's further evaluation of technical and costing aspects of the short listed options to extend and update analysis previously undertaken.

The scope included undertaking preliminary engineering design investigations for the project and comprised the following tasks:

- Summarising the long list of potential options
- Informing the selection of the preferred water supply option/s
- Undertaking preliminary mapping of the proposed options
- Completing preliminary hydraulic designs to size all required water supply infrastructure capacities: pump stations, rising mains, reservoirs/tanks
- Preparing preliminary cost estimates for project budget setting purposes (for business case only)
- Providing recommendations.

To facilitate this assessment GHD has:

- Reviewed earlier reports and updated costs where relevant data is available to facilitate comparison
- Considered conceptual pipeline/reticulation alignments, capital and operating costs for these water distribution systems.

11.2 Short list options

The general concept for the major capital infrastructure options comprises:

- Dam (either existing, augmented or new)
- Urban pipeline - for urban demands only to connecting the dam to the Stanthorpe water treatment plant at Mount Marley
- Irrigation pipeline - for agricultural demands only, supplied to a range of offtake points to high-value agricultural areas within the Granite Belt region
- Pump stations, with associated power supply and control arrangements
- Required storage tanks.

GHD has developed the options considered based on previous reports and options contained therein with new options identified during this project phase. The options have been listed in section 8.5.

The sizing and alignment of distribution infrastructure for the options have been undertaken at a high concept level only. GHD has reviewed pipeline alignments based initially on the existing pre-concept design configuration, considering topographical constraints (to minimise localised high points) and to follow existing road corridors and property boundaries where possible.

Further constraints associated with land use availability and easement limitations have not been assessed at this stage to determine the feasibility of each alignment.

The existing pre-concept design and available mapping drawings for the Emu Swamp Dam Project by SKM (2006) have provided initial information to develop the distribution system for all the options shown in Figure 11-1.

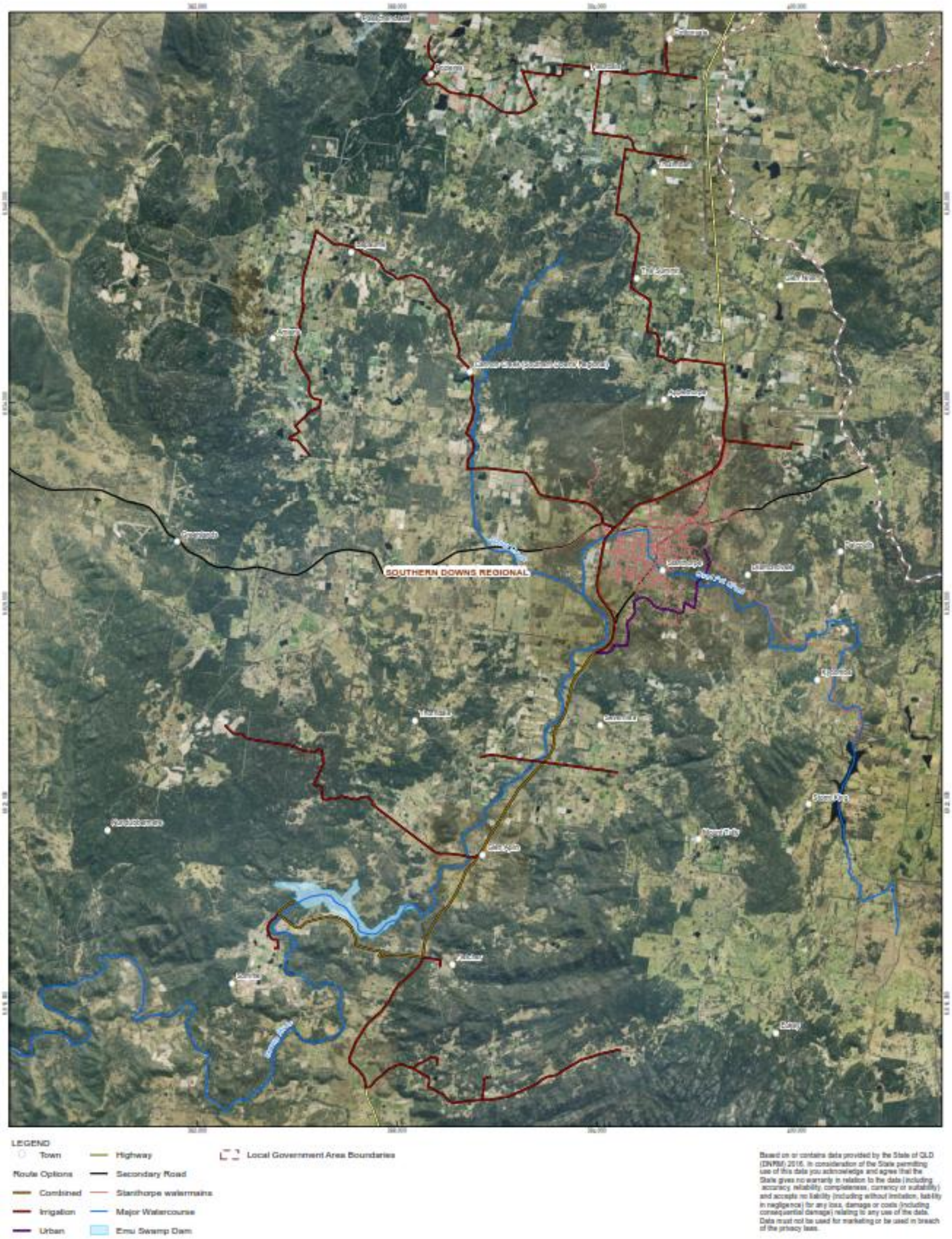


Figure 11-1 Emu Swamp Dam system overview

GHD has created GIS maps for the proposed alignments based on road corridors, in or adjacent to existing services easements and where unavoidable, alongside property boundaries on private properties (requiring new easements). Critical services and topography obstacles, highly developed land and known areas of environmental sensitivity have been avoided as much as possible.

11.3 Basis of cost estimates

For the selected shortlist of options, GHD has prepared concept construction cost estimates using information from previous works. All assumptions in these previous assessments have been adopted for this project, with some additional assumptions made based on judgements by GHD.

The cost estimates presented in this section were developed solely for the purpose of comparing and evaluating proposed options. They are sufficiently well developed (generally a P50 level, that is it is 50% as likely for costs to exceed a particular number as be below it) only to serve this purpose and should not be relied on as a cost estimate in their own right. A more detailed design with a budget estimate should follow this initial concept phase.

The cost estimate should not to be used for budgeting purposes. The scope and quality of the works has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some items, extrapolation of recent similar project pricing and experience. The accuracy of the estimates is not expected to be better than approximately +/- 40% for the items described in this report.

The indicative capital cost have been based on escalated cost estimate from previous reports and adjusted to match recent dam bench mark costs for similar dams has been assumed to include the following elements:

- Contingency (30%)
- Design and supervision (12%)
- All rates are reference to 2017 and rounded to the nearest thousand dollars.

11.3.1 Assumptions

GHD has adopted the following main objectives and associated assumptions as part of this investigation:

- This is a high level options study
- Potential irrigation areas assessed are based on the results cadastral data
- No Land Tenure investigations have been undertaken other than through previous investigations for the Emu Swamp Dam option
- No Cultural Heritage/Native Title Survey have been performed other than through previous investigations for the Emu Swamp Dam option
- Potential water infrastructure solutions (e.g. pipeline alignments, pumping heads etc.) associated with options were derived from available topographic data
- The purchase price of water allocation has not been factored into any of the options and is assumed to be the same for all
- No allowance has been made for storages for irrigators at the on-property discharge points
- Irrigation areas are assumed only, no confirmation has been given of location and required areas. Therefore pipes, pump stations and storage sizes are preliminary only
- Stanthorpe water supply connection is to the existing tank at the Mt Marley Water Treatment Plant

- Irrigation water supply is up to the existing connection with the private property for existing landowners
- No soil type or ground condition factors have been added to the cost rates.

11.3.2 Dams

Due to the lack of design information for any of the options other than limited information for Emu Swamp Dam available from previous reports, GHD has developed cost estimates for the dam options by escalating historic costs from earlier reports to $2017 terms and then comparing these to costs for similar dam designs recently undertaken by GHD. GHD has then applied a scaling factor to bring the escalated costs in line with recent design costs, taking into account differences between the designs, such as height and length of dam wall.

GHD has compared this adjustment factor for the overall dam costs with adjustment factors required to be applied to unit rates used in previous estimates, e.g. $/m^3 concrete as a cross check.

11.3.3 Pump stations

- For pump station, mechanical and electrical fit-out for pumpsets and electrics such as switchboards are assumed to be included in total capex cost for new pump stations
- Assumed pump efficiency and motor to be 80%
- Pump Operation time 20 hrs/d
- Power supply connection is close to the pump station sites
- Unit rate costs for varying pump duties have been developed based on a combination of industry standards rates, actual supplier quotations, construction tenders and other sources obtained by GHD.

11.3.4 Water storages

- For water panel tanks, unit rate costs have been developed based on a combination of industry standards rates, actual supplier quotations, construction tenders and other sources obtained by GHD

11.3.1 Pipelines

- Pipeline unit rates include supply of pipe material, equipment and labour with depth of cover less than 1.0 m plus valves supply and installation.
- All rates for pipelines are based on unit rate costs developed from a combination of industry standards rates, actual supplier quotations, construction tenders and other sources obtained by GHD
- Updated lengths have been taken from spatial modelling software.

11.4 Raising Storm King Dam

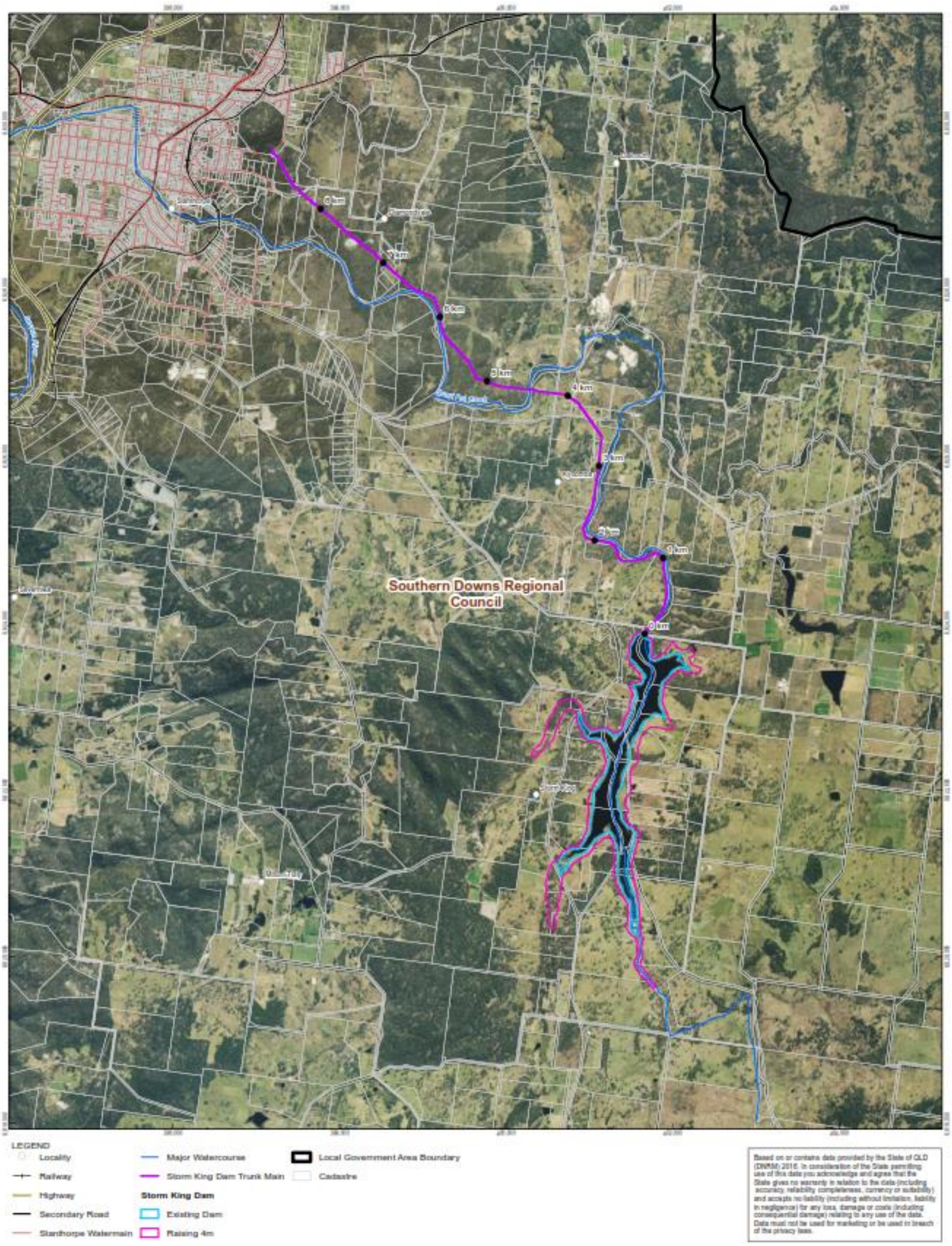


Figure 11-2 Raising Storm King Dam - urban supply pipeline

11.4.1 Dam infrastructure

This option is based on raising Storm King Dam by 4 m (from 9.5 m to 13.5 m in height) by constructing a new concrete dam either over the top of existing dam structure. The raised dam would have an increase of capacity at fully supply level capacity up to 7,300 ML from its existing capacity of 2,180 ML.

Table 11-1 Raising dam wall capex – Storm King Dam

Raising Storm King Dam	Total Capex (2017)
Storm King Dam upgrade – raising wall 4 m	$42,000,000

The dam will be connected to Stanthorpe's water supply system at Mount Marley Water Treatment Plant via a second raw water pipeline running in parallel with the existing raw water pipeline.

Although the pipeline could flow normally by gravity, at times of high demand, flows are boosted by pumps at Storm King Dam (see Section 5.3). Therefore, an upgrade is likely to be required to the existing booster pump station at Storm King Dam.

Table 11-2 Pump station capex – Storm King Dam

Raising Storm King Dam	Total Capex (2017)
Storm King Dam upgrade additional pump station	$380,000

The urban water pipeline will be constructed next to the existing pipeline and within the same easement. GHD notes that some elements of this route have been based on from preliminary information from (Vosloo 2017). Long section of pipeline is shown on Figure 11-3 below.

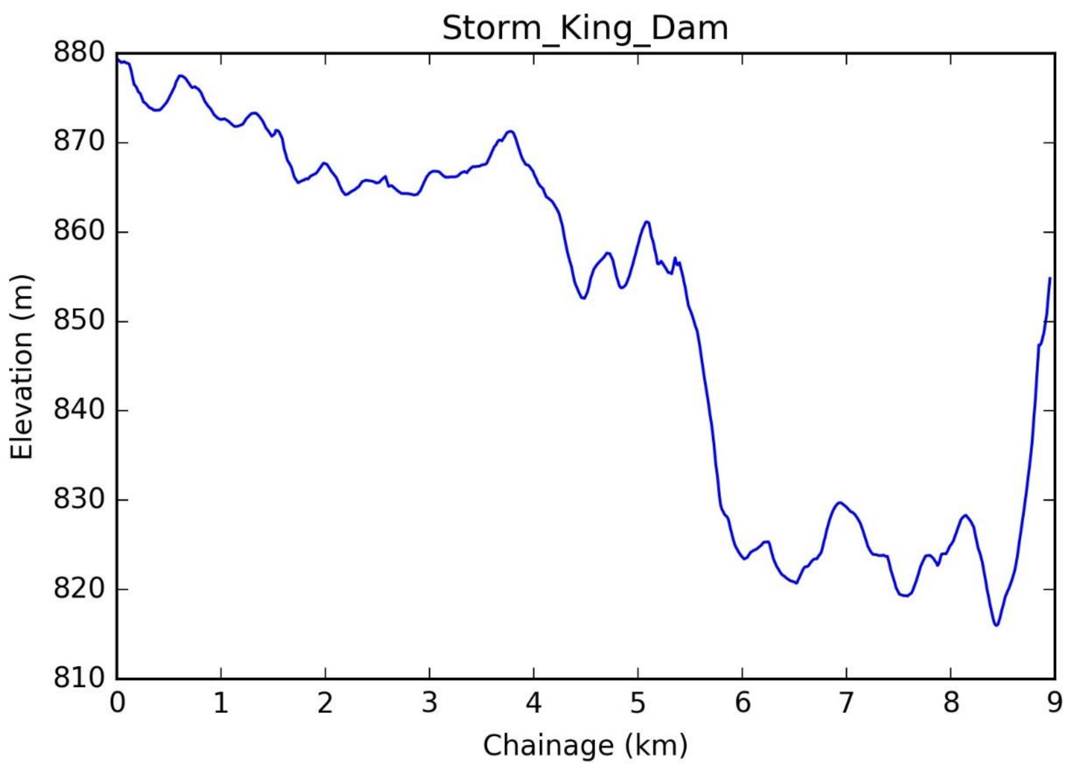


Figure 11-3 Storm King Dam - urban water pipeline long section

The main pipeline data is described in Table 11-3.

Table 11-3 Pipeline lengths and capex – Storm King Dam

Raising Storm King Dam	Length	Total Capex

	(m)	(2017)
Storm King Dam Urban Water	8,940	$3,270,000

A summary of the scheme capital and operational costs for the pipeline, pump stations, and storages are shown in Table 11-4 and Table 11-5 below.

Table 11-4 Total infrastructure capex (2017) – Storm King Dam

Areas	Pump Stations Capex (2017)	Storages & Tanks Capex (2017)	Pipelines Capex (2017)	Contingency + Design & Supervision Capex (2017)	Total Capex (2017)
Raising Storm King Dam	$383,000	$0	$3.267,000	$1,533,000	$5,183,000

Table 11-5 Total infrastructure opex (2017) – Storm King Dam

Areas	Pump Stations	Storages & Tanks	Pipelines	Total Opex per year
Raising Storm King Dam	$24,000	$0	$8,000	$32,000

11.4.2 Deliverability

While some engineering information exists regarding raising Storm King Dam, little was for the purpose of design. To develop Storm King Dam for urban supply only, the following engineering studies are required:

- Undertake yield/capacity studies to ensure the size of dam relevant to the required yield and reliability including environmental flow compliance
- Detailed survey of the site for the purpose of design
- Geotechnical investigations sufficient to establish a geological model (design surface for excavation, water tightness, faulting/jointing) and to develop geotechnical parameters for design and to investigate the suitability of materials for construction
- Hydrological modelling to enable development of the design floods passing the site
- Hydraulic modelling to route the design floods and enable design of the spillway sizing
- Computational fluid dynamics modelling to enable stilling basin and spillway channel loads to be developed
- Dam design including stability and stabilising anchors, appurtenant structures (intake tower, outlet works, etc.)
- Spillway design including stability, structures, erosion protection
- Laydown areas and constructability aspects such as river diversion
- Power, instrumentation and controls aspects.

All these studies, along with procurement for construction and a construction period have a lead-time of between 5 and 10 years.

The constructability of this project benefits from a gravity feed which lowers operational costs, as well as existing pipeline easement and diversion. The cost of raising the walls will depend on stability and whether or not anchors are necessary, the dam is due for a stability upgrade for acceptable flood capacity in the next few years irrespective of whether the dam wall is raised or not.

11.4.3 Environmental

No field investigations have been undertaken for raising Storm King Dam as part of the Stage 1 scope and information specific to environmental matters reported in documentation reviewed is limited.

A high-level desktop review of information publically available on State and Commonwealth government databases indicates the potential for the raise to impact on matters of national environmental significance (MNES) and matters of State environmental significance (MSES):

- MNES: white box-yellow box-Blakely's red gum grassy woodland and derived native grassland threatened ecological community (TEC) is Critically Endangered under the EPBC Act. In Queensland, the TEC is represented by RE13.12.8 and RE13.12.9, both of which are mapped for two small areas impacted by inundation associated with a raise of the dam.
- MNES: *Phascolarctos cinereus* (combined populations of Qld, NSW and the Australian Capital Territory (ACT)) (koala) is listed as Vulnerable under the EPBC Act (and the *Nature Conservation Act 1992* (NC Act)). Species or species habitat is recorded as 'known to occur' in areas associated with inundation footprint of a raised dam. Wildlife Online records exist for the species within the area surrounding the dam. Self-assessment under the EPBC Act referral guidelines for the vulnerable koala is required to determine the referral trigger and the level of assessment required. Field validation of the habitat and assessment of the relative impact is required to inform the self-assessment.
- MNES: *Maccullochella peelii* (Murray cod), (listed as Vulnerable) and *Wollumbinia belli* (Bell's turtle) (listed as Vulnerable) are predicted as 'may occur'. While there are no Wildlife Online records for these species within the dam area, they have been recorded elsewhere in the catchment and will need consideration in future assessments.
- MSES: Regulated vegetation listed as Endangered is mapped in two small patches potentially impacted by the inundation footprint, namely RE13.12.9/13.12.8. SKM (2005a) report a loss of 1.5 ha of Endangered RE associated with a raise. Quart Pot Creek, on which Storm King Dam is located, is mapped as regulated vegetation intersecting a watercourse. No essential habitat is mapped and connectivity areas are limited.
- MSES: High ecological significance (HES) wetlands are mapped for Quart Pot Creek immediately downstream of the existing dam wall. Environmental flows will need to be considered in this regard.
- MSES: Protected wildlife habitat is mapped for koala in two small areas associated with the inundation footprint and there are confirmed records for the species.
- MSES: Quart Pot Creek is mapped by Queensland Fisheries (Department of Agriculture and Fisheries (DAF)) as being at risk from impacts of development. The risk of impact is classified as 'major'. Assessment requirements dictate that a development approval is required for waterway barrier works (WWBW) on major risk watercourses. Fish passage will be required to be implemented to avoid and minimise impacts. Subject to assessment, offsets may be required.
- SKM (2005a) report that given Storm King Dam's location high up in the catchment and the nature and extent of land use in the catchment that impacts on water quality are

limited. Storm King Dam does not historically report issues associated with water quality and it would be expected that similar conditions persist into the future.

- Environmental flows are not currently legislated for Storm King Dam (SKM 2005a). To maintain HES wetlands downstream and support fish and aquatic fauna habitat, subject to the requirements of the Water Plan and ROP (or water management protocol as developed), environmental flows will be required. Implications for yields as forecast should be considered.
- Land use adjacent to Storm King Dam comprises intensive, residential and rural living. Some commercial operations are noted (holiday parks). The area is mapped as a priority agricultural area with pockets of strategic cropping areas (SCAs) and Class A and B agricultural land. The inundation area is estimated at a total 202 ha; 125 ha additional to existing 80 ha (SKM 2005a). Additional acquisition of land for a flood easement up to the probable maximum flood (PMF) is required (SKM 2005a).
- There are no Indigenous cultural heritage sites recorded, nor cultural heritage parties nominated for a selection of lots within the dam area. The dam site is previously disturbed and a duty of care assessment Under the Aboriginal Cultural Heritage Act 2003 (ACH Act) may be adequate to address potential impacts on cultural heritage. If an EIS is nominated as an assessment process and formal cultural heritage management plan (CHMP) will be mandatory. No Queensland or National heritage places are mapped.

An EPBC Act referral is likely to be required to address potential impacts on MNES. Subject to confirmation from Department of Environment and Energy (DEE), the action is likely to be 'not controlled' as the nature, scale and extent of the impacts on MNES are limited. It may be necessary to provide management and offset commitments in advance (at the time of referral) to secure the assessment approach and avoid a more onerous approach being decided by DEE.

State approvals for raising Storm King Dam are likely to be addressed through the development approvals under the Sustainable Planning Act 2009 and the Integrated Development Assessment System (IDAS). Of note is the development approval likely to be required for waterway barrier works (WWBW) as a result of raising the dam wall. Permits and licences under other State legislation (non-IDAS) such as the Water Act, NC Act and EP Act will also be required. Field investigations will be required to confirm the presence or absence of listed species and/or species habitat to confirm the need (or not) for a high impact species management programme. Offsets are likely to be required for MSES in accordance with the *Environmental Offsets Act 2014*.

Storm King Dam (an associated raise and supporting trunk main pipeline) achieves the use definition for a utility installation under the Southern Downs Region Planning Scheme for the Southern Downs Region area (2012), being a premises to provide the public with (amongst others) supply or treatment of water and network infrastructure. The use includes maintenance and storage depots and other facilities for the operation of the use. The dam and inundation footprint is located within the Rural Zone. Confirmation from SDRC is required with regard to whether an impact assessable material change of use (MCU) approval is triggered. Site investigations and environmental, cultural and social impact assessment would be required to satisfy reporting requirements. Opportunities for exemptions and alternative planning approval approaches should be considered in discussion with SDRC and State agencies.

Storm King Dam wall raising is a brownfield development. While not exempt from environmental assessment, the regulatory and approvals requirements are reduced, or at least more streamlined, compared to processes governing greenfield developments at Emu Swamp Dam and Ballandean Dam. SKM (2008a) concluded that an approval for raising Storm King Dam could be obtained through the IDAS process and is unlikely to require an EIS.

11.5 Emu Swamp Dam (urban and irrigation)

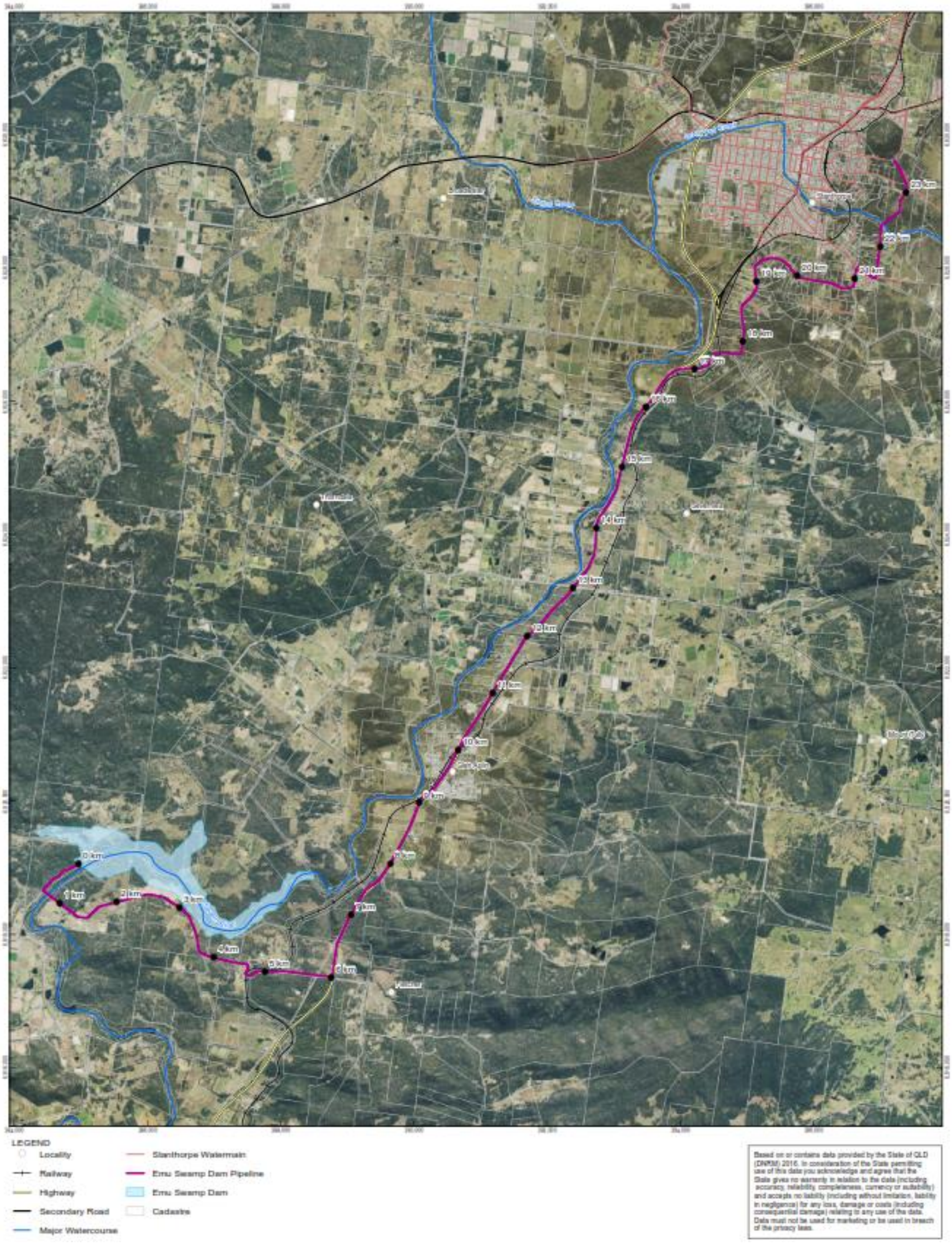


Figure 11-4 Emu Swamp Dam - urban pipeline lay out

11.5.1 Dam infrastructure

A concept design was developed by SKM (SKM 2007c) for the Emu Swamp Dam option. A Roller Compacted Concrete (RCC) dam is proposed with a vertical upstream faces and a 0.8 horizontal (H) to 1 vertical (V) downstream face. The spillway section comprises and ogee crest and stepped downstream face. No stilling basin design is shown in SKM's report suggesting that this has not been captured in SKM's cost estimates. GHD's experience is that some form of stilling basin will be required.

Flood hydrology and hydraulics were investigated by SKM but reporting on the methodology was not sighted. A low-level spillway is provided with a capacity to accommodate the 1 in 100 ARI event with the maximum design flood (1 in 100,000 ARI) being accommodated by overtopping the dam. This might be a risky strategy depending on the tailwater development and ground conditions with respect to erosion potential.

An intake tower is provided with the ability to selectively draw off water from different levels of the reservoir. The intake tower is integrated into the RCC dam. The design report does not articulate the seismicity of the site nor the structural capacity of the intake tower.

The outlet works comprise a 1,500 mm diameter steel pipe leading to a control house. The valve is a 1000 mm diameter fixed cone valve or jet flow gate.

GHD's estimate of the costs for the urban and irrigation supply Emu Swamp Dam (10,500 ML) is provided below:

Table 11-6 Urban and irrigation and urban only supply Emu Swamp Dam capex

Emu Swamp Dam	Total Capex (2017)
Urban and irrigation (10,500 ML)	$101,600,000
Urban only (5,000 ML)	$92,600,000

11.5.2 Pipe and pumping

The general concept for the Emu Swamp Dam Scheme involves a 365-day water supply with 1,500 ML for irrigation and 750 ML for water supply to Stanthorpe server from a new Emu Swamp Dam.

The proposed pipeline would be designed for urban and irrigation demand. Urban pipeline would extend 23.5 km to connect with Mount Marley Water Treatment plant and would traverse along Fletcher Road, the New England Highway, several other existing road reserves and short sections of private land. The proposed irrigation pipeline is to be supplied by the urban pipeline and would extend 96 km along existing road reserves with some short sections crossing through private land.

The distribution system carried out in previous reports compromises the following:

- 5 No. pump stations, with associated power supply and control arrangements
- 5 No. storages
- 96 km pipeline for agricultural demands only, supplied to a range of to a number of offtake points in the supply area
- 23.5 km pipeline for urban demands only (supplied to the Stanthorpe water treatment plant at Mount Marley).

Table 11-7 Pump station capacities – Emu Swamp Dam

Emu Swamp Dam - Combined Town Water System (TWS) & Irrigation	Power (kW)	Total Capex (2017)
Stanthorpe Booster Pump Station Urban	10	$224,000
Emu Swamp Dam Pump Station Irrigation	420	$2,876,000

Amiens Pump Station Irrigation	10	$224,000
Pozeries Pump Station Irrigation	50	$539,000

Table 11-8 Storages data

Emu Swamp Dam - Combined Town Water System (TWS) & Irrigation	Type	"Total Capex (2017)
Stanthorpe Balance Tank - Urban	Panel Tank	$1,175,000
Nundubbemere Balance Tank - Irrigation	Panel Tank	$928,000
Amiens Balance Tank - Irrigation	Panel Tank	$1,175,000
Summit Balance Tank - Irrigation	Panel Tank	$928,000
Pozeries Balance Tank - Irrigation	Panel Tank	$928,000

Table 11-9 Pipeline lengths

Emu Swamp Dam - Combined Town Water System (TWS) & Irrigation	Length (m)	"Total Capex (2017)
Urban	23,500	$7,940,000
Irrigation	96,301	$27,545,000

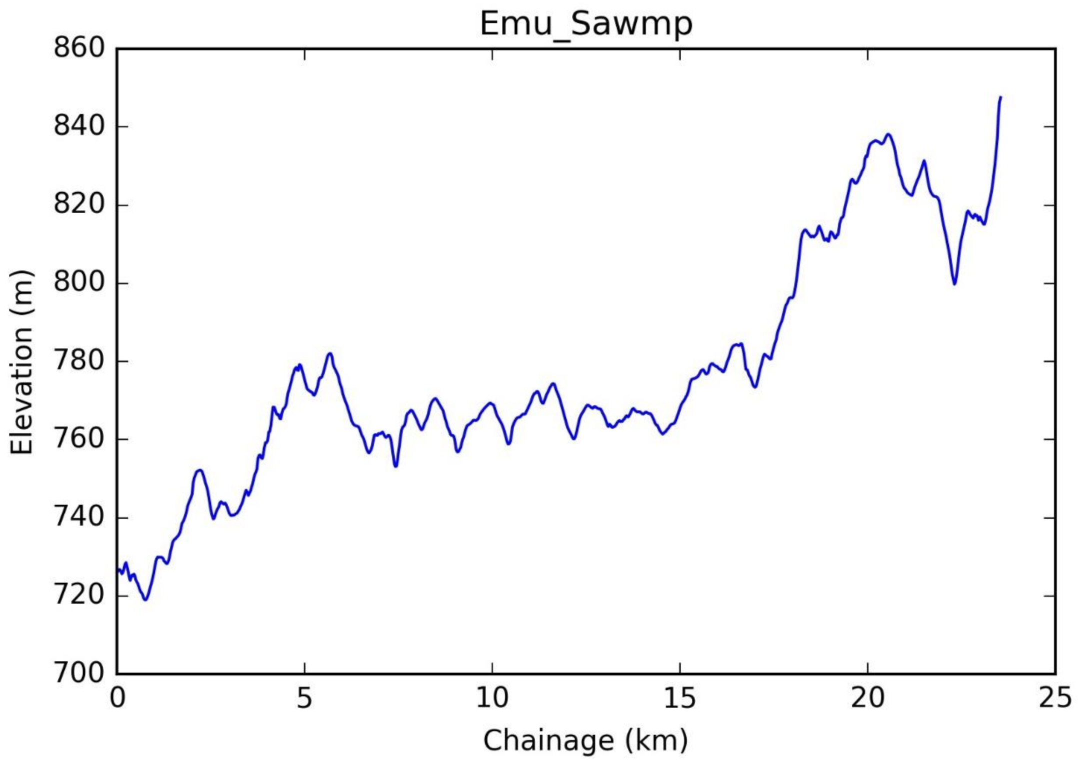


Figure 11-5 Emu Swamp Dam - urban water pipeline long section

A summary of the scheme capital and operational costs for the pipeline, pump stations, and storages are shown in Table 11-10 and Table 11-11 below.

Table 11-10 Total infrastructure capex (2017)

Areas	Pump Stations	Storages & Tanks	Pipelines	Contingency + Design & Supervision	Total Capex (2017)
Emu Swamp Dam - Urban Water	$800,000	$1,175,000	$7,940,00	$4,164,000	$17,079,000
Emu Swamp Dam - Irrigation	$3,065,000	$3,959,000	$27,545,000	$14,519,000	$49,086,000
Emu Swamp Dam - Combined	$3,864,000	5,134,000	$35,485,000	$18,683,000	$61,165,000

Table 11-11 Total infrastructure opex (2017)

Areas	Pump Stations	Storages & Tanks	Pipelines	Total Opex per year
Emu Swamp Dam - Urban Water	$8,000	$9,000	$20,000	$37,000
Emu Swamp Dam - Irrigation	$375,000	$32,000	$69,000	$476,000
Emu Swamp Dam - Combined	$383,000	$41,000	$89,000	$513,000

11.5.3 Deliverability

There is no substantial difference between the deliverability of Emu Swamp Dam compared with Storm King Dam raising as discussed in Section 11.4.2.

11.5.4 Environmental

An EIS has been completed and approved for the proposed Emu Swamp Dam project. The EIS addresses potential impacts on MNES and MSES and social and cultural values. The Queensland Coordinator-General has recommended that the project proceed subject to conditions. The Commonwealth Minister has approved the project subject to conditions.

Conditions associated with the approvals, and commitments made by SDRC do require some additional surveys and investigations, development of management plans, etc. that are required to be submitted to and approved by various regulatory agencies.

Environmental considerations associated with the proposed Emu Swamp Dam are discussed in more detail in Section 3.9. GHD notes that some of the conditions in the EIS and EA, such as offset requirements and requirements for fish ladders and turtle passage, have the potential to be prohibitively expensive.

11.6 Ballandean Dam (urban and irrigation)

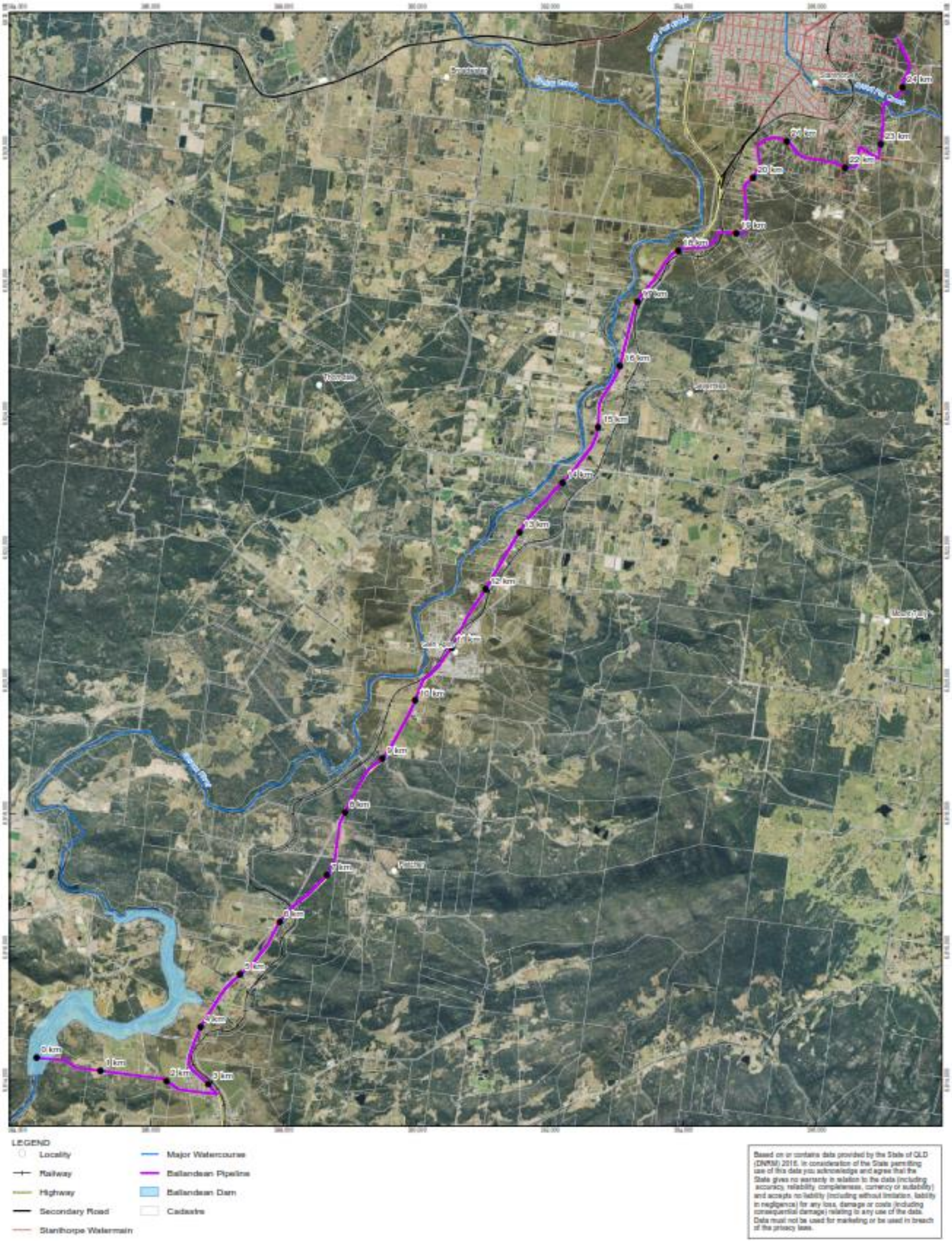


Figure 11-6 Ballandean Dam - urban supply pipe line

11.6.1 Dam infrastructure

There were no engineering designs sighted for Ballandean Dam. However, from the information available and from observing terrain contours, GHD considers that this site is likely to present lower construction risks than the Emu Swamp Dam site.

Table 11-12 Urban and irrigation and urban only supply Ballandean Dam capex

Ballandean Dam	Total Capex (2017)
Urban and irrigation (10,500 ML)	$67,500,000
Urban only (5,000 ML)	$57,700,000

11.6.2 Pipe and pumping

The proposed pipeline would be designed for urban and irrigation demand very similar to the Emu Swamp Dam. Urban pipeline would be 1 km longer than Emu Swamp Dam. Therefore, it would be required 24.5 km to connect with Mount Marley Water Treatment plant. The elevation of the dam is supposed to be at 690 m RL in comparison with Emu Swamp Dam to be at 738 m RL, which will require an additional 40 m head for the intake pump station.

The proposed irrigation pipeline is to be the same 96 km as per Emu Swamp Dam.

The distribution system carried out in previous reports compromises the following:

- 5 No. pump stations, with associated power supply and control arrangements
- 5 No. storages (similar to Emu Swamp Dam)
- 96 km pipeline for agricultural demands only, supplied to a range of to a number of offtake points in the supply area
- 24.5 km pipeline for urban demands only (supplied to the Stanthorpe water treatment plant at Mount Marley).

Table 11-13 Pump station capacities and capex– Ballandean Dam

Emu Swamp Dam - Combined Town Water System (TWS) & Irrigation	Power (kW)	Total Capex (2017)
Stanthorpe Booster Pump Station Urban	10	$224,000
Ballandean Pump Station Irrigation	490	$3,217,000
Amiens Pump Station Irrigation	10	$224,000
Pozeries Pump Station Irrigation	50	$539,000

Table 11-14 Storages data – Ballandean Dam

Emu Swamp Dam - Combined Town Water System (TWS) & Irrigation	Type	Total Capex (2017)
Stanthorpe Balance Tank - Urban	Panel Tank	$1,175,000
Nundubbemere Balance Tank - Irrigation	Panel Tank	$928,000
Amiens Balance Tank - Irrigation	Panel Tank	$1,175,000
Summit Balance Tank - Irrigation	Panel Tank	$928,000
Pozeries Balance Tank - Irrigation	Panel Tank	$928,000

Table 11-15 Pipeline lengths – Ballandean Dam

Emu Swamp Dam - Combined Town Water System (TWS) & Irrigation	Length (m)	Total Capex (2017)
Urban	24,500	$8,297,000
Irrigation	96,301	$27,545,000

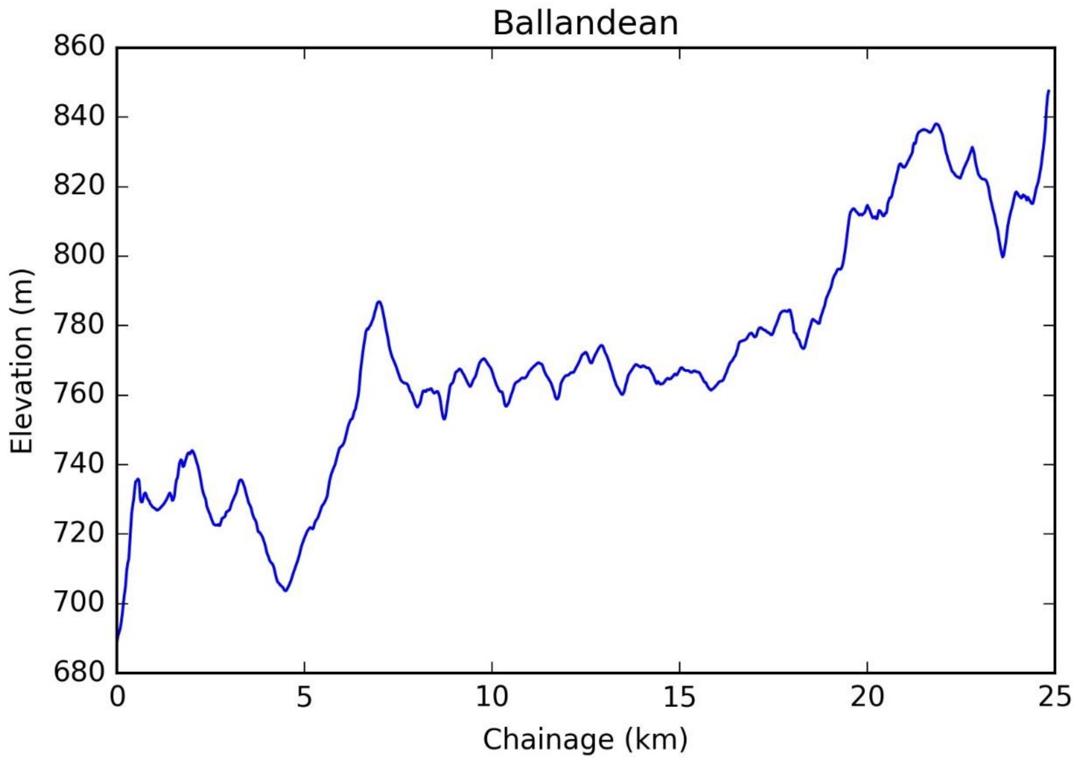


Figure 11-7 Ballandean - urban water pipeline long section

A summary of the scheme capital and operational costs for the pipeline, pump stations, and storages are shown in Table 11-10 and Table 11-11 below.

Table 11-16 Total infrastructure capex (2017) – Ballandean Dam

Areas	Pump Stations	Storages & Tanks	Pipelines	Contingency + Design & Supervision	Total Capex (2017)
Ballandean Dam - Urban Water	$868,000	$1,175,000	$8,297,000	$4,343,000	$14,683,000
Ballandean Dam - Irrigation	$3,337,000	$3,959,000	$27,545,000	$14,633,000	$49,474,000
Ballandean Dam - Combined	$4,205,000	$5,134,000	$35,842,000	$18,976,000	$64,157,000

Table 11-17 Total infrastructure opex (2017)

Areas	Pump Stations	Storages & Tanks	Pipelines	Total Opex per year
Ballandean Dam - Urban Water	$8,0000	$9,000	$21,000	$38,000
Ballandean Dam - Irrigation	$430,000	$32,000	$69,000	$530,000
Ballandean Dam - Combined	$438,000	$41,000	$90,000	$568,000

11.6.3 Deliverability

There is no substantial difference between the deliverability of Emu Swamp Dam compared with Storm King Dam raising as discussed in Section 11.4.

11.6.4 Environmental

No field investigations have been undertaken in relation to the proposed Ballandean Dam as part of the Stage 1 scope and information specific to environmental matters reported in documentation reviewed is limited.

A high-level desktop review of information publically available on State and Commonwealth government databases indicates the potential for construction and operation of a new dam on the Severn River at the proposed Ballandean site to impact on MNES and MSES. Conclusions are also drawn from the EIS and Supplementary EIS prepared for the proposed Emu Swamp Dam project based on the proximity to the proposed Ballandean site. MNES and MSES and other cultural and social environmental values and impacts are discussed below:

- MNES: white box-yellow box-Blakely's red gum grassy woodland and derived native grassland TEC is Critically Endangered under the EPBC Act. In Queensland, the TEC is represented by RE13.3.1 which is mapped for areas impacted by inundation
- MNES: *Melaleuca williamsii* (syn. *Callistemon pungens*), listed as Vulnerable under the EPBC Act, is recorded for the area through Wildlife Online records. The species is recorded from field validation surveys undertaken from Emu Swamp Dam upstream of the Ballandean site. Essential habitat is mapped for the species with the mandatory RE 13.3.1 also mapped for the area.
- MNES: Koala is listed as Vulnerable under the EPBC Act (and the NC Act). Species or species habitat is recorded as 'known to occur' in areas associated with the inundation footprint. No Wildlife Online records exist. SKM (2008a) recorded koala as present in the area for Emu Swamp Dam. Self-assessment under the EPBC Act referral guidelines for the vulnerable koala is required to determine the referral trigger and the level of assessment required. Field validation of the habitat and assessment of the relative impact is required to inform the self-assessment.
- MNES: *Chalinolobus dwyeri* (large-eared pied bat) (listed as Vulnerable under the EPBC Act) *Dasyurus maculatus* (SE mainland population) (spot-tailed quoll) (Endangered under the EPBC Act), *Kardomia granitica* (shrub) (Vulnerable under the EPBC Act), *Rhipidura rufifrons* (rufous fantail) (Migratory terrestrial species under the EPBC Act) and *Haliaeetus leucogaster* (white-bellied sea eagle) (migratory marine under the EPBC Act) are predicted 'known to occur'. Species are not recorded through Wildlife Online. Large-eared

pied bat and spot-tailed quoll are recorded from field validation surveys undertaken for Emu Swamp Dam and are likely to be present in the Ballandean area.

- MNES: Murray cod (listed as Vulnerable) does not occur naturally in the Severn River system and fish stocking has sustained population since the mid-1900s (SKM 2008a). Bell's turtle (listed as Vulnerable) was record from field surveys undertaken for Emu Swamp Dam in Bald Rock creek and a weir pool at Somme Land, which are downstream from the proposed Emu Swamp dam site (SKM 2008a). It is expected therefore that the species may be present within the Ballandean area and will need consideration in future assessments.
- MSES: Regulated vegetation listed as Endangered is mapped in the area potentially by the inundation footprint, namely RE13.3.1 and RE13.12.9. SKM (2005a) report a loss of 67.4 ha of RE13.3.1 and 2.8 ha of RE13.12.9 associated with a dam at Ballandean. Total RE impacted is 67.7 ha (including 0.5 ha of RE13.12.5 which is not of concern). The Severn River is mapped as regulated vegetation intersecting a watercourse. Essential habitat is mapped with *Melaleuca williamsii* subsp *Fletcheri* recorded mandatory RE13.3.1 mapped. Connectivity areas are likely to be impacted.
- MSES: High ecological significance (HES) wetlands are mapped for areas within the Severn River impacted by a proposed Ballandean Dam. Environmental flow impacts upstream (within the proposed impoundment area) and downstream will need to be considered in this regard. Offsets may be required.
- MNES: The proposed Ballandean Dam project areas are within areas mapped as being within high-risk flora survey trigger areas. This requires specific surveys to be undertaken in accordance with DEHP guidelines, including a 100 m from the impact area. *Melaleuca williamsii* is recorded for the area and subject to survey likely requires a high impact species management programme to be developed to mitigate, manage and offset impacts on the species
- MSES: Based on Emu Swamp Dam is likely that protected wildlife habitat is mapped for koala in inundation footprint areas and there are confirmed records for the species.
- MSES: The Severn River is mapped by Queensland Fisheries (Department of Agriculture and Fisheries (DAF)) as being at risk from impacts of development. The risk of impact is classified as 'major'. Assessment requirements dictate that a development approval is required for waterway barrier works (WWBW) on major risk watercourses. Fish passage will be required to be implemented to avoid and minimise impacts. Subject to assessment, offsets may be required.
- SKM (2008a) report for the proposed Emu Swamp Dam that existing water quality within and upstream and downstream of the proposed site are generally within water quality objective criteria. Ballandean is slightly lower in the catchment with more opportunity for catchment runoff to impact on water quality. However, it is unlikely to differ significantly to that reported for the proposed Emu Swamp Dam. As for Emu Swamp Dam, the current level of development in the catchment is compatible with dam development (SKM 2005a)
- Operational management and controls defined in the Emu Swamp Dam EIS (SKM 2008a) would be applicable to the operation of the proposed Ballandean Dam and would need to be considered in future assessments.
- Environmental flows will be required to comply with the Water Plan and ROP (or water management protocol as developed to maintain HES wetlands downstream and support fish and aquatic fauna habitat. Yield analysis reported in SKM 2005a, based on water balance undertaken by SKM (1997) assumes that flows of less than the 10^{th} percentile would need to be released from the dam for environmental purposes.

- Land use adjacent to the proposed Ballandean Dam comprises: mostly grazing native vegetation; some intensive uses (residential, rural living); irrigated cropping; and irrigated seasonal horticulture. The area is mapped as a priority agricultural area with pockets of strategic cropping areas (SCAs) and Class A and B agricultural land. The inundation area is estimated at 116 ha (based on a dam with a capacity of 3,750 ML at FSL and a spillway height of 11.5 m) (SKM 2005a). Additional acquisition of land for a flood easement up to the PMF will be required.
- There are no Indigenous cultural heritage sites recorded, nor cultural heritage parties nominated for a selection of lots within the proposed dam area. It is expected however that cultural heritage values will be similar to those associated with Emu Swamp Dam. It is expected that cultural heritage surveys and management of cultural heritage will be required. Where an EIS is used as the assessment approach a CHMP is mandatory. No Queensland or National heritage places are mapped, but similarly historical or European history surveys and management measures will be required, consistent with findings reported in the Emu Swamp Dam EIS (SKM 2008a).

An EPBC Act referral is likely to be required to address potential impacts on MNES. Subject to confirmation from DEE, the action is likely to be ‘controlled’ with assessment by EIS requested as a result of the nature, scale and extent of the impacts on MNES.

Assessment of environmental impacts associated with the construction and operation of a new dam at Ballandean are likely best addressed through declaration of the project as a ‘coordinated project’ with assessment by EIS coordinated by the Queensland Coordinator-General. A bilateral assessment process can apply to address MNES and MSES in a single EIS. This process will support subsequent planning and environmental approvals. Investigations and development of an EIS is estimated to at two years plus, with additional time to develop subsequent approvals and to implement and comply with EIS approval conditions and commitments.

Estimated timeframes would be in the order of five years, subject to availability of information (including design, construction and operations information) and consultation requirements. Conditions can be expected to be similar to those imposed, stated and recommended for Emu Swamp Dam project.

Field investigations will be required to confirm the presence or absence of listed species and/or species habitat to confirm the need (or not) for a high impact species management programme. Offsets are likely to be required for MSES in accordance with the *Environmental Offsets Act 2014* and for MNES under the EPBC Act.

As for the proposed Emu Swamp Dam, GHD expects that SDRC would seek to designate land for community purposes (a community infrastructure designation (CID)) in relation to the Ballandean site. This will provide some exemptions from approvals and permits required under State legislation. The EIS developed for the proposed Ballandean Dam project can be used to support a CID application. SDRC Planning Scheme will not apply to the project if a CID is obtained.

11.7 Connolly Dam Pipeline – urban only

The Connolly Dam was built near the junction of Rosenthall and Fitz Creeks (tributaries of the Upper Condamine River) in 1927 to provide the primary source of Warwick's urban water supply. The dam is owned and operated by SDRC and is located 15 km southeast of Warwick with a catchment area of approximately 130 km^2.

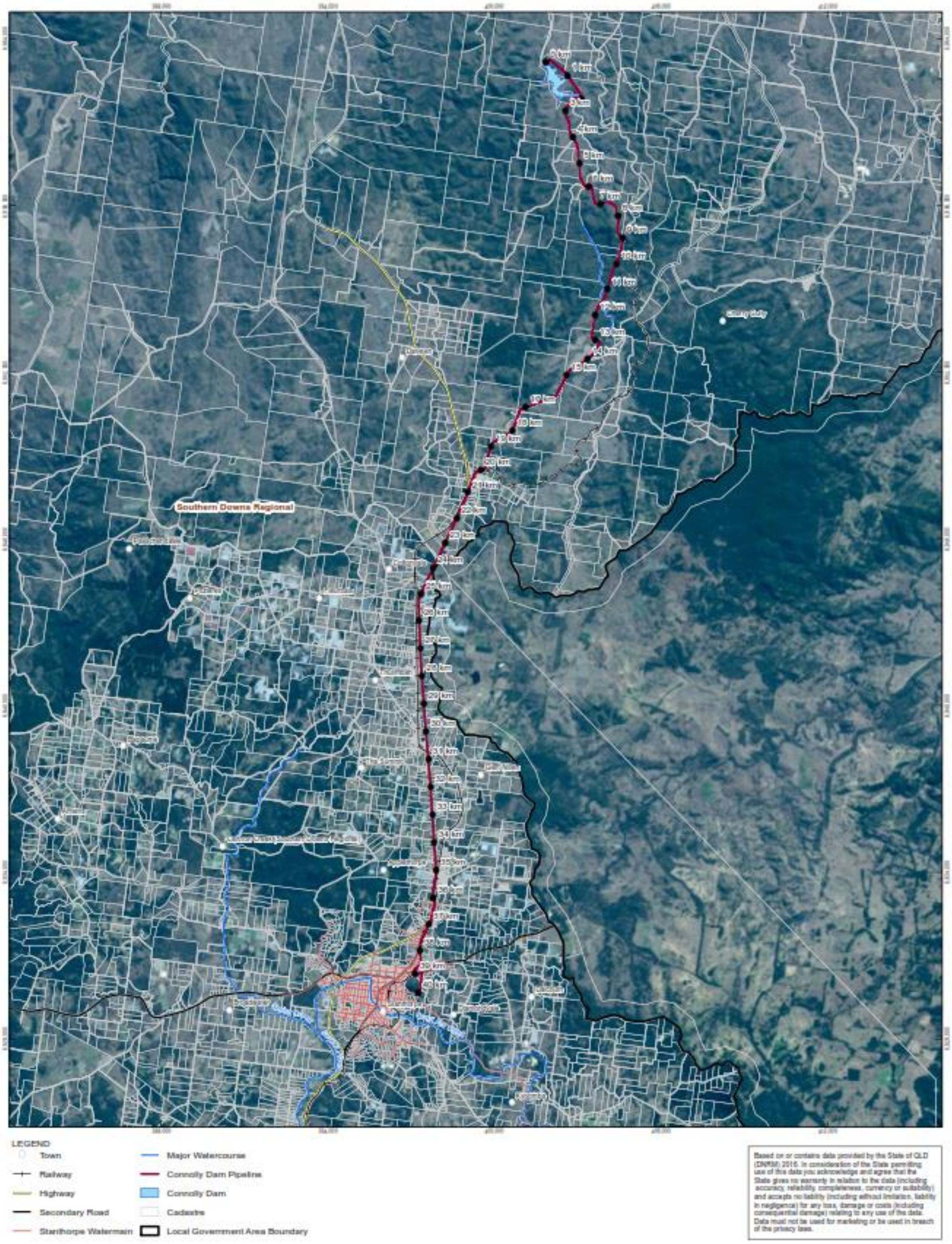


Figure 11-8 Connolly Dam Pipeline - urban supply pipeline

11.7.1 Pipe and pumping

The proposed pipeline would be designed from Connolly Dam to Marley Water Treatment Plant water pumped from Connolly Dam along a 40 km pipeline against a static pumping head of 435 metres. A balancing tank would be required at The Summit where the flow will by gravity.

The distribution system carried out in previous reports compromises the following:

- 1 No. intake pump station , with associated power supply and control arrangements
- 1 No. storage
- 40 km pipeline for urban demands only (supplied to the Stanthorpe water treatment plant at Mount Marley).

Table 11-18 Pump Station Capacities – Connolly Dam

Connolly Dam Pipeline	Power (kW)	Total Capex (2017)
Connolly Dam Intake Pump Station	220	$1,734,000

Table 11-19 Storages data – Connolly Dam

Connolly Dam Pipeline	Type	Total Capex (2017)
Summit Balance Tank	Panel Tank	$1,175,000

Table 11-20 Pipeline lengths – Connolly Dam

Connolly Dam Pipeline	Length (m)	Total Capex (2017)
Urban water pipeline	40,071	$14,416,000

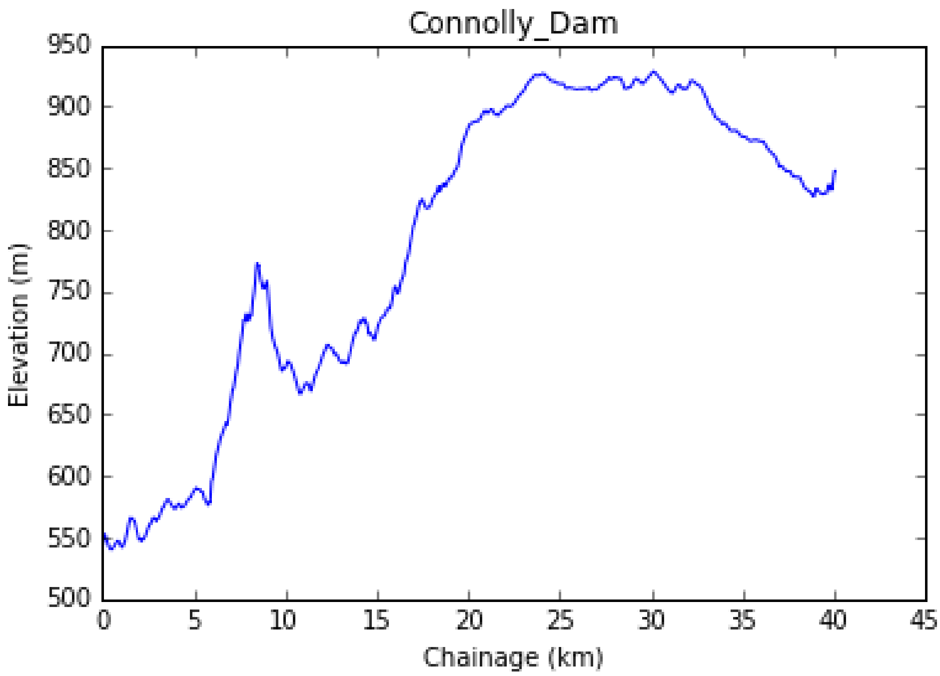


Figure 11-9 Connolly Dam - urban water pipeline long section

A summary of the scheme capital and operational costs for the pipeline, pump stations, and storages are shown in Table 11-21 and Table 11-22 below.

Table 11-21 Total Infrastructure capex (2017) – Connolly Dam

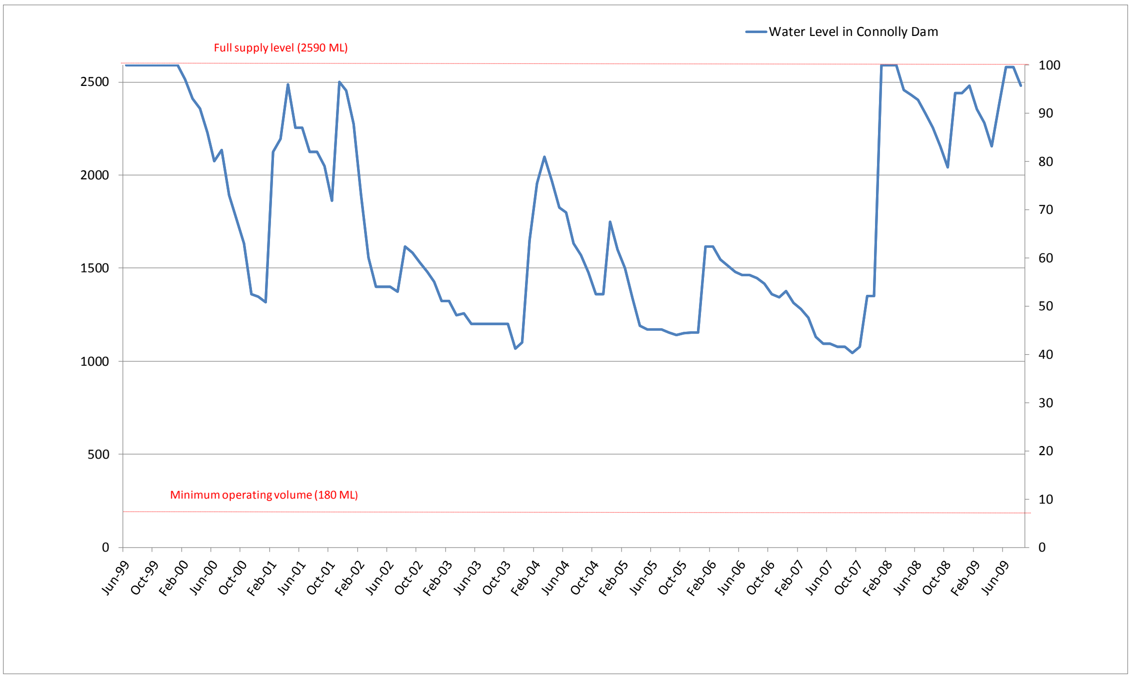
Areas	Pump Stations	Storages & Tanks	Pipelines	Contingency + Design & Supervision	Total Capex (2017)
Connolly Dam Pipeline	$1,734,000	$1,175,000	$14,416,000	$7,277,000	$24,602,000

Table 11-22 Total infrastructure opex (2017) – Connolly Dam

Areas	Pump Stations	Storages & Tanks	Pipelines	Total Opex per year
Connolly Dam Pipeline	$172,000	$9,000	$36,000	$217,000

11.7.2 Yield and water allocations

Over the last 8 years (July 2008 to June 2016) Connolly Dam supplied an average of 23% (range: 21.1% to 25.7%) of Warwick's annual water supply (Personal comment, DEWS 17/5/2017). Utilising water stored in Connolly Dam minimises costs to ratepayers as it does not attract SunWater charges (as does water supplied from Leslie Dam). Preliminary modelling, as advised by DEWS, suggests that during extended dry periods the dam water level may drop below minimum operating levels (Ibid.). However, actual storage level data is only available from 1999 to 2009 and is shown below in Figure 11-10.



Source: (DEWS 2017).

Figure 11-10 Connolly Dam - storage level 1999 - 2009

Connolly Dam's yield has historically been poorly defined with modelling currently being undertaken by Department of Science, Information Technology and Innovation (DSITI) as part of the DEWS study into Warwick's water security. It remains unclear the volume of water that could be reliably supplied to Stanthorpe from Connolly Dam in the event Warwick sourced none (or a more limited volume) of its water from Connolly Dam. However, it is apparent that this would result in significant trade-offs (e.g. increasing costs to Warwick's rate payers as water supply costs increased) and it would need to be considered in the context of Warwick's forecast growth and the capacity of Leslie Dam to reliably meet this forecast increase in water demand.

Under current operating arrangements, GHD expects that Connolly Dam would be an unreliable source of water to meet Stanthorpe's future water demand in the medium to long term, particularly during extended dry periods. Preliminary modelling also suggests that this would be further challenged when Warwick's future urban water demand exceeds 3,200 ML/a.

11.7.3 Environmental

Approval triggers associated with construction of a new pipeline would not likely require an EIS and can be addressed through IDAS and relevant State legislation. There is more likely opportunity to avoid or mitigate impacts on environmental values when building a pipeline as route selection can focus on the use of already cleared and disturbed land, be contained within existing road or rail reserves or power easements, temporarily impact on water course areas during construction, etc. Environmental values are likely to be limited within these areas and impacts not deemed significant. The regulatory process is therefore simpler and provided route selection and a concept design are developed investigations and approvals can generally be achieved with a 12-month period.

11.8 Leslie Dam Pipeline – urban only

Leslie Dam is located on Sandy Creek approximately 12 km west of Warwick. At full capacity, the dam holds in the order of 106,200 ML. Leslie Dam was first commissioned in 1965. Increasing water demand resulted in the dam being raised and radial gates added in 1986, to more than double the dam's original storage capacity.

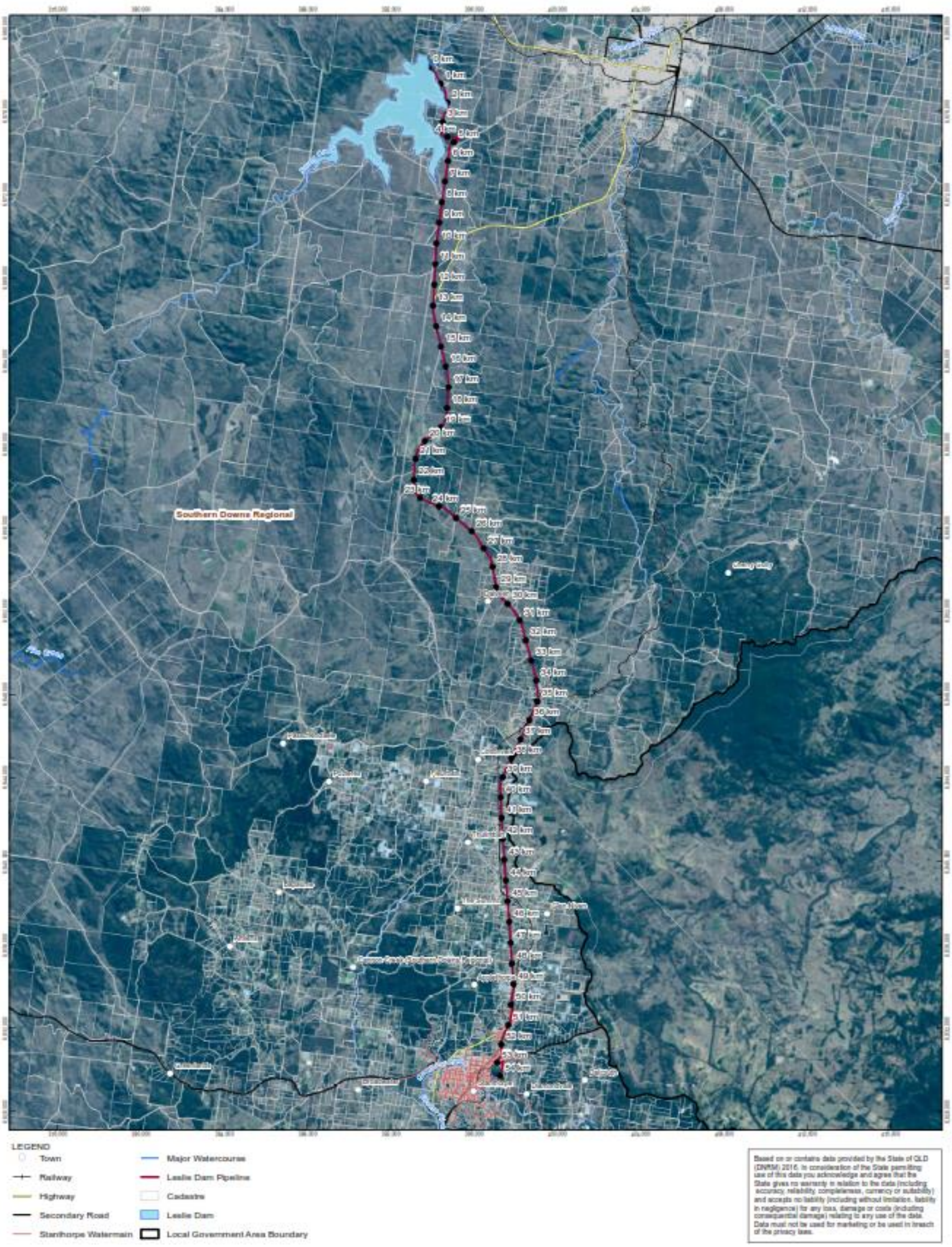


Figure 11-11 Leslie Dam Pipeline - urban only lay out

11.8.1 Pipe and pumping

The proposed pipeline would be designed from Connolly Dam to Marley Water Treatment Plant water pumped from Leslie Dam along a 54 km long pipeline against a static pumping head of 461 metres. A balancing tank would be required at The Summit where the flow will by gravity.

The distribution system carried out in previous reports compromises the following:

- 1 No. intake pump station, with associated power supply and control arrangements

- 1 No. storages
- 54 km pipeline for urban demands only (supplied to the Stanthorpe water treatment plant at Mount Marley).

GHD's estimates of costs for this option are provided below.

Table 11-23 Pump station capacities – Leslie Dam

Leslie Dam Pipeline	Power (kW)	Total Capex (2017)
Leslie Dam Intake Pump Station	260	$1,984,000

Table 11-24 Storages data – Leslie Dam

Leslie Dam Pipeline	Type	"Total Capex (2017)
Summit Balance Tank	Panel Tank	$1,175,000

Table 11-25 Pipeline lengths – Leslie Dam

Leslie Dam Pipeline	Length (m)	Total Capex (2017)
Urban water pipeline	54,107	$19,359,000

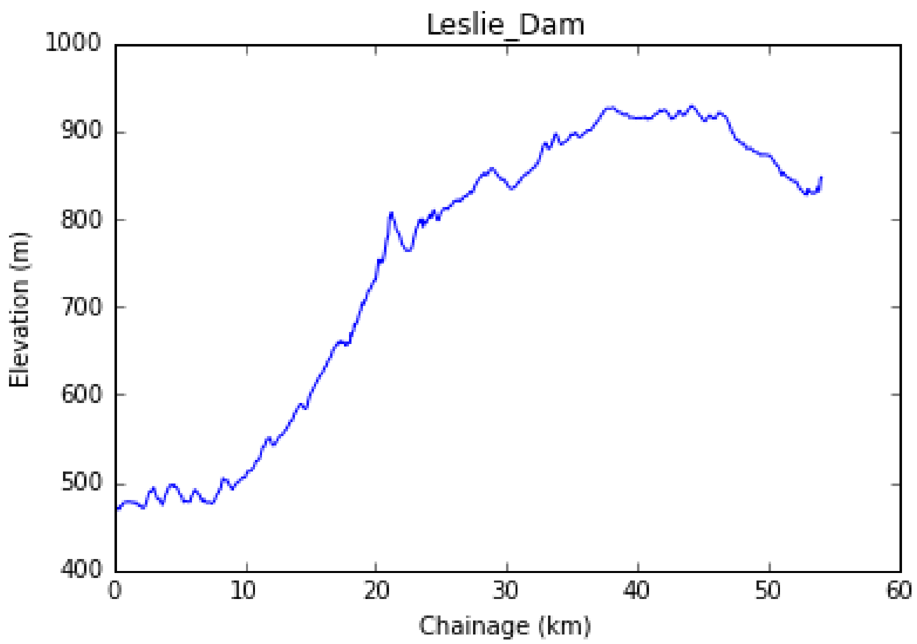


Figure 11-12 Leslie Dam - urban water pipeline long section

A summary of the scheme capital and operational costs for the pipeline, pump stations, and storages are shown in Table 11-10 and Table 11-11 below.

Table 11-26 Total infrastructure capex (2017) – Leslie Dam

Areas	Pump Stations	Storages & Tanks	Pipelines	Contingency + Design & Supervision	Total Capex (2017_
Connolly Dam Pipeline	$1,984,000,	$1,175,000	$19,359,000	$9,458,000	$31,976,000

Table 11-27 Total infrastructure opex (2017) – Leslie Dam

Areas	Pump Stations	Storages & Tanks	Pipelines	Total Opex per year
Leslie Dam Pipeline	$203,000	$9,000	$48,000	$261,000

11.8.2 Yield and water allocations

Whilst Leslie Dam is a relatively large dam for the area, GHD has been advised by DEWS (15/05/17) that it is fully committed and therefore should not be considered as an option for augmenting supplies from Storm King Dam. As such, GHD has not considered this option further.

11.8.3 Environmental

Approval triggers associated with construction of a new pipeline would not likely require an EIS and can be addressed through IDAS and relevant State legislation. There is more likely opportunity to avoid or mitigate impacts on environmental values when building a pipeline as route selection can focus on the use of already cleared and disturbed land, be contained within existing road or rail reserves or power easements, temporarily impact on water course areas during construction, etc. Environmental values are likely to be limited within these areas and impacts not deemed significant. The regulatory process is therefore simpler and provided route selection and a concept design are developed investigations and approvals can generally be achieved with a 12-month period.

12. Short list option assessment

In this section a combination of economic, environmental, social impact and deliverability assessments are used to establish those options that GHD recommends to be taken to Stage 2 (Preliminary Business Case).

12.1 Short list options financial assessment

Using the capital costs developed for each option as described in Sections 10 and 11 together with the urban and irrigation demand projections, GHD has produced discounted cash expenditure and water demand models (covering the period 2017 to 2050) for urban and irrigation supplies for each of the shortlisted options. This has enabled an economic comparison between options covering:

- Levelised cost of water $/ML at a 10% discount rate (nominal pre-tax) (the amount that would need to be paid pre ML to meet the 10% hurdle rate (discount rate)
- Total capex/yield ($/ML)
- Total capex/yield$_{p.a.}$ ($/ML$_{p.a.}$)
- Total capex/capacity ($/ML)
- Present value (PV) of total costs/ML$_{p.a}$ (the one-off up-front payment that an irrigator would need to pay secure water supplies over the period of assessment (33 years) being the total fixed costs for those supplies i.e. excluding variable costs)
- Total bulk supply capex $2017
- Total distribution capex $2017
- Total capex $2017
- Urban distribution opex $2017
- Irrigation distribution opex $2017
- Total Opex $2017

GHD has used these metrics to inform the economic criteria used on its multi criteria analysis MCA analysis (Section 12.2).

The results are separated into urban supply only options covering:

- Integrated Water Supply Management
- Raising Storm King Dam
- Emu Swamp Dam (5,000 ML for town water supply only (TWS))
- Ballandean Dam (5,000 ML for TWS only)
- Pipeline from Connolly dam

an irrigation only option in the form of on-farm storage (Table 12-2) which may be combined with any of the above urban only solutions taken forward to provide an urban and irrigation water solution and combined major dam infrastructure urban and irrigation supply options (Table 12-3) covering:

- Emu Swamp Dam (10,500 ML urban and irrigation supply and distribution)
- Ballandean Dam (10,500 ML urban and irrigation supply and distribution).

Finally the irrigation supply only component metrics for the combined major dam infrastructure and on-farm storage are compared in Table 12-4.

Table 12-1 Urban only supply options economic assessment

URBAN ONLY										
Supply Option		Raising SKD		ESD TWS		BD TWS		CD Pipeline TWS		IWSM
LCOW (Regular Demand)	●	$4,300	●	$9,700	●	$7,000	●	$2,600	●	$400
LCOW (Dry Demand)	●	$3,700	●	$8,400	●	$6,000	●	$2,200	●	$300
Total Capex/Yield ($ '17/ML)	●	$5,300	●	$4,000	●	$2,900	●	$2,700	●	$500
Total Capex/Yield p.a. ($ '17/ML p.a.)	●	$160,000	●	$120,000	●	$86,000	●	$81,000	●	$14,000
Total Capex/Capacity ($ '17/ML)	●	$7,800	●	$18,000	●	$12,900				
PV Total Costs/ML ($ '17/ML)	●	$161,500	●	$121,000	●	$86,700	●	$96,400		
Supply Capex $2017	●	$41,900,000	●	$92,600,000	●	$61,700,000	●	$300,000	●	$7,100,000
Urban Dist Capex $(2017)	●	$5,000,000	●	$13,500,000	●	$14,100,000	●	$23,600,000		
Total Capex $(2017)	●	$46,900,000	●	$106,100,000	●	$75,800,000	●	$23,800,000	●	$7,100,000
Urban Dist Opex $(2017)	●	$33,000	●	$39,000	●	$40,000	●	$227,000		
Total Opex $(2017)	●	$33,000	●	$39,000	●	$40,000	●	$227,000		

Table 12-2 On-farm storage irrigation water supply option economic assessment

URBAN ONLY	IRRIGATION ONLY	
Supply Option	OFS ONLY	
LCOW (Regular Demand)	●	$300
LCOW (Dry Demand)	●	$300
Total Capex/Yield ($ '17/ML)	●	$3
Total Capex/Yield p.a. ($ '17/ML p.a.)	●	$100
Supply Capex $2017	●	$6,000,000
Total Capex $(2017)	●	$6,000,000

The on-farm storage option can be combined with any of the urban only options taken forwards to provide a combined urban and irrigation supply option that results in lower cost metrics than either of the large dam urban and irrigation supply options set out in Table 12-3.

Table 12-3 Combined urban and irrigation supply option economic assessment

	URBAN AND IRRIGATION	
Supply Option	ESD Urban and Irrigation	BD Urban and Irrigation
LCOW (Regular Demand)	$4,500	$3,600
LCOW (Dry Demand)	$3,900	$3,100
Total Capex/Yield ($ '17/ML)	$2,200	$1,700
Total Capex/Yield p.a. ($ '17/ML p.a.)	$65,000	$52,000
Total Capex/Capacity ($ '17/ML)	$15,400	$6,400
PV Total Costs/ML ($ '17/ML)	$58,700	$46,700
PV Irrigation Costs/Discounted Irrigation ML ($ '17/ML)	$56,500	$46,600
Supply Capex $2017	$101,600,000	$67,500,000
Urban Dist Capex $(2017)	$13,500,000	$14,100,000
Irrigation Dis Capex $(2017)	$47,000,000	$47,400,000
Total Capex $(2017)	$162,100,000	$129,000,000
Urban Dist Opex $(2017)	$39,000	$40,000
Irrigation Dis Opex $(2017)	$497,000	$554,000
Total Opex $(2017)	$536,000	$594,000

Table 12-4 Comparison of irrigation only infrastructure component metrics from irrigation water supply options

Comparison of Irrigation Water Only Supply Metrics from Irrigation Supply Options			
Supply Option	**ESD Urban and Irrigation**	**BD Urban and Irrigation**	**OFS ONLY**
LCOW (Regular Demand)	$4,500	$3,600	$300
LCOW (Dry Demand)	$3,900	$3,100	$300
Total Capex/Yield p.a. ($ '17/ML p.a.)	$65,000	$52,000	$100
Total Capex/Capacity ($ '17/ML)	$15,400	$6,400	$3,429
PV Irrigation Costs/Discounted Irrigation ML ($ '17/ML)	$56,500	$46,600	$4,300
Total Irrigation Supply Component of Capex	$118,120,000	$94,650,000	$6,000,000
Irrigation Distribution Opex	$497,000	$554,000	$0

Analysis of the above data indicates that the IWSM solutions offers a more attractive economic option than any of the major capital infrastructure options. However, the analysis indicates that this option is unlikely to achieve the sustained 30% savings required to enable the existing infrastructure (Storm King Dam) to meet the 2050 urban demand requirement. As such, a major capital infrastructure option is required at some stage to meet projected urban demand. However, GHD considers that by implementing a robust IWSM programme may defer major capital infrastructure by between four and six years.

With respect to meeting irrigator supply needs, the on-farm storage option (market led with irrigators bidding for water allocation and augmenting existing on-farm storage infrastructure) is a significantly more cost effective solution than a large dam to meet irrigation and urban water needs. However, the reliability of the water will not be as high from on-farm storage as from a dam due to higher evaporation loss and reliance on recharge during a season leading to potential shortages during drought periods. This reduced reliability is compensated by the difference in costs, and could be mitigated by measures such a covers to reduce evaporation loss. It is unlikely that the additional costs of large dam solution would make the additional premium required to provide high reliability water to irrigators viable without significant government subsidy.

GHD has compared the calculated levelised cost of water for each option with the net annual benefit (representing the economic maximum $/ML$_{p.a.}$ that an irrigator will be able to pay for additional water by crop type).

GHD has also compared the calculated PV of all future costs per ML$_{p.a}$. with the total net on-farm return (representing the PV of all future net benefits per ML) respectively. The irrigator ability to pay amounts have been determined through GHD's consultation process with irrigators and via economic analysis of the benefit derived per ML of water by crop type. This analysis allows a direct comparison between the cost of water by option and the net benefit to irrigators of that water.

The full analysis for each crop type considered and for all crop types as a weighted average per volume of additional water allocated to each crop type on a merit order basis is detailed in Table 12-5.

Table 12-5 Comparison of calculated cost of water with net economic benefit of additional water to irrigators

Option		Emu Swamp Dam - Irrigation	Ballandean Dam - Irrigation	On-Farm Storage
LCOW - Irrigation ($ '17/ML)		$ 4,500	$ 3,600	$ 300
Net Annual Benefit ($ '17/ML p.a.)	Apples (existing - low water security producers)	$ 4,150	$ 4,150	$ 4,150
	Apples (existing - high water security producers)	$ 2,350	$ 2,350	$ 2,350
	Apples (new crops)	$ 3,150	$ 3,150	$ 3,150
	Tomatoes (new crops)	$ 3,550	$ 3,550	$ 3,550
	Strawberries (new crops)	$ 5,250	$ 5,250	$ 5,250
	Wine Grapes (existing)	$ 1,850	$ 1,850	$ 1,850
	Wine Grapes (new crops)	$ 2,250	$ 2,250	$ 2,250
	Strawberry Runners (new crops)	$ 1,050	$ 1,050	$ 1,050
	Green Vegetables (existing)	$ 2,350	$ 2,350	$ 2,350
	Green Vegetables (new)	$ 2,850	$ 2,850	$ 2,850
	Average Weighted by volume by crop	$ 3,300	$ 3,300	$ 3,300

Option		Emu Swamp Dam - Irrigation	Ballandean Dam - Irrigation	On-Farm Storage
PV Irrigation Costs/Irrigation Yield ($ '17/ML)		$ 56,500	$ 46,600	$ 2,900
Total On-Farm Return ($ '17/ML)	Apples (existing - low water security producers)	$ 41,500	$ 41,500	$ 41,500
	Apples (existing - high water security producers)	$ 23,500	$ 23,500	$ 23,500
	Apples (new crops)	$ 31,500	$ 31,500	$ 31,500
	Tomatoes (new crops)	$ 35,500	$ 35,500	$ 35,500
	Strawberries (new crops)	$ 52,500	$ 52,500	$ 52,500
	Wine Grapes (existing)	$ 18,500	$ 18,500	$ 18,500
	Wine Grapes (new crops)	$ 22,500	$ 22,500	$ 22,500
	Strawberry Runners (new crops)	$ 10,500	$ 10,500	$ 10,500
	Green Vegetables (existing)	$ 23,500	$ 23,500	$ 23,500
	Green Vegetables (new)	$ 28,500	$ 28,500	$ 28,500
	Average Weighted by volume by crop	$ 32,600	$ 32,600	$ 32,600

Only on-farm storage delivers water at an economic maximum price irrigators will be able to pay for all crop types. Large dam options could only supply water at a price irrigators are able to pay for strawberries.

However, it is unlikely that irrigators will be willing to pay this maximum economic rate for water in the long run. The sensitivity to market prices analysis, a 10% reduction in prices results in a 40% reduction in net benefits. GHD also understand from discussions with SDRC that some irrigators are unwilling to pay $180/ML for recycled water that is an order of magnitude below the above figures. GHD has also been advised, anecdotally by irrigators in the Stanthorpe region, that irrigators over the state boundary in New South Walers are paying $240/ML.

Finally, from the stakeholder consultation with irrigators, GHD understands that a significant proportion of the additional water that would be made available by a large dam option would be used to increase water security for existing crops, as opposed to increasing the area used to grow crops. As such, these high water values for existing crops would only hold during times of low supply from on-farm storages.

Given the sensitivity of the benefit per ML to market prices, the expectation driven from existing pricing structures, and the fact that much of the water will be used on a ‘stand by and top up basis in times of drought, it is unlikely that irrigators will be willing to pay equivalent to the maximum net economic benefit.

GHD therefore considers it reasonable to contrast the calculated cost of water for each option with a projected willingness to pay, on average, of 50% of net economic benefit. The results of this comparison are shown in Table 12-6.

Table 12-6 Comparison of estimated cost of water that irrigators will be willing to pay with net economic benefit of additional water to irrigators

Option		Emu Swamp Dam - Irrigation	Ballandean Dam - Irrigation	On-Farm Storage
LCOW - Irrigation ($ '17/ML)		$ 4,500	$ 3,600	$ 300
Net Annual Benefit ($ '17/ML p.a.)	Apples (existing - low water security producers)	$ 2,075	$ 2,075	$ 2,075
	Apples (existing - high water security producers)	$ 1,175	$ 1,175	$ 1,175
	Apples (new crops)	$ 1,575	$ 1,575	$ 1,575
	Tomatoes (new crops)	$ 1,775	$ 1,775	$ 1,775
	Strawberries (new crops)	$ 2,625	$ 2,625	$ 2,625
	Wine Grapes (existing)	$ 925	$ 925	$ 925
	Wine Grapes (new crops)	$ 1,125	$ 1,125	$ 1,125
	Strawberry Runners (new crops)	$ 525	$ 525	$ 525
	Green Vegetables (existing)	$ 1,175	$ 1,175	$ 1,175
	Green Vegetables (new)	$ 1,425	$ 1,425	$ 1,425
	Average Weighted by volume by crop	$ 1,650	$ 1,650	$ 1,650

Option		Emu Swamp Dam - Irrigation	Ballandean Dam - Irrigation	On-Farm Storage
PV Irrigation Costs/Irrigation Yield ($ '17/ML)		$ 56,500	$ 46,600	$ 2,900
Total On-Farm Return ($ '17/ML)	Apples (existing - low water security producers)	$ 20,750	$ 20,750	$ 20,750
	Apples (existing - high water security producers)	$ 11,750	$ 11,750	$ 11,750
	Apples (new crops)	$ 15,750	$ 15,750	$ 15,750
	Tomatoes (new crops)	$ 17,750	$ 17,750	$ 17,750
	Strawberries (new crops)	$ 26,250	$ 26,250	$ 26,250
	Wine Grapes (existing)	$ 9,250	$ 9,250	$ 9,250
	Wine Grapes (new crops)	$ 11,250	$ 11,250	$ 11,250
	Strawberry Runners (new crops)	$ 5,250	$ 5,250	$ 5,250
	Green Vegetables (existing)	$ 11,750	$ 11,750	$ 11,750
	Green Vegetables (new)	$ 14,250	$ 14,250	$ 14,250
	Average Weighted by volume by crop	$ 16,300	$ 16,300	$ 16,300

Using this estimate for willingness to pay, no crops are viable on a $/ML basis under any option other than the on-farm storage option.

12.1.1 Required government support

GHD has used the financial models developed to assess capital grant support (that is a non-refundable grant bearing no interest or capital repayment, i.e. not a loan) that would be required from State or Federal Government for each of the large dam options to reduce the levelised cost of water (LCOW) to a level comparable with the assessed irrigator willingness to pay for additional water. The results of this analysis are shown in Table 12-7 below:

Table 12-7 Required State or Federal funding to reduced LCOW to irrigators to affordable levels

Option	Government Subsidy as a percentage of irritation component capital	Government Subsidy $(2017)	Levelised Cost of Irrigation Water post subsidy $/ML	Present Value Irrigation Costs/Irrigation Yield $/ML
Ballandean Dam (10,500 ML) Urban and Irrigation	60%	59,000,000	1,700	21,900

Emu Swamp Dam (10,500 ML) Urban and Irrigation	68%	83,000,000	1,600	21,400

Note: Dollar figures are rounded to three significant figures

If this same level of state or federal funding was applied to all infrastructure to reduce costs commensurately to all users (urban, business, industry and irrigators) then the level of state or federal funding required by option is as shown in the table below:

Table 12-8 State of Federal funding required to achieve a commensurate reduction in costs to all water users

Option	Government Subsidy as a percentage of irritation component capital	Government Subsidy $(2017)	Levelised Cost of Irrigation Water post subsidy $/ML	Present Value Irrigation Costs/Irrigation Yield $/ML
Ballandean Dam (10,500 ML) Urban and Irrigation	59%	80,000,000	1,700	22,300
Emu Swamp Dam (10,500 ML) Urban and Irrigation	68%	119,000,000	1,600	21,400

Note: Dollar figures are rounded to three significant figures

In short, the level of support in the form of a non-refundable, interest free grant ranges between $59 million and $119 million depending on option and on whether the funding is applied to infrastructure for irrigations supply only or for all water users.

This contrasts to the estimated total net return from additional irrigation crops (in Present Value terms based on a real discount rate of 10%) based on a supply of 1,700 ML per annum of circa $71 million (Section 6). SDRC has advised that Council cannot sell treated water at this price indicating that SDRC considers it will be unable sell raw water at this price. GHD notes that irrigators contracted to take recycled water from Stanthorpe pay $180/ML for this recycled water and, anecdotally, irrigators across the border in NSW pay $240/ML for irrigation supplies.

12.1.2 Required irrigator commitment

Whilst GHD considers that neither the 10,500 ML capacity Emu Swamp Dam nor Ballandean dam options to meet urban and irrigation demand are economically viable without significant government subsidy, GHD recognises that there is a demand for high priority water for irrigation.

As such, GHD recommends that, prior to any decision to proceed with either the Emu Swamp Dam or the Ballandean Dam combined urban and irrigation dam option, commitment is sought from irrigators to pay an up-front capital contribution per ML. This

capital contribution needs to be equivalent to the present value of per ML of future capital costs for the dam and irrigation reticulation system. In addition to this up-front capital contribution, the contract for water supply to irrigators will need to include an annual charge to meet fixed operating and maintenance costs of the infrastructure plus volume related charges (i.e. per ML) equivalent to the variable costs of water supply.

This will need to be over and above any payment required for water allocation from the water reserves nominated for irrigation.

GHD considers that this commitment should be in the form of a Heads of Terms prior to any detailed design studies being undertaken, subsequently engrossed to a binding contract for water as a pre-requisite for achieving financial closure and commitment of funds for the construction of a dam for urban and irrigation supplies.

From the economic analysis, the order of magnitude of required committed capital contribution from irrigators for each dam option with and without government subsidy net of any payment required for water allocation for each urban and irrigation supply dam option is shown in Table 12-9:

Table 12-9 Required irrigator commitment to enable an urban and irrigation dam option to proceed.

Urban and irrigation dam option	Irrigator Capital Contribution Without Government Subsidy		Irrigator Capital Contribution With Government Subsidy	
	$/ML contracted	Aggregate $(2017) For 1750 ML contracted	$/ML contracted	Aggregate $(2017) For 1750 ML contracted
Emu Swamp Dam (10,500 ML)	56,500	98,800,000	22,300	39,030,000
Ballandean Dam (10,500 ML)	46,600	81,550,00	21,400	37,450,000

Note: These payments are net of any additional contribution required to pay for water allocation from the water reserves nominated for irrigation supplies

GHD understands that this approach of securing contractual commitment from irrigators to meet some of the capital cost through one-off payments for allocation has been adopted successfully in Tasmania to secure government funding to enable irrigation infrastructure to be constructed. Given that SDRC has advised that it does not have the capacity to borrow, variations of this option where, for example, some of the capital contribution component is incorporated into future volume related charges are not viable.

12.2 Short list options multi criteria analysis

12.2.1 Methodology

The options identified in Section 8.5 that could potentially meet the needs of urban users and irrigators were considered in a two-step MCA assessment process. Both market / demand side management measures *and* new build / improvements to existing infrastructure solutions were considered. This approach is consistent with the Building Queensland and Infrastructure

Australia requirements to consider the full range of strategic responses, including reform and non-build measures that could defer (or even negate) the need for major capital infrastructure investment.

GHD assessed options first by their ability to meet the demand forecast for each of the user groups. GHD has assumed that to be viable, the option must deliver:

- A minimum of 250 ML for urban users (at a high reliability of 98% minimum),
- A minimum of 1,750 ML for irrigation users (at a reliability of 96%), or
- A combined total of 2,000 ML to meet the demand of both groups.

Where capital build options lacked the capacity to accommodate irrigator demand requirements, GHD has assumed that on-farm storage (market response) will be sufficient to supplement any irrigation supply shortages, up to a maximum of 1,740 ML. Subject matter specialists in dam construction, agriculture, irrigation, social impact assessment, environmental impact assessment and capital costing then assessed and scored each of the options against a set of criteria and sub-criteria that respond to triple bottom line considerations and project feasibility. Weightings were assigned as described below. Appendix H provides a detailed breakdown of the scoring outcomes from the MCA workshop.

Table 12-10: MCA criteria and sub-criteria

Criteria	Weight	Sub-Criteria	Weight
Economic	40%	Capital cost $ (rank least to highest)	30%
		Capital cost $/ML yield p.a.	20%
		Levelised costs $/ML yield (lifecycle costing)	40%
		Enabling industry excluding irrigation growth and regional development (function of yield)	10%
Environmental	15%	Impact on water quality -	20%
		Impact on environmental flows	30%
		Inundation impact score	20%
		Land use impact - % take of land larger – smaller blocks, infrastructure relocation, commercial enterprise impacted	30%
Social	30%	Reliability of supply to 2050	45%
		Future proofing (i.e. supplies beyond 2050)	30%
		Likelihood of community support	15%
		Cultural heritage impact	10%
Project Deliverability	15%	Speed with which option can be implemented (captures whether existing EAs exist)	30%
		Complexity of project delivery	30%
		Risk of project delivery	40%

12.2.2 Options Assessment

The MCA process generated the following rankings:

Table 12-11 Results of multi-criteria analysis

Rank	Urban Only	Weighted Score	Urban and Irrigation^	Weighted Score
1	IWSM	3.42	Connolly Dam Pipeline + On-farm Storage	3.39
2	Connolly Dam Pipeline	3.35	Ballandean Dam TWS + On-farm Storage	3.06
3	Raise Storm King Dam	2.90	Raise Storm King Dam + On-farm Storage	3.02
4	Ballandean Dam (small)	2.88	Ballandean Dam Urban + Irrigation Supply	2.89
5	Emu Swamp Dam (small)	2.78	Emu Swamp Dam Urban + Irrigation Supply	2.87

^ Omitting IWSM and On-farm Storage as an option

The merits and drawbacks of each of the options as discussed in the MCA workshop, as well as, recommendations for further action, are described below.

12.2.3 Market / demand side measures

The market and demand side measures considered are as follows:

Integrated water supply management (IWSM)

IWSM covers a suite of measures designed to improve the management of the existing water supply and minimise water use. Such measures minimise environmental disturbance, and are quicker to implement than major capital infrastructure options. This is also the least cost measure of all options considered, and will likely lower the operating expense for the utility, which may translate into lower rates. However, it pushes some of the costs onto consumers, requiring subsidies to offset some of the upfront expenses and encourage participation in the scheme.

The effectiveness of IWSM depends upon community uptake. Residents already live with permanent water restrictions, and may resist additional water saving measures. Yet, the water usage of Stanthorpe residents remains relatively high in comparison to other South-East Queensland households. There are likely further opportunities to reduce water consumption, and this solution was the preferred outcome from the MCA process.

GHD therefore recommends that water efficiency and demand management measures be taken forwards for further analysis. If the project proceeds to the Preliminary Business Case Stage, detailed investigations of current end use patterns, the range of demand management measures, cost effectiveness, social acceptability and funding models should be explored.

On-farm storage (market lead response)

On-farm storage offers similar advantages to IWSM for irrigators: it is relatively quick to implement, and generates fewer environmental impacts. This option enables irrigators to construct their own on-farm storage solutions and bid for a portion of the ROP water reserve. Coupled with an urban only supply solution, it meets most of the requirements for urban and irrigation supplies.

On-farm storage reduces risk to the Council by transferring the responsibility for the delivery and uptake of the water allocation to users. From the analysis, it is also projected to be a significantly lower cost solution, as the dam builds occur on individual irrigator’s properties, according to their allocation. However, on-farm storage is less reliable than dams during dry periods. Smaller water volumes are more prone to evaporation or running dry during extended droughts (although this can be mitigated by placing covers over on-farm dams where practicable). As such, this option will result in less reliable water yield than an urban and irrigation supply dam option and will not meet the high priority water demand element of the identified unsatisfied demand of the irrigation sector.

However, GHD recommends that this option be taken forward for further analysis in Phase 2 (Preliminary Business case) as an alternative to a major urban and irrigation dam and pipeline infrastructure option, in case it is ultimately decided not to proceed with a major urban and irrigation dam and pipeline infrastructure option due to the cost versus return.

12.2.4 Major capital infrastructure options for urban only supplies

Descriptions of the comparative benefits and constraints of the five shortlisted major capital investment options (Section 11) as discussed in the MCA workshop are summarised below. A recommendation as to whether to progress these options to Stage 2 (Preliminary Business Case) follows.

Connolly Dam Pipeline (Rank 2)

This option is not defined in the Water Plan or ROP but operates in conjunction with Leslie Dam, which is defined in the ROP. While construction costs are significantly lower than other options, the pipeline would cover 40 km and requires a static lift over 400 m resulting in relatively high pumping costs. However, overall it is the lowest cost solution outside IWSM and is the highest ranked option, after IWSM, from the MCA analysis due to ease of constructability, lower costs, and fewer economic and social impacts.

At present, Connolly Dam supplies an average of 23% of Warwick's annual water and is unlikely to provide the requisite yield for Stanthorpe. Opportunity costs also arise sourcing water from other users. SDRC has advised that it is likely that there is the opportunity for further income to be generated from raw water sales out of Connolly Dam, potentially further limiting available yield to supply Stanthorpe.

However, DEWS is currently investigating whether there is residual capacity for the Stanthorpe region. GHD recommends that this option be taken forwards into Stage 2 in order to gain a more accurate understanding of its potential to meet urban demand needs to 2050. For example, it is conceivable that this option, coupled with IWSM will be capable of meeting urban demand up to 2050.

Raise Storm King Dam (Rank 3)

Raising the walls of Storm King Dam allows Stanthorpe's existing water supply to meet urban demand to 2050. This site generates the least environmental disturbance of all dam-build options, and as a result, is less likely to be subject to onerous environmental approvals. The impacts of a larger inundation area must be further assessed though, and the expansion will likely require property acquisition.

The constructability of this project benefits from a gravity feed which lowers operational costs, as well as existing pipeline easement and diversion, though the cost of raising the walls will depend on stability and whether or not anchors are necessary. This solution is not a viable source for irrigation though, and would need to be supplemented by other measures to meet irrigator demand.

GHD recommends that this option is taken forward for further analysis as it meets future urban water needs, has relatively low environmental impact, high constructability, and has lower costs than the remaining options that are projected will meet urban supply needs to 2050.

Ballandean Dam urban only (5,000 ML) (Rank 4)

This option comprises a smaller dam at the Ballandean site with pumping station and raw water pipeline to Stanthorpe's water treatment plant. Advantages over the Emu Swamp Dam site are that:

- Given the steeper sides to the valley, particularly at the dam wall site, the surface area to volume will be lower than for Emu Swamp Dam resulting in less evaporation
- It is lower down the catchment and hence inflows to the dam should be higher
- The topography indicates that the bedrock at the dam wall site is likely to be less fractured
- The steeper sided valley at the dam wall site will result in a shorter wall.

Both last two points are likely to result in lower construction costs.

However, there are question marks around potential inundation of existing infrastructure such as the New England Highway (although this will be less of an issue for the 5,000 ML urban only dam over the 10,500 ML) and, potentially, a major fibre optic trunk main (identified in an earlier report). The Emu Swamp Dam site suffers from neither of these issues.

Nevertheless GHD recommends that this option be taken forward to stage 2 in case that the previous ranked options are determined not to be capable of being undertaken or of meeting urban demand to 2050.

Emu Swamp Dam urban only (5,000 ML) (Rank 5)

This option comprises a smaller dam at the Emu Swamp Dam site than the urban and irrigation dam option together with pumping station and raw water pipeline to Stanthorpe's water treatment plant. It represents one of the options capable of meeting the projected 2050 urban demand at high reliability.

However, it is the most expensive of the urban supply only options and is considered to be an inferior dam site to the Ballandean Dam site. However, advantages over the Ballandean Dam option is that it does not impact on other major infrastructure and it has an existing EIS. As such, there is more certainty as to constructability than with respect to the Ballandean urban only dam option and the raising Storm King Dam option.

GHD therefore recommends that this option be taken forward to Stage 2 for further analysis.

12.2.5 Options to meet urban and irrigation supply needs

All of the viable urban only supply options may be combined with an on-farm storage solution to meet both urban and irrigation supply needs with the caveat that the on-farm storage solution may not address all of the high priority water demand requirements identified through the stakeholder consultation with irrigators.

The following options are the only options that meet urban and irrigation water high priority water supply demand requirements out to 2050.

Ballandean Dam (Rank 4)

This option supplies both urban and irrigation needs at a reliability comparable to Emu Swamp Dam. Estimating costs is complicated by a lack of information on the site, though the distribution network required for irrigation supply will likely be similar to Emu Swamp Dam.

The environmental impact has not been previously assessed, creating uncertainty around potential costs and time delays. The deliverability of this project will also depend on the extent of impact on the New England Highway, rail corridor and fibre optic cable. However, relative to

Emu Swamp Dam, Ballandean may be easier to build, benefitting from a tighter valley and more suitable geology.

GHD recommends that this option be taken forward for assessment in Stage 2 (Preliminary Business Case) if it is decided that the higher cost to supply high priority water to meet irrigator needs for such is economically viable. GHD considers that such a decision will depend on whether adequate government subsidy will be provided for this option (see Section 12.1.1)

Emu Swamp Dam (Rank 6)

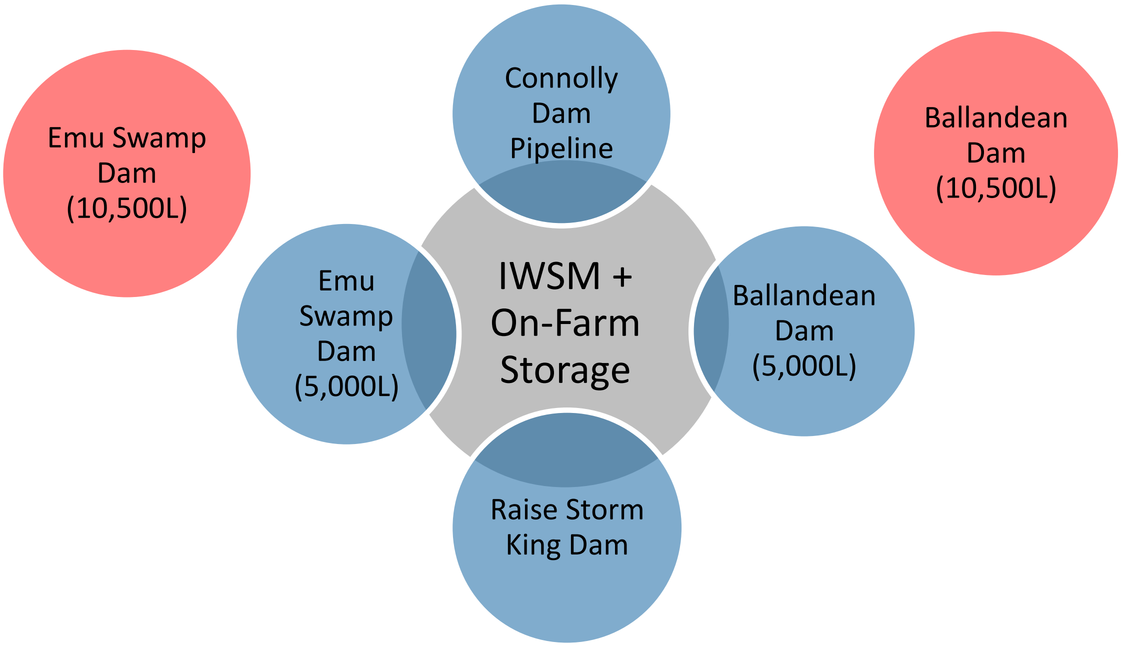
A 10,500 ML Emu Swamp Dam can deliver high reliability water for both urban and irrigation usage. The high reliability and yields enable the take up of fallow land and expansion of the market, exploiting the region's growth potential. The use of the proposed dam for recreational purposes may also add value to the economy and improve social amenity. The proposed site is supported by extensive prior works and detailed assessments, and its Environmental Impact Statement is currently approved. Some land has already been acquired by Council. The costs of this option are significantly higher than other options. Emu Swamp Dam would not be gravity fed, necessitating pumping from a static head of approximately 120 m (a significant ongoing operational expense) – this option is almost twice the price of raising Storm King Dam. Operational maintenance is likely to be complex and costly due to the length of pipes and number of pump stations, and the distribution network required for irrigation supply will further add to maintenance costs. A number of considerations, such as environmental offsets, have not yet been factored in to the costs of the build.

Long lead conditions specified in the Environmental Impact Statement approval are likely to delay construction by at least 2 years, further increasing costs and posing deliverability risks. Constructability is also complicated by more difficult terrain than other sites.

Due to the current unknowns around the potential for Ballandean Dam to impact on other major infrastructure, resulting in, potentially prohibitively expensive relocation costs, GHD recommends that this option be taken forward for assessment in Stage 2 (Preliminary Business Case).

However, it should only be considered for taking forward to Stage 2 if it is decided that the higher cost to supply high priority water to meet irrigator needs for such is economically viable. GHD considers that such a decision will depend on whether adequate government subsidy will be provided for this option (see Section 12.1.1).

The interrelationship between the options is represented in Figure 12-1.



Key: Grey – market response and Demand-side management (DSM), blue urban only infrastructure, red- urban and irrigation infrastructure

Figure 12-1 Diagrammatical representation of options considered

13. Conclusions

13.1 Southern Downs Region and social demographics

The township of Stanthorpe connected to the reticulated water network has a slowing rate of population growth. The age profile of the township is increasing and in 2015 the number of registered deaths outnumbered births. The Stanthorpe township is growing at a slower rate than the surrounding regional area and the rest of the local government area. A low number of building approvals indicate that there is no significant increase in the number of houses requiring a reticulated water supply. The high proportion of the Stanthorpe urban area on the aged pension, the low per person income and high degree of social disadvantage indicates that the ability to pay for an additional water supply is likely to be limited.

13.2 Review of previous studies and gap analysis

The water needs for the Stanthorpe (Granite Belt) region and options to supply those needs have been studied for many years. However, from the analysis of previous work it is apparent that many of the reports were developed with an emphasis on one potential solution, Emu Swamp Dam.

Only this option has been analysed in detail, including with respect to design concepts. All other options were considered at a superficial level. There are also significant inconsistencies between the different reports in terms of assessment criteria, such as potential yield from different options, making it difficult to compare options directly to draw definitive conclusions as to a preferred option.

In particular, GHD finds that the yield analysis and assessment has generally not been in consistent across reports. Equally, GHD considers that the basis and techniques used for development of cost estimates in many of the reports has not been rigorous given the high-level nature of the reports.

For example, GHD expects to see concept designs for different dam wall heights, capacity and yields for a given average monthly reliability (say 96%) to have been developed such that the optimum dam height could be determined on a cost per ML of yield basis.

GHD also notes that many of the underlying assumptions and basis of earlier analysis have changed. In particular:

1. Population growth in Stanthorpe has been significantly less than predicted in the mid-2000s, with current population being approximately half of what was predicted
2. Average water consumption per capita is materially less now than was assumed to be the case in the mid-2000s. At that time an average consumption of 500 L/c/d was assumed whereas the current consumption is running at 324 L/c/d.
3. GHD and DEWS' demand forecasts project a shortfall of 250 ML/a by 2050, whereas earlier reports forecasts a projected shortfall in excess of 500 ML/a.

This is also the case for a number of the key assumptions underpinning the EIS and approvals for Emu Swamp Dam. In addition to the assumptions described above, it is noted that assumptions around cost of demand side measures considered in the EIS underpinning the benefit cost ratio, as an avoided cost if Emu Swamp Dam was constructed, are materially higher than is the case now. If this analysis was undertaken now with current data, the benefit cost ratio for urban supplies would likely be less than one[28].

As a result of this, there has been an emphasis on Emu Swamp Dam as a solution at the expense of other options that could potentially meet urban and irrigation needs. For example the Ballandean Dam site:

- Is lower in the catchment, is in a steeper valley and hence will have less surface area for a given volume both resulting in greater yield;
- Has terrain more conducive for dam construction with steeper side walls, particularly at the dam wall site (which infers less fractured base rock);

In addition, GHD considers that lower cost options such as, raising Storm King Dam coupled with integrated water supply management (water distribution leakage reduction coupled with demand side measures) have not been adequately considered in the past evaluations.

Finally, little attention paid in past studies to the potential for auctioning water allocation to irrigators to enable greater surface water harvesting and increased use of on-farm storages to address irrigation needs.

13.3 Urban water demand assessment

The analysis of historic urban demand forecasts compared with actual demand has shown that early forecasts have significantly overestimated population growth and did not take into account changes in consumption patterns leading to a sustained reduction in demand (L/c/d).

Independent demand forecasts, drawing on current consumption patterns, population growth data, housing construction data and location of new developments (many of which are acreage properties off the potable water reticulation system) compares favourably with that recently produced by DEWS.

From consultation with the urban and local non-agricultural (irrigation) business community, typically represented by non-water intensive businesses, GHD concludes that:

- Overall water demand for Stanthorpe has been far less than predicted in previous studies (1,246 ML/a predicted for 2015 versus 590 ML/a actual)
- Water demand for non-water intensive business (the predominant business type in the area) is likely to increase in line with population growth and hence there will be no material contribution to growth above trend from business in the region
- Stanthorpe's water demand by 2050 is 844 ML/a. This is consistent with the most recent forecast by DEWS
- Storm King Dam is capable of supplying 600 ML/a from Storm King Dam (at circa 98% average monthly reliability). In absence of water conservation and or water restrictions, Storm King Dam will fail to meet Stanthorpe's urban water demand by 2036 and there will be a circa 250 ML/a shortfall in supply capacity by 2050
- As such, a 'do nothing' option with respect to urban water supplies is not a viable option.

13.4 Industrial and irrigation water demand assessment

GHD's sub-consultants, Synergies, undertook a detailed assessment of demand for water from irrigators in the dam supply area and of potential water demand from water intensive industries that may be attracted to the area given greater availability of high priority water. The conclusions

[28] A benefit cost ratio greater than one is required in order to consider that the option being underpinned by the benefit cost ratio provides greater economic benefit than it costs.

of this analysis conducted through extensive stakeholder engagement, literature research, data collection and analysis are:

13.4.1 Irrigation demand

In relation to current irrigation water supply and use in the Southern Downs:

- Producers are currently reliant upon on-farm storages and the harvesting of overland flows for irrigation water supply
- The volume of irrigation water to be made available by the construction of the proposed Emu Swamp Dam would represent a relatively marginal increase (estimated at less than 10 per cent) in total irrigation water use in the region. As such water from the proposed Emu Swamp Dam is more likely to supplement the water supplies of established producers , e.g. on a 'standby and top-up arrangement' during periods of drought, as opposed to being used by greenfield producers to meet base water requirements.
- Access to suitable land is unlikely to represent a constraint on the expansion of crop production in the region.

Based on the documentation reviewed and consultation, there is significant demand for additional irrigation water within the dam footprint either to increase security for existing crops (apples, wine grapes), or through expansion of crops by existing irrigators (tomato, capsicum, strawberry and strawberry runners):

- 2,000 ML (for all crops without green vegetables)
- 2,263 ML (for all crops including green vegetables).

The results of this economic analysis are:

- The average net total return[29] is $27,600 per additional ML[30]
- The average[28] net annual benefit for each ML consumed is $3,300/ML.

These are, on average, the theoretical economic maximum amounts that irrigators would be able to pay as a one-off payment or on a volume related basis respectively for water allocation and supply under current market conditions.

Sensitivity analysis conducted demonstrates that irrigators' net present value benefits and annual returns per ML are highly sensitive to changes in crop prices. A 10% reduction in crop price results in a 40% reduction in return and an increase in production, all else being equal, will result in a likely decrease in crop market prices. Further these figures represent the economic maximum that irrigators would be able to pay and do not represent what irrigators will be willing to pay.

GHD considers it reasonable therefore to assume a willingness to pay amount over the long term of half the theoretical average economic maximum for current crop prices i.e.:

- $16,300/ML as one off payment for water entitlements and supply; or
- $1,650/ML on a volume related basis.

13.4.2 Industrial demand

During stakeholder discussions, the Stanthorpe and Granite Belt Chamber of Commerce identified Emu Swamp Dam as its number one priority for promoting economic development in

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[29] Present value of all net return per ML in perpetuity at a 10% real discount rate
[30] On a weighted basis according to additional ML consumption per crop type

the Stanthorpe region. It considers that there is considerable scope to attract agrifood processors to Stanthorpe if a reliable source of treated water became available.

Discussions with horticultural producers in the region found that not all share this view of the opportunity for locally based value adding to crop production. Even if an additional reticulated water source became available, few producers spoken to displayed any interest in shifting to food processing, as they are currently securing solid returns from supplying fresh produce to Brisbane and northern Queensland markets.

In the assessment, it is unlikely that an agrifood processing industry will become a major new demand driver for additional water in Stanthorpe. The reason for this is twofold:

- The volumes of additional water capable of being supplied by the proposed Emu Swamp Dam are relatively small, and so would only allow a marginal increase in horticultural output. This increase in output is unlikely to be of sufficient scale to underpin a major, local food processing hub; and
- Stanthorpe producers currently have the option of transporting their produce to nearby Warwick for processing, where there is no water constraint and better access to major transport routes and labour. However, there is little evidence of this occurring, so GHD is cautious of claims that a new water source for Stanthorpe would expand local processing.

While non-residential water demand is expected to increase over time, it is GHD's view that there is insufficient evidence to support a forecast that would have industrial demand outstripping residential demand in the foreseeable future or exhibiting a 'step change' in economic development if a new bulk water supply was developed[31].

13.5 Water availability

The revised Water Plan for the Border Rivers and Moonie systems is likely to retain Strategic (Surface) Water Reserves within the Stanthorpe Water Management Area i.e. 3,000 ML/a for irrigation and associated industry and 1,500 ML/a for town water supply. These are the only remaining additional water allocation volumes that are available under the Water Plan to support future consumptive water development and use in the local district. A moratorium on water development remains in place in advance of the Water Plan being updated and finalized through a structured review process

13.6 Investment logic map and risk assessment

An Investment Logic Mapping workshop held with key representatives from SDRC identified three core problems, as well as several expected benefits and potential business changes or solutions that could be pursued to address the identified problems. The three key problems identified were:

1. Restrictions in urban water supply are reducing the attractiveness of the region to live and invest in
2. Lack of water security is a barrier to future investment in agriculture and horticulture.
3. Not securing available water from Murray-Darling Basin may lead to loss of future competitive advantage

The expected benefits of addressing the problems through the project include:

[31] During our consultation we only identified one water intensive industrial company in the region that indicated that a lack of water availability was inhibiting growth: This company advised that it could achieve a circa tenfold increase in production within a few years given access to greater water volumes (raising consumption from 3-4 ML p.a. to 50 ML p.a.)

1. Increasing social amenity and liveability for residents of Stanthorpe
2. Servicing demand from anticipated future residential and commercial growth
3. Providing additional water capacity for spray irrigation to support high value horticulture crops
4. Securing the Murray Darling Basin water allocation for future use.

A risk workshop held with same key representatives identified a number of high risks:

- **Financial -** arising from Council's current debt level and ability to fund a major infrastructure project
- **Strategic** - Council has been identified as the proponent for a major infrastructure project to serve urban and irrigation supply needs. However, it is not within Council's ambit to fund and develop irrigation infrastructure projects
- **Social** - Because of significant recent stakeholder consultation on this issue, there is concern of a low participation rate in consultation process, which results in insufficient data for a conclusion, and a low level of acceptance of the study by stakeholders.

13.7 Supply options short list

Previous studies and recent initiatives have identified multiple potential supply options to meet the forecast urban demand or to meet both urban and irrigator demand. GHD applied a yield filter to narrow these options down to a short list of options for further analysis in this Stage 1 Final Feasibility Study. GHD also added in non-major capital infrastructure options. These are:

- Integrated water supply management (demand side management or water conservation measures coupled with supply side management such as leak detection and repair in urban water reticulation systems)[32].
- On-farm storages coupled with an auction for water allocation from reserves assigned to irrigation supply.
- The short list of options to meet urban only demand needs are:
- Integrated Water Supply Management (IWSM);
- Raising Storm King Dam and additional raw water infrastructure;
- Emu Swamp Dam (small with capacity to meet urban demand up to and beyond 2050)
- Ballandean Dam (small with capacity to meet urban demand up to and beyond 2050)
- Pipeline from Connolly Dam
- The short list of options to meet urban and irrigation demand needs are
- The urban only short list each combined with on-farm storage
- Emu Swamp Dam (large with urban raw water and irrigation distribution infrastructure)
- Ballandean Dam (large with urban raw water and irrigation distribution infrastructure)

13.8 Analysis of short list options

The results of the economic and multi criteria assessment of shortlisted options is provide below:

[32] IWSM is unlikely to deduce consumption by the required 30% to enable Storm King Dam is able to meet supply needs up to 2050. However, we consider it will enable deferral of capital infrastructure for urban supplies by 4 years.

13.8.1 Economic assessment

The results of the economic analysis of shortlisted options are provided below in and Table 13-1 to Table 13-3.

Table 13-1 Urban only supply options economic analysis results

Option	Capital Cost $(2017)	Operating Cost p.a. $(2017)	Levelised Cost of Water $(2017)/ML	Present Value of Total Costs/ML p.a. $(2017)/ML
IWSM	7,100,000	N/A	400	14,000
Connolly Dam Pipeline	23,800	227,000	2,600	96,400
Raising Storm King Dam	46,900,00	33,400	4,300	160,000
Ballandean Dam (5,000 ML)	75,800,000	40,000	7,000	86,700
Emu Swamp Dam (5,000 ML)	106,100,000	39,100	9,700	120,000

Table 13-2 Irrigation only supply option (on-farm storage) economic analysis results

Option	Capital Cost $(2017)	Operating Cost p.a. $(2017)	Levelised Cost of Water $(2017)/ML	Present Value of Total Costs/ML p.a. $(2017)/ML
On-farm storage	6,000,000	N/A	300	100

Table 13-3 Urban and irrigation supply options economic analysis results

Option	Capital Cost $(2017)	Operating Cost p.a. $(2017)	Levelised Cost of Water $(2017)/ML	Present Value of Total Costs/ML p.a. $(2017)/ML
IWSM + on-farm storage	13,100,000	N/A	300	4,300
Connolly Dam Pipeline + on-farm storage	29,800,000	227,400	1,000	14,600
Raising Storm King Dam	43,500	33,000	1,300	18,700

(urban only) + on-farm storage				
Emu Swamp Dam (urban only) + on-farm storage	112,100,00	39,100	3,300	38,300
Emu Swamp Dam (urban + irrigation) (10,500 ML)	162,100,000	536,000	4,500	58,700
Ballandean Dam (urban only) + on-farm storage	81,800,000	39,100	2,400	28,000
Ballandean Dam (urban + irrigation) (10,500 ML)	128,900,000	594,100	3,600	46,700

Note: These results represent combined metrics for urban and irrigation supply for each option to meet urban and irrigation water demand needs to enable comparative ranking.

These results were incorporated into a multi-criteria analysis as described below:

13.8.2 Multi Criteria Analysis

The multi-criteria analysis process enlisted subject matter specialists to rank each option (from 1-5) against economic, environmental, social and project deliverability criteria. The score for each option was multiplied by its relative criteria and sub-criteria weightings to produce a final ranking. The scores and rankings are as follows:

Table 13-4 Results of multi-criteria analysis

Rank	Urban Only	Weighted Score	Urban and Irrigation^	Weighted Score
1	IWSM#	3.42	Connolly Dam Pipeline + On-farm Storage	3.39
2	Connolly Dam Pipeline	3.35	Ballandean Dam TWS + On-farm Storage	3.06
3	Raise Storm King Dam	2.90	Raise Storm King Dam + On-farm Storage	3.02
4	Ballandean Dam (small)	2.88	Ballandean Dam Urban + Irrigation Supply	2.89
	Emu Swamp Dam (small)	2.78	Emu Swamp Dam Urban + Irrigation Supply	2.87

Note: IWSM will not reduce demand sufficiently to avoid capital infrastructure to meet the 2050 demand for Stanthorpe

^ Omitting IWSM as an option given it will not enable the 2050 urban demand to be met with existing infrastructure

14. Recommendations and further work

In this section, GHD sets out its recommendations for the options to be considered to take forward to Stage 2 and outlines the work that will be required to analyse further these options. In particular, GHD sets out in brief the method required to analyse dam infrastructure options to address some of the gaps in previous dam option evaluations. GHD notes that DEWS approval under the funding agreement may be required to enable other options in addition to Emu Swamp Dam to be assessed using NWIDF funding.

14.1.1 Urban supply only options

A major capital option will be required to secure Stanthorpe's water future supply. However, the need for capital expenditure may be deferred by up to 4 years if IWSM measures are implemented. As an interim measure, GHD recommends implementing IWSM measures to encourage the efficient use of the existing water supply and notes that this recommendation is consistent with DEWS report (DEWS 2015b).

GHD therefore recommends that the following short listed options to address Stanthorpe urban water supply needs be taken through to Stage 2 (Preliminary Business Plan) for further analysis and filtering of options.

Integrated Water Supply Management (Rank 1 in MCA for urban only supplies)

This option scored highest in our MCA and is the least cost option; being an option that does not involve capital infrastructure investment. However, GHD considers that it is unlikely that this option will be able to achieve a sustained 30% reduction in water demand required to enable Storm King Dam to meet urban water demand up to 2050.

This option may best be considered, therefore as a mechanism to defer expenditure in a major capital infrastructure project and is therefore recommended for further analysis and potential implementation irrespective of any major capital infrastructure option selected to meet urban or urban and irrigation demand. As it will not be sufficient to offset forecast urban demand in its own right, a capital intensive infrastructure option is required to meet the forecast 2050 demand.

GHD notes that SDRC has recently established a Water and Wastewater Advisory Committee to inform Council of potential opportunities for demand management. A recommendation of this committee in a meeting held on the 17 February 2017[33] was that Council will, in the 2017-18 financial year, seek to encourage water efficiency through providing homeowners that are on town water with a financial incentive to install a water tank. GHD has been advised by Council (email of 17 May 2017) that this initiative is being listed in the revenue statement that is currently in the draft 2017/18 budget.

Connolly Dam Pipeline (Rank 2 in MCA for urban only supplies)

This option involves installing a pipeline and pumping infrastructure to transfer water from Connolly Dam to the water treatment plant in Stanthorpe. It relies on there being sufficient available yield in Connolly Dam to meet the forecast shortfall in yield from Storm King Dam of approximately 250 ML/a by 2050.

However, GHD has been advised by DEWS that DEWS has only undertaken yield modelling for Connolly dam to 2036. As such, this option cannot be relied on as a potential option to meet

[33] Southern Downs Regional Council Water and Wastewater Advisory Committee Minutes 17 February 2017

forecast demand at this stage. It is possible, that this option combined with IWSM will be a viable option but this requires more analysis.

GHD therefore recommends taking forward other, alternative, capital infrastructure options to meet urban demand to Stage 2 for analysis as set out below should current modelling being undertaken by DEWS demonstrate that Connolly Dam has insufficient available yield to meet the projected 2050 demand after implementation of an IWSM strategy. These alternative options (Raise Storm King Dam, Ballandean Dam (5,000 ML – TWS only) and Emu Swamp Dam (5,000 ML – TWS only) all scored relatively close in our MCA, scoring 2.90, 2.88 and 2.78 respectively but are all significantly more capital intensive than the Connolly Dam pipeline option. GHD recommends investigating these options in the order of their MCA ranking and only proceeding to the next less favourably ranked option if a given option being evaluated is found not to be technically viable.

Raise Storm King Dam (Rank 3 in MCA for urban only supplies)

This option involves raising Storm King Dam by 4 m and building an additional raw water urban supply main and pump station from Storm King Dam to the Mount Marley Water Treatment Plant. This option is the most cost effective of the capital infrastructure options where yield modelling has demonstrated that the option is capable of meeting the forecast required additional supply volumes of 250 ML per annum by 2050. However, there is some uncertainty as to whether the dam wall abutments are capable of withstanding this raising of the dam wall (GHD has assumed in our cost analysis that stabilising rock anchors will be needed as a minimum). Given this, together with uncertainties around the previous two options, GHD recommends that at least one other capital intensive option be considered in Stage 2 as detailed below. However, these options should only be analysed if the above options for urban supply prove not to be technically viable.

Ballandean Dam (5,000 ML) (Rank 4 in MCA for urban only supplies)

This option involves constructing a smaller dam at the Ballandean dam site that was previously envisaged to meet urban and irrigation supply needs, together with a raw water pipeline and pumping station to deliver water to the water treatment plant at Stanthorpe. As an urban supply only option, this option does not require the construction of irrigation distribution and pumping infrastructure and is the lowest cost option that is considered, will fully meet the required additional 250 ML of demand by 2050. GHD recommends evaluating this option only if the higher ranked options (IWSM, Connolly Dam pipeline and or Raise Storm King Dam) prove not to be technically viable.

Emu Swamp Dam (5,000 ML) (Rank 5 in MCA for urban only supplies)

GHD recommends taking this option forward into Stage 2 option for analysis only in the event that investigations of the Ballandean Dam (5,000 ML) urban supply only option indicate that the Ballandean Dam option is not viable. One potential issue that would prevent Ballandean Dam being progressed is if the inundation (either at full storage or under flood conditions) impacts on other infrastructure, such as the New England Highway and or the fibre optic trunk main (identified in earlier reports) results in infrastructure relocation costs that make Ballandean Dam prohibitively expensive.

GHD notes that these last two options for urban only water supply (Ballandean Dam (5,000 ML) and Emu Swamp Dam (5,000 ML) may not be economically viable for Council without significant government funding.

14.1.2 Irrigation demand only options

GHD recommends that the following option be taken forward to Stage 2 for further assessment:

On-farm storage

From our economic and MCA analysis, a market lead solution of auctioning irrigation water reserves and enabling irrigators in expand their ability to harvest surface water through construction of on-farm water storage systems to augment existing, extensive on-farm storage and surface water harvesting systems is the lowest cost option for meeting irrigator's additional irrigation water supply needs. However, it does not meet the need, identified through stakeholder consultation, for high reliability water to augment water from existing on-farm storages in times of drought to enable irrigators to increase existing production from existing crop areas. It would, though allow expansion of cropping areas which, from our consultation with irrigators, represents approximately half of the required additional irrigation water supply. Given this, GHD considers it necessary to also take forward options that meet this requirement for high reliability water to supplement existing, lower reliability, irrigation supplies.

If found viable, this option may be combined with any of the urban only supply options found to be viable to provide both urban and irrigation water demand needs. If this option is found not to adequately address irrigator needs for high reliability water, GHD recommends that a combined urban and irrigation infrastructure solution involving an urban and irrigation supply dam and reticulation system be evaluated as discussed below.

14.1.3 Combined infrastructure urban and irrigation supply options

These options relate to solutions that will meet urban demand out to 2050 and irrigator high reliability water supply requirements and involve the construction of a larger scale dam with capacity of 10,500 ML, urban raw water pipeline and pumping station and irrigation pumping and distribution system. They are the most expensive of all options in terms of both capital and operating expenditure but they are the only options that are certain to meet both the urban demand requirement and the high reliability water portion of the irrigation demand requirement. GHD therefore recommends that these options be evaluated only if it is found that the higher ranked options (Connolly Dam Pipeline, Raising Storm King Dam, Ballandean Dam (urban only 5,000 ML) and Emu Swamp Dam (urban only 5,000 ML)) combined with on-farm storage prove not to be viable.

However, both of the combined infrastructure urban and irrigation supply options (Ballandean Dam (urban and irrigation 10,500 ML) Emu Swamp Dam (urban and irrigation 10,500 ML)) will not be viable without significant government funding (up to $120 million). As such, GHD recommends that a commitment by Council to investigate further these options in Stage 2 should be subject to an indication of government interest in providing capital funding.

GHD considers that such indication of interest will be contingent (as in recent irrigation projects in Tasmania) of confirmed willingness of irrigators to commit contractually to pay up-front capital contribution to fund the necessary portion of irrigation infrastructure capital costs net of government funding support.

- **Ballandean Dam (10,500 ML) urban and irrigation supply (Rank 5).** This option will meet the urban water demand and irrigation water demand, including the requirement for high priority (high reliability water) to augment existing irrigation supplies in times of drought. However, there are possible issues with respect to potential inundation of the New England Highway during flood events that will need to be investigated as a priority. GHD also understands from our review of earlier reports that the dam inundation may impact on a major Melbourne-Brisbane fibre-optic trunk line, although GHD has not be able to identify this aspect in GIS based infrastructure information. As such, it is possible that this option will need to be excluded relatively early on in the more detailed investigation phase in Stage 2 as the costs of relocating both these pieces of infrastructure may be prohibitive. It is for this reason that GHD also recommends that the urban and irrigation Emu Swamp Dam be taken forward to Phase 2 in case the Ballandean option proves not to be technically viable.

- **Emu Swamp (10,500 ML) urban and irrigation supply (Rank 6).** This option will meet the urban water demand and irrigation water demand, including the requirement for high priority (high reliability water) to augment existing irrigation supplies in times of drought. In addition and, given that this option has received much more detailed assessment in previous studies than all other options, it suffers none of the uncertainties outlined in the description of the other options. However, it is by a significant margin, the most expensive option in terms of capital and operating cost based on available information. As such, GHD recommends that this option is evaluated in Stage 2 only if all other options prove not to be viable.

14.2 Further work and governance recommendations

Meeting Stanthorpe's future water security needs will require close cooperation between all levels of government. GHD recommends that Council consider establishing appropriate governance arrangements to guide the project through the next stage. This should ideally include relevant stakeholders from State government agencies, including DEWS, Department of State Development (DSD) and Building Queensland, to ensure key government agencies are adequately informed and engaged in the decision making process as the project progresses.[34]

Project sponsorship and the assignment of responsibility to each level of government must also be considered, especially given that future policy commitments (e.g. around the water allocation) may be sought.

It must be clarified whether the proposed project will address urban only, or urban and irrigation demand. Understanding the needs of each user group will determine which response – policy / market or major capital build – will be the most effective. This will necessarily involve engagement with a much wider range of stakeholders, allowing different interest groups to provide inputs and feedback.

In line with Building Queensland guidance, further risk assessments will need to be undertaken across all aspects of business case development, including:

- Identifying risks associated with any changes to the proposal background, service need, stakeholders, options generated, or strategic and political context
- Identifying Business Case development risks—including methodology, assumptions and practices underpinning the assessments (social, economic, environmental and financial), data reliability, accuracy and currency
- Identifying process risks—including stakeholder engagement activities, timing etc., to ensure the process for developing the Business Case supports required outcomes
- Identifying potential project risks—including timing, delivery, funding and governance arrangements.

Addressing funding and governance risks will be especially important given concerns raised by Council in relation to the ongoing operational costs that would be result from a major capital investment and their potential impact on Council's financial position.

[34] Building Queensland has developed a number of guides to help project sponsors with governance. The guides provide governance information for government agencies and government-owned corporations that work with Building Queensland. They detail governance structures, roles and responsibilities, and how Building Queensland engages with agency-specific processes.

Given that the CGER will lapse in September 2017 GHD recommends that an extension is requested of the Coordinator General ahead of the lapse date.

14.2.1 Recommended dam option assessment method for Preliminary Business case

To enable an options assessment in line with Building Queensland Business Case Guidelines, a comparative study of each dam option for various full supply levels is recommended. This study should assess:

- At least four different full supply levels at both Ballandean and Emu Swamp dam sites to identify most cost effective dam size and optimise capital cost/yield.
- A 4 m raise at Storm King Dam

For all assessment options, the study should include:

- Site visit for dams engineer, engineering geologist specialising in dams, and an environmental scientist to all 3 sites
- Desktop geological assessment and literature review to augment information gained by the site visit
- Yield estimates including environmental releases targeting a minimum annual and monthly reliability so that each option can be compared on a level basis
- Concept dam designs so that key quantities can be developed in a consistent manner across all options and full supply levels
- A review of other impacts such as telecommunications, power, road/rail infrastructure
- GIS impact mapping for a variety of environmental attributes (such as land use, vegetation types, agricultural values, etc.) for each potential full supply level option, notwithstanding the EIS for Emu Swamp Dam, so that quantities for impacts and offsets can be measured and assessed consistently
- Notwithstanding the EIS for Emu Swamp Dam, obtaining planning data, species impact searches for flora and fauna, cultural heritage and native title values, and a review of environmental factors.
- Obtaining and assessing social data; Census data as a minimum
- A risk assessment for each concept design (engineering), construction risk and project delivery, environmental and social risk
- Developing engineering and environmental cost estimates for all options. These should be completed to a Class 3 or 4 level at a minimum
- A report providing comparative cost per ML per annum yield of each option.

GHD recommends that this be undertaken in one study so that a consistent methodology and timeframe can be applied across all options allowing for a direct and robust comparison. Only through completing such a study can the major infrastructure options to address the needs of urban water supply and irrigation water supply be adequately assessed; allowing one preferred option to progress to the Detailed Business Case stage.

14.3 Summary conclusions and recommendations

The analysis reveals that Storm King Dam will not be able to meet urban water supply needs reliably beyond 2036, with a 250 ML shortfall in supply by 2050. From discussions with the irrigation community, there is a clear unsatisfied demand for additional irrigation water supplies, of which, a significant proportion is high priority water to augment on farm supplies during times of low rainfall.

Of the options considered for urban water supply, GHD recommends that integrated water supply measures (combining demand side management and supply side management – leakage management) should be implemented as a least cost measure. However, IWSM will not reduce urban water demand sufficiently to avoid the need of a capital infrastructure solution to meet the projected 2050 demand.

When considering a solution in the context of the broader needs of the region a large infrastructure solution in the form of either Emu Swamp Dam or Ballandean Dam will be required to meet both urban and irrigation high priority water demand. However, the financial analysis indicates that such solutions are not economically viable without significant (circa $100 million) government subsidy. Whilst SDRC has a specific obligation in respect to urban water supply it does not have the same direct obligation with respect to developing and providing water sources to meet irrigation needs.

On-farm storage coupled with auctioning of water reserves nominated for irrigation supplies is the least cost option to meet irrigation needs and generate economic benefit. However, on-farm storage will not provide the same level of reliability of water supplies as a large urban and irrigation Emu Swamp Dam or Ballandean Dam solution.

Multiple options are available for urban supply that require further investigation in order to establish a preferred strategy. These range (in increasing capital expenditure, complexity and ability to meet or exceed forecast demand requirements) from constructing a pipeline from Connolly Dam, through increasing the height of Storm King Dam to building a smaller (5,000 ML) urban only supply dam at either the Emu Swamp Dam site or the Ballandean Dam site.

A major infrastructure option involving a 10,500 ML dam at either the Emu Swamp Dam site or the Ballandean Dam site together with urban and irrigation distribution infrastructure should only be progressed if there is commitment from government (State or Federal) to provide funding support.

GHD also considers that prior commitment (in the form of a Heads of Terms to be subsequently engrossed to binding supply contracts prior to financial closure) is obtained from irrigators to make substantial up-front capital payments of up to $21,400/ML for each ML allocated ($37.5 million in aggregate) in conjunction with government subsidy.

GHD recommends that SDRC considers progressing the urban supply strategic options in Stage 2 (Preliminary Business Case) alongside market led solutions for irrigation supply needs noting that a re-negotiation of the funding deed may be necessary if an urban only supply is progressed.

GHD also recommends that the urban and irrigation supply major infrastructure options of Emu Swamp Dam and Ballandean Dam be progressed to Stage 2 subject to an indication of government interest in providing funding support to the implementation of these options. GHD considers that such indication of interest will be contingent (as in recent irrigation projects in Tasmania) upon a confirmed willingness of irrigators to commit contractually to make an up-front capital contribution to fund the necessary portion of irrigation infrastructure and fixed operating costs net of government funding support.

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15.2 Documents identified but not available for review

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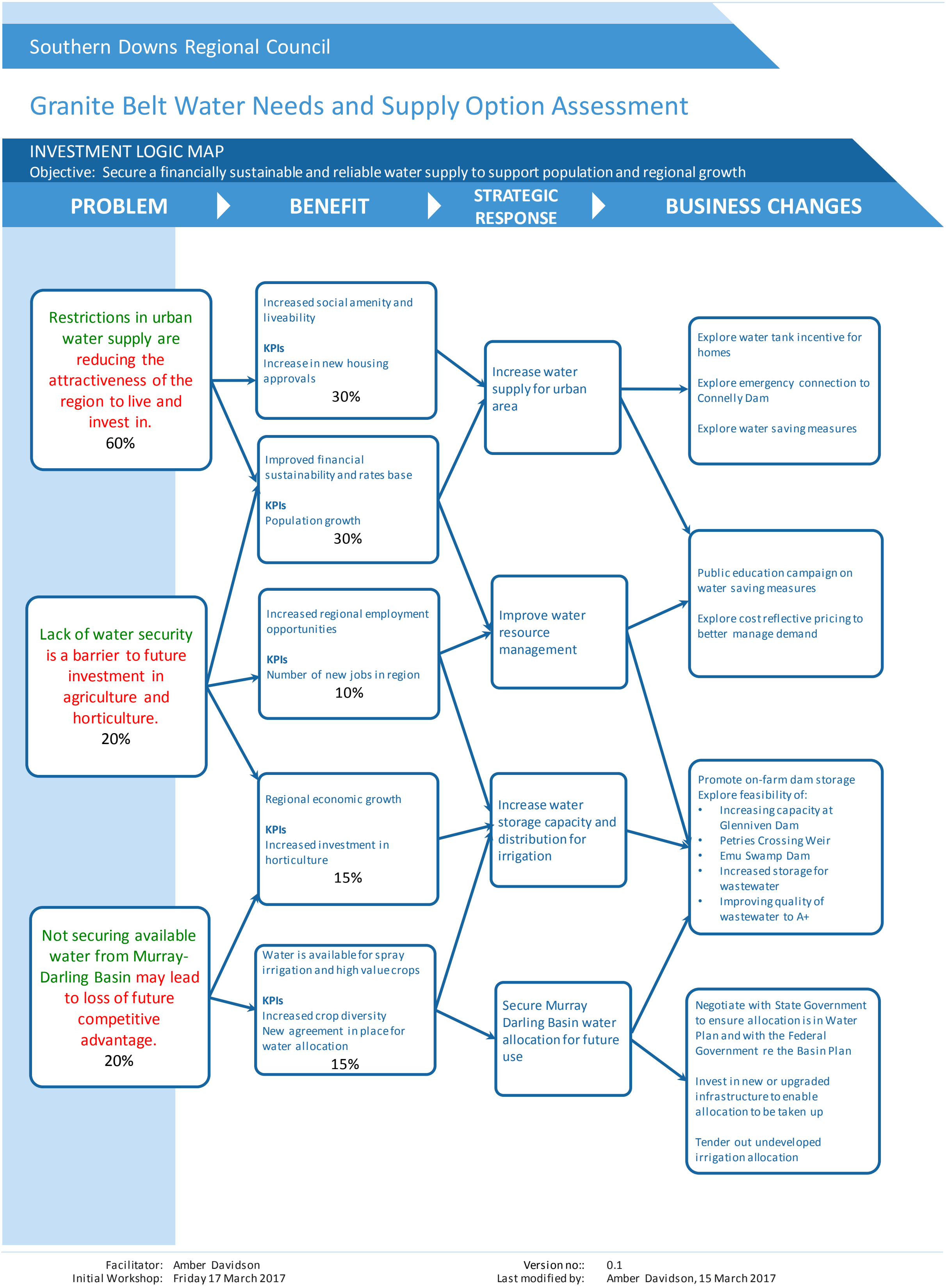
Appendices

Appendix A –Investment Logic Map



Appendix B Project risk assessment

The following captures the output from a structured risk workshop held with SDRC to capture and assess the proponent's considerations of risk for the project. GHD recognises that this assessment only draws on one major stakeholder for the project and propose to widen this risk analysis to a broader major stakeholder group should the work proceed to Stage 2 (Preliminary Business Case)

Stakeholder engagement

The Southern Downs Regional Council, as the key stakeholder at this stage of the Business Case development, participated in the risk assessment along with four GHD subject matter specialists in the fields of irrigation systems, water resources and allocation, water economist, and agricultural economist to develop the preliminary project risk register. The risk assessment was undertaken in line with the risk management principles described in the Building Queensland Business Case Development Framework.

The Business Case is being developed with the aim of supporting a decision to proceed with the project, abandon the project and maintain the status quo, or explore alternative options. Whilst there are many additional stakeholders involved in whether the Business Case for the Emu Swamp Dam proceeds, it was felt that at this preliminary stage, Council's appreciation of the risks would assist them in their decision on whether and how to proceed with the Emu Swamp Dam option.

Governance

From the workshop with SDRC it is clear that Council considers Emu Swamp Dam to be a high risk project from their perspective. Capital cost estimates for some of the potential urban and irrigation dam solutions indicate the project value could be in excess of $50 million and may exceed $100 million. A capital build solution of this scale will likely require State and potentially federal funding to deliver.[35]

Given this, consideration may need to be given to engaging an appropriate sponsor within State government to help progress the project through to detailed business case (Stage 3), should a major capital build option be preferred.

High level summary

The risk assessment focussed primarily on the financial, strategic and social impacts of the Emu Swamp Dam project. The environmental, delivery and safety impacts are best assessed when the Business Case is prepared for a firmly established project concept.

Table B-16-1 shows the key and description for the significance of the risk and Table B-16-2 provides an assessment of the significance of each risk identified with respect to Council's decision based on the response required through the development of the preliminary Business Case.

[35] Depending on the overall capital costs of the option taken forward to detailed business case, the project may become subject to the legislative requirements of the Building Queensland Act, 2015.

Table B-16-1 Significance of risk

Level of Risk	Response
High	Insufficient or inadequate risk mitigation identified, needs further investigation during the preliminary business case
Medium	Some risk mitigation identified, but requires further investigation during the preliminary business case
Low	Sufficient risk mitigation identified, follow up during the preliminary business case

The team identified and evaluated 14 risks. A breakdown of the risks is provided in Table B-16-2.

Table B-16-2 Risk evaluation

	High	Medium	Low
Financial	7	1	0
Strategic	2	0	0
Social	2	2	0
TOTAL	**11**	**3**	**0**

Risks were identified through discussion with the project sponsor, SDRC, and hence constitute risks perceived by just one major stakeholder. Additional risk workshops with other stakeholders will be required should the project proceed to Stage 2 (Preliminary Business Case).

Review of project risks

It is the view of the Southern Downs Regional Council that there are a range of risks in progressing the Emu Swamp Dam business case. The high risks are summarised below.

Financial

Financial risks rated as a high were:

- The Council is operating under existing financial stress. Should a dam solution be built, the net contribution required by the Council, after deduction from the revenue of the depreciation and operational/maintenance costs, exceeds the funding received, further increasing the financial stress on the Council.
- Financial returns to the Council from the projected revenue from non-urban users are insufficient to service the debt, forcing the Council to increase debt levels and / or increase water charges to urban users, with urban user cross-subsidising irrigation.
- Pressures from certain stakeholders to build the Emu Swamp Dam may preclude the delivery of an alternate water supply solution that could still meet desired outcomes while avoiding increased costs for Council and residents.
- The key financial risk mitigation would be to find an alternative sponsor for a project to develop a water supply project for the region that would service the irrigation needs, but without further financial impost on the Council.

Strategic

The following strategic risks was rated high:

- For historic reasons, Council has been identified as the proponent for a major infrastructure project to serve urban and irrigation supply needs. However, it is not within Council's ambit to fund and develop irrigation infrastructure projects.

The key strategic risk mitigation would be for SDRC to develop a comprehensive water supply strategy for the Southern Downs Region and then assess the capabilities of the Southern Downs Regional Council to deliver this strategy. This could be achieved through modifying the ancillary infrastructure owned by the Council through investment and resourcing in order to meet the water supply strategy. Such a plan could take the form of an update to SDRC's existing 2009 Drought Management Plan

Social

The following social risks was rated high:

- Because of significant recent stakeholder consultation on this issue, there is concern of a low participation rate in consultation process, which results in insufficient data for a conclusion, and a low level of acceptance of the study by stakeholders

The key social risk mitigations would be to conduct a robust stakeholder consultation process and prepare a full lifecycle costing for a water supply project for the region with capex requirements and opex forecasts.

With the risk mitigations identified, all of the risks to the Business Case for the Emu Swamp Dam could be reduced to medium. However, further investigation of each of the risks and their mitigation would be required for the preparation of the Preliminary Business Case. There are also a range of other risks to be considered, involving the input from a wider group of stakeholders and across a broader range of criteria including:

- Governance risks
- Environmental risks
- Engineering risks
- Regulatory risks
- Community health and safety risk

However, the level of detail for considering these stakeholder inputs and additional criteria is lacking. The proper assessment of the project risks would require a more substantive assessment to be undertaken once the strategic direction for the Business Case is decided.

As the above risks are the perception of only one major stakeholder, additional risk workshops with other stakeholders will be required should the project proceed to Stage 2 (Preliminary Business Case).

Appendix C – Social profile

Appendix C.1 Executive summary

This Appendix sets the social context for the water supply needs and option assessment to the Stanthorpe region, known as the Emu Swamp Dam Final Feasibility Study and provides information at the Southern Downs Regional Council (SDRC) level. Where appropriate information at the statistical level area for the regional area surrounding Stanthorpe (Stanthorpe Regional SLA) and the Stanthorpe urban area (Stanthorpe Urban SLA) is also provided.

- Population growth in the Southern Downs region over the past 5 years has been 0.7% over the past five years that is far lower than for the rest of Queensland at 1.6%. The Stanthorpe Regional SLA grew at 0.7% and the Stanthorpe Urban SLA at 0.3%.
- 21.9% of the Southern Downs region population is older than 65 compared to the rest of Queensland at 14.4%. 26.6% of the population in the Stanthorpe SLA is older than 65.
- The region has a low percentage of indigenous population (3.3%).
- 74.5% of the population were affiliated with a Christian religion in comparison to 64% across the rest of Queensland.
- The majority of housing stock is separate housing accommodating a single family
- Levels of education across the population are lower than the rest of Queensland.
- 42.5% of Southern Downs Region population were considered to be in the most socially disadvantaged quintile compared to 20% of the population overall. Social disadvantage was greatest in the Stanthorpe Urban SLA.
- Crime in the Southern Downs region area was lower than the rest of Queensland. Crime rates in the Stanthorpe Urban SLA were higher than the rest of Queensland.
- Incomes in the Southern Downs region were lower than the rest of Queensland. 42.5% of the population earned less than $20,000 per annum.
- Unemployment rates are lower than the rest of Queensland.
- Agriculture is the major employer in the region. There were 133 housing development approvals in the entire Southern Downs region are in the 12c moths leading up until February 2017 with 15 in the Stanthorpe Urban SLA.
- The average house price across the Southern Downs region was $258,000. The Stanthorpe Urban SLA had a slightly higher median house price than the Southern Downs Region as a whole.
- The major findings for the Emu Swamp Dam Feasibility Study of this social profile are that population growth in the Stanthorpe Urban area is slowing and the ability of residents to pay for an additional urban water supply is limited.

Appendix C.2 Purpose

The purpose of this section is to present the social context where the Emu Swamp Dam project is occurring. The study area is located in the Darling Downs regional area of Queensland and covers an area of 7,122 km^2. The project is occurring within the boundaries of SDRC (the study area). In this analysis, data is presented mainly at the local government level, in this case SDRC, although where appropriate additional information is presented at the Statistical Level Area (SLA). Information on two Statistical Level Areas are provided, as these are the ones that the proposed Emu Swamp Dam will have the major impact on. These are the regional areas surrounding Stanthorpe (Stanthorpe Regional SLA) and the area encompassing Stanthorpe itself (Stanthorpe Urban SLA). Figures for Queensland are presented for a comparative basis.

Appendix C.3 Population

At 30 June 2016, the estimated resident population of the study area (SDRC) was 35,854 persons. (Queensland Government Statisticians Office 2017).

The population of the study area grew at a lower rate than Queensland, with average population growth at 0.7% over the five years to June 2016 and 1.0% over the ten previous years. This is compared to 1.6% and 1.9% over the five and ten years to June 2016 respectively for Queensland. The Stanthorpe Regional SLA grew at 0.7% over the previous 5-year period and 1.2% over the previous ten years. Stanthorpe Urban SLA grew at 0.3% over the previous 5-year period and 0.7% over the previous ten years.

By June 2036, the population of the study area is projected to increase to 40,924 persons, an average increase of 0.7% per year (Queensland Government Statisticians Office 2017). Stanthorpe Regional SLA growth is expected to be 0.5% while Stanthorpe Urban SLA is expected to 0.4%. This is below the average population growth expected for Queensland as a whole over the same period (at 1.7% per annum).

Appendix C.4 Age

The study area has an older population than for Queensland with a high median age and a high proportion of elderly people. The following table shows the population age distribution and indicates a higher proportion of residents aged 65 years or older (21.9%) in comparison to the rest of Queensland (14.4%). Stanthorpe Urban has 26.7% of the population in the 65+ age bracket.

Table C-1 – Estimated regional population by age

Region	0-14		15-24		25-44		45-64		65+	
	No.	%	No.	%	No.	%	No.	%	No.	%
Stanthorpe Urban	1,053	18.8	493	8.8	1,297	23.1	1,271	22.6	1,498	26.7
Stanthorpe Region	1,024	17.9	564	9.8	1,059	18.5	1,915	33.4	1,166	20.4
SDRC	6,953	19.5	4,138	11.6	7,072	19.8	9,748	27.3	7,827	21.9
Queensland	943,992	19.8	647,983	13.6	1,327,470	27.8	1,173,195	24.5	686,214	14.4

Source: ABS 3235.0 Population by Age and Sex regions of Australia 2015

The median age of the region in 2015 was 44.3 years compared to the median age for the rest of Queensland of 36.9 years. The median age for the region increased from 40.0 years as at 30 of June 2005 to 44.3 in 2015 compared to an increase in the median age across Queensland from 35.9 years in 2005 to 36.9 years in 2015. The median age of the population within the region is projected to increase to 48.9 years in June 2036 in comparison to the projected median age for Queensland in 2036 of 39.9 years (Queensland Government Statisticians Office 2017).

The median age for Stanthorpe Regional SLA was 47.9 years (predicted to increase to 52.4 in 2036) while for the Stanthorpe Urban SLA it was 44.4 years (predicted to increase to 46.9 years in 2036.

The median age of the population is growing faster than the rest of Queensland and this trend is predicted to continue. In the future, based on trends, there will be an older population with a continued decline in the proportion of younger working people. All other things being equal, this trend will lead to a declining population in the Stanthorpe region over the long term.

In 2015 there were 408 registered births in SDRC and 378 registered deaths. In the Stanthorpe Regional SLA there were 52 registered births and 42 deaths while in the Stanthorpe Urban SLA there were 54 registered births and 90 deaths (Queensland Government Statisticians Office 2017).

Appendix C.5 Indigenous population

Based on the 2011 Census of Population and Housing, 3.3% of the regional population is identified as Indigenous as compared to 3.6% for Queensland (Queensland Government Statisticians Office 2017). The indigenous population in the Stanthorpe Urban SLA was 2.2%

Appendix C.6 Ethnicity and language

Based on the 2011 Census of Population and Housing, 9.9% of people in the study area were born overseas in comparison to 20.5% for Queensland overall. 30.5% of the population indicated that they spoke a language other than English at home in comparison to 36% for Queensland overall. 1.4% of the total regional population indicated that they spoke Italian at home, the top non-English language spoken at home (Queensland Government Statisticians Office 2017).

Appendix C.7 Religion

74.5% of the population in the study area indicated that they were affiliated with a Christian religion compared to 64.33% of the Queensland population overall.

Table C-2 – Southern Downs region religious profile

Religious Affiliation	Percentage
Catholic	27.2%
Anglican	24.4%
No religion	16.0%
Uniting Church	3.3%
Presbyterian and Reformed	4.1%

Source: ABS 3235.0 Population by Age and Sex regions of Australia 2015

Appendix C.8 Families and housing

Within the study area there were 12,860 households. 69.8% of total households were a one family household. The majority of the housing stock (91.7%) is defined as separate houses. The percentage of total occupied private dwellings in the study area that were fully owned was 39.3% (Queensland Government Statisticians Office 2017).

Appendix C.9 Department of social services payments

As of the first quarter of 2016, 5,995 residents received the age pension (Stanthorpe Region SLA 871, Stanthorpe Urban SLA 1,225). 1,091 received the disability support pension. 1,453 received the Newstart allowance (Queensland Government Statisticians Office 2017).

Appendix C.10 Education

Education levels in the study area are lower than for the rest of Queensland. Table C-3 summarises the highest level of schooling achieved.

Table C-3 – Level of schooling achieved

Area	Did not go to school or Year 8 or below		Year 9 or 10 or equivalent		Year 11 or 12 or equivalent		Total
	number	%	number	%	number	%	number
Stanthorpe Urban	608	14.4	1,488	35.2	1,749	41.4	4,225
Stanthorpe Region	436	10.3	1,653	38.9	1,855	43.6	4,254
SDRC	2,931	11.4	10,337	40.2	10,414	40.5	25,741
Queensland	219,102	6.6	977,116	29.4%	1,836,995	55.3%	3,320,761

Source: ABS Census of Population and Housing 2011

In terms of higher education 9.1% of people aged over 15 held a Bachelor degree or higher compared to 15.9% for the Queensland population. Similarly, 5.6% held an Advanced Diploma or Diploma compared to 7.5% for the Queensland population while 19.4% held a certificate in comparison to 19.9% for Queensland overall (ABS 2011).

Table C-4 – Non-school qualifications by field of study

Field of Study	Region		Queensland
	number	%	%
Natural and Physical Sciences	203	1.7%	2.3%
Information Technology	136	1.1%	2.2%
Engineering and Related Technologies	1,920	16.0%	16.8%
Architecture and Building	737	6.1%	6.6%
Agriculture Environment and Related Studies	522	4.3%	2.0%
Health	1,183	9.8%	9.3%
Education	1,187	9.9%	7.5%
Management and Commerce	1,583	13.2%	16.6%
Society and Culture	1,036	8.6%	9.6%
Creative Arts	207	1.7%	2.8%
Food, Hospitality and Personal Services	751	6.2%	5.6%
Mixed Field Programs	17	0.1%	0.2%
Total	12,032	100%	100%

ABS, Census of Population and Housing, 2011

Appendix C.11 Socio economic index of areas

Socio-Economic Indexes of Areas is a summary measure of the socio-economic condition of geographic areas across Australia. The Index of Relative Socio-Economic Disadvantage generally focuses on low-income earners, with relatively lower education attainment, high unemployment and dwellings without motor vehicles.

42.5% of the study area population were considered to be in the most disadvantaged quintile compared to 20% of the Queensland population overall. (Stanthorpe Regional SLA 23.4%, Stanthorpe Urban 71.8%). 0.9% of the population was considered to be in the least disadvantaged quintile compared to 20% of the Queensland population overall (Queensland Government Statisticians Office 2017).

Appendix C.12 Reported offences

In 2015-2016 the study area generally had lower levels of crime, with 9,262 reported offences per 100,000 persons compared to Queensland at 9,856 per person (Stanthorpe Regional SLA 7,547, Stanthorpe Urban SLA 12,522). Offences against persons were lower in the study area than Queensland overall for the same period (615 offences per 100,000 persons versus 634 offences). Offences against property were lower in the study area than Queensland overall (2,483 per 100,000 people versus 4,250 offences) (Queensland Government Statisticians Office 2017).

Appendix C.13 Income

Incomes in the study area were lower than those for Queensland overall. Median annual personal income in the study area in 2011 was $23,296 compared to $30,524 for Queensland overall. 42.5% of the population aged 15 years or older earned less than $20,000 per annum compared to 34.6% for Queensland overall.

Approximately 19.9% of families in the study area were classified as low income compared to 13.0% of families for Queensland overall. Median family income in the region was $52,052 per year compared to $75,556 for Queensland overall (Queensland Government Statisticians Office 2017).

Appendix C.14 Unemployment

In the December 2016 quarter, there were 745 unemployed persons in the study area. The unemployment rate was 4.3% compared to 6.1% for Queensland (Stanthorpe Regional SLA 4.0%, Stanthorpe Urban SLA 4.8%). 608 or 17.6% of families with children under 15 years had no parent in employment compared to 13.5% for Queensland overall (Queensland Government Statisticians Office 2017).

Appendix C.15 Employment

Table C-5 indicates the agriculture is the major direct employer in the region. Farmer and farm manager were listed as the top occupational categories in the study area.

Table C-5 – Employment by industry – Southern Downs Region & Queensland (2011)

Industry	SDRC Region		Queensland
	number	%	%
Agriculture, forestry and fishing	1,971	13.7%	2.7%
Mining	147	1.0%	2.6%
Manufacturing	1,319	9.2%	8.4%
Electricity, gas, water and waste	115	0.8%	1.2%
Construction	1,018	7.1%	9.0%
Wholesale trade	417	2.9%	3.6%
Retail trade	1,869	13.0%	10.7%
Accommodation and food services	1,067	7.4%	7.0%
Transport, postal and warehousing	849	5.9%	5.3%
Information, media and telecommunications	117	0.8%	1.2%
Financial and insurance services	188	1.3%	2.7%
Rental, hiring and real-estate services	153	1.1%	1.8%
Professional, scientific and technical services	447	3.1%	6.5%
Administrative and support services	251	1.8%	3.2%
Public administration and safety	761	5.3%	6.7%
Education and training	1,167	8.1%	7.9%
Health care and social assistance	1,534	10.7%	11.9%
Arts and recreation services	112	0.8%	1.4%
Other services	500	3.5%	3.9%
Total	17,806	100%	100%

ABS Census of Population and Housing 2011

The Stanthorpe Regional SLA had a far higher percentage of employment in the agriculture category at 28.7%. The 2011 ABS Census of Population and Housing reports the top five occupation sub major groups of employment for the study area were:

1. Farmers and Farm Mangers (8.5%)
2. Sales Assistants and Salespersons (6.7%)
3. Carers and Aides (5.1%)
4. Factory Process Workers (4.7%)

5. Hospitality, Retail and Service Managers (4.6%).

Appendix C.16 Industry and development

There were 133 approvals for new in study area in the 12 months leading up until the 28 of February 2017. There were 27 approvals in the Stanthorpe Regional SLA area and 15 in the Stanthorpe Urban SLA.

Appendix C.17 Residential dwelling sales

The median residential sales price for the study area in the twelve months ending 30 September 2016 was $258,000. (Stanthorpe Regional SLA 290,000, Stanthorpe Urban SLA 247,000).

Appendix C.18 Conclusions and implications

The township of Stanthorpe has a slowing rate of population growth. The age profile of the township is increasing and in 2015 the number of registered deaths outnumbered births. The Stanthorpe township is growing at a slower rate than the surrounding regional area and the rest of the local government area. There were a low number of building approvals indicating that there is no significant increase in the number of houses requiring a reticulated water supply. The high proportion of the Stanthorpe urban area on the aged pension, the low per person income and high degree of social disadvantage indicates that the ability to pay for an additional water supply may be limited.

Appendix D – Agricultural and industrial water demand assessment

Final report to the Southern Downs Regional Council

Emu Swamp Dam - Agricultural and industrial water demand assessment

May 2017

Synergies Economic Consulting Pty Ltd
www.synergies.com.au

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ECONOMIC CONSULTING

Glossary

Dam supply footprint	The proposed irrigation distribution system coverage area, or the area of land that could be supplied by the proposed Emu Swamp Dam. This is based on previous designs of the irrigation pipeline for the project.
Discount rate	The rate applied to future cashflows to determine the 'Present Value'. In commercial analysis, this is effectively the interest rate.
Environmental Impact Statement	An assessment conducted on major projects to determine the extent to which the project will impact on the existing environment (natural, social, economic and built).
Greenfield producers	Agricultural producers who are not currently established in the Southern Downs region (i.e. would need to set up a new operation to produce crops in the region).
Gross margin	Total on-farm revenue less operating costs. Can be expressed per hectare or per ML.
Irrigation application rate	The volume of water (in megalitres) applied to a crop area (i.e. per hectare).
Irrigation diversions	Total volume of water that is diverted from river systems/catchments for use as irrigation water.
Overland flow harvesting	The practice of capturing and storing overland flows, being water that runs across the land after rainfall.
Preliminary Business Case	The second stage in Building Queensland's Business Case Development Framework, the purpose of which is to assess potential options to respond to the identified service need.
Present Value	The 'present day' value of future cashflows, calculated by discounting cashflows using a discount rate.

Sensitivity analysis	Analysis conducted to demonstrate how the results of an analysis respond to changes to key parameters or assumptions.
Supplemented water allocations	Allocations managed under a Resource Operations Licence (i.e. a licence granted to operators of water supply storage infrastructure.
Unsupplemented water allocations	Allocations from an unsupplemented supply such as a natural flow that is not dependent on water infrastructure.
Water Plan	Plans developed through technical and scientific assessment and community consultation to determine the appropriate balance between the economic, social and environmental demands on water resources.

Executive Summary

GHD has been engaged by the Southern Downs Regional Council (SDRC) to undertake a Final Feasibility study into the proposed Emu Swam Dam. As part of this work, GHD has engaged Synergies Economic Consulting (Synergies) as their sub-consultants to undertake an assessment of the agricultural and industrial water demand that could potentially be met by the proposed Emu Swamp Dam. The dam has a storage capacity of approximately 10,500 ML, with an estimated combined (urban and irrigation) yield (96% monthly reliability) of 2,418 ML per annum of which approximately 1,700 ML per annum high priority water is reserved for irrigation supplies. The purpose of this report is to provide a robust assessment of agricultural and industrial demand for water within the proposed irrigation distribution system coverage area (dam supply footprint) to inform the Strategic Assessment of the project.

Agricultural water demand

Several previous studies have assessed demand for irrigation water for agricultural production in the region. Whilst these studies have found that agricultural producers in the region have an appetite for additional irrigation water, the studies have not been sufficiently robust to enable a decision to be made on whether to proceed with the construction of the dam, or an alternative option, largely due to the absence of any detailed assessment of the on-farm financial return from the use of additional irrigation water.

The principle underpinning our methodology for assessing demand for irrigation water is as follows: For those crops that are identified as likely sources of demand for additional volumes of irrigation water, we estimate the financial return from the use of additional volumes of irrigation water ($ per ML) net of all costs incurred in the expansion of production (including crop production costs and on-farm capital infrastructure costs).[1] This represents the upper bound of what producers would be able to pay (in total) for additional irrigation water entitlements. It is important to note that this estimate does not necessarily represent the upper bound of what irrigators are willing to pay. The latter is likely to be lower than the derived estimates due to the other factors that producers take into account when determining what they are willing to pay for water entitlements (e.g. irrigation prices in other jurisdictions). This is also supported by our review of previous studies and reports relevant to the project.

1 The total return to irrigation water is calculated by applying a discount rate commensurate with producers deriving a commercial return from irrigation water entitlements.

The key steps for the agricultural demand assessment are as follows:

- establish the current irrigation water supply-demand situation within the dam supply footprint;
- review financial crop production information;
- consult with producers[2] in the dam supply footprint; and
- develop farm-level financial models for individual crops and estimate the total returns to additional irrigation water for each crop.

In relation to current irrigation water supply and use in the Southern Downs, we make the following observations:

- producers are currently reliant upon on-farm storages and the harvesting of overland flows and the intersection of near-surface groundwater resources for irrigation water supply;
- the volume of irrigation water to be made available by the construction of the proposed Emu Swamp Dam would represent a relatively marginal increase (estimated at less than 10 per cent) in total irrigation water use in the region and as such is more likely to supplement water supplies of established producers as opposed to being used by greenfield producers to meet base water requirements. In short, the additional water will be predominantly used for 'stand by and top up' purposes to cover periods of drought and for the incremental expansion of crop production by established producers;
- the thinness of water trading markets in the region, including in the Stanthorpe Water Management Area, means there is little price information for water that would otherwise reveal how much producers are prepared to pay for water;
- there is significant variability in irrigation application rates across crops produced in the region (3 to 12 ML per ha); and
- access to suitable land is unlikely to represent a constraint on the expansion of crop production in the region.

We conducted consultation with producers in the Southern Downs region through three streams – focus groups, an internet-based survey, and one-on-one telephone interviews. The key outcomes from the consultation were as follows:

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2 Predominantly horticultural.

- water availability is a significant constraint on crop production in the region, particularly in relation to tomatoes, strawberry runners and strawberries;
- market factors (e.g. insufficient demand, competition from other regions) are the other major constraint on production, particularly for apples, other tree fruits, wine grapes and a range of vegetable crops;
- consistent with the results of the 2013 agricultural land audit, producers confirmed that they have access to significant areas of additional land (at minimal cost) for the expansion of crop production;
- additional volumes of irrigation water, either from a dam or other means would be used to supplement existing irrigation water supply sources in the region (i.e. on-farm storages) rather than to underpin new greenfield developments (as opposed to existing farm expansion/use of currently uncultivated farming land);
- there is a significant desire for additional volumes of irrigation water from producers of a wide range of crops, including apples, tomatoes and capsicums, strawberries, wine grapes, strawberry runners, green vegetables and specialty crops (e.g. vegetable seedlings, mushrooms); and
- water shortages resulting in the reduced application of water has a significant negative impact on yield and/or product quality for several crops.

Based on the documentation reviewed and consultation conducted, the following sources of demand for additional irrigation water within the dam supply footprint were identified:

- apple producers, predominantly for increased water security for existing crops in addition to small scale incremental expansion of cropping area;
- tomato and capsicum producers, for the expansion of crop production, predominantly for tomatoes;
- strawberry producers, for the expansion of crop production;
- wine grape producers, predominantly for application to existing crops, but also to facilitate small scale expansion of crop production; and
- strawberry runner producers, for the expansion of crop production.

Limited consultation was undertaken with producers of green vegetables, due to the unavailability of green vegetable producers to engage during the consultation period. Whilst farm-level analysis has been undertaken for this crop, it has not been included in the base demand assessment.

There are two potential uses of additional volumes of irrigation water for producers within the dam supply footprint – application to existing crops and the expansion of production. The table below summarises the extent to which additional irrigation water is likely to be applied for these two purposes by crop type.

Uses of additional volumes of irrigation water by crop type

Crop	Likelihood of application to existing crops	Potential for expansion of area of production
Apples	**HIGH** – Producers expressed a strong interest in securing additional volumes of irrigation water to avoid yield and product quality losses in 'dry' years.	**LOW** – Market factors are the primary constraint on apple production in the region.
Tomatoes and capsicums	**LOW** – Due to the significant planting costs and the need to maintain product yield and quality, tomato and capsicum producers normally scale production in accordance with their water availability.	**HIGH** – Water availability is the key constraint on the expansion of tomato production in the region. Producers estimated that production could increase 20-30 per cent without price reductions.
Strawberries	**LOW** – Strawberry producers ensure they have sufficient water to maintain existing production levels in order to meet quality and yield requirements.	**MEDIUM** – Whilst water is a constraint, market factors also constraint production. Expansion would therefore be incremental.
Wine grapes	**HIGH** – Whilst there is significant variability in crop yields and irrigation application rates across producers, several producers stated that their primary use of additional irrigation water would be for established crops.	**LOW** – Market factors are the key constraint on wine grape production in the region. An increase in irrigation water supply may facilitate the small scale expansion of some producers, in particular the planting of new varietals.
Strawberry runners	**LOW** – Producers of strawberry runners scale production based on their water availability due to the need to meet crop yield and quality requirements.	**HIGH** – Water is the primary constraint on production. Subject to this constraint being addressed, producers advised that production could expand by 20-30 per cent.
Green vegetables	**MEDIUM** – It is understood that some green vegetable producers are likely to benefit from application of additional water during dry periods.	**LOW** – Based on anecdotal information from other crop producers, any expansion in production of green vegetable crops is likely to involve incremental expansion by existing producers.

The following table presents the results of the crop-by-crop analysis of the returns from increased availability of irrigation water within the dam supply footprint.

Summary of modelling results

Crop	Approx. area of production within dam footprint (ha)	Total return for existing crops (Present Value per ML)	Total return for new crop production (Present Value per ML)
Apples (lower water security)	1,202	$43,800	$33,900
Apples (higher water security)		$26,300	
Tomatoes	65		$38,400
Strawberries	160		$55,400
Wine grapes	170	$20,900	$25,400
Strawberry runners	170		$12,600
Green vegetables	500	$25,600	$30,700

Note: Total returns calculated based on a real discount rate of 10 per cent. Areas are approximations only. Estimates are rounded to the nearest $100.

Source: Synergies modelling. Areas of production are based on the assessment undertaken by Orchard Services in 2013, informed by an updated assessment undertaken by Orchard Services in April 2017.

The table below sets out the potential demand for additional irrigation water by crop type and use, based on an assessment of the likelihood of additional volumes of water being applied to existing crops and used for new crop production.

Demand for additional irrigation water by crop type and use

Crop	Area within dam footprint (ha)	Demand for existing crop production		Demand for new crop production			
		Demand per ha	Total demand	% expansion in area	Additional area of crop production (ha)	ML/ha required for expansion	Total demand
Apples (lower water security)	1,202	0.55 ML	330.5 ML	5	60	6.05	363.5 ML
Apples (higher water security)		0.55 ML	330.5 ML				
Tomatoes	65			60	39	6.05	236 ML
Strawberries	160			15	24	8.80	211 ML
Wine grapes	170	0.53 ML (to 50% of ha)	45 ML	5	8.5	1.93	16.5 ML
Strawberry runners	170			25	42.5	11.00	467.5 ML
Green vegetables	500	0.5 ML (to 50% of ha)	125 ML	5	25	5.50	137.5 ML

Notes: Assumed that 50 per cent of apple producers have lower water security and 50 per cent have higher water security.

The percentage expansions of areas were estimated by Synergies, based on a review of recent production trends in the region and consultation with producers.

For wine grapes and green vegetables, it has been assumed that only 50 per cent of producers will demand access to additional irrigation water for application to existing crops (based on consultation with stakeholders and past reports and studies).

Source: Synergies modelling.

Based on the above table, the estimates of demand for additional irrigation water within the dam supply footprint are as follows:

- 2,000.5 ML (for all crops without green vegetables)
- 2,263 ML (for all crops including green vegetables).

As noted above, the proposed Emu Swamp Dam has an indicative yield of approximately 1,700 ML per annum for irrigation use. The following table provides a break-down of the take-up of these additional volumes by crop type and use, based on the outcomes of this assessment.

Illustrative demand take-up for additional volumes of irrigation water (without green vegetables)

Use	Additional ML used	Cumulative ML supplied[a]	Total returns (Present Value)	Cumulative returns (Present Value)
Strawberries – new crops	211.2	211.2	$11.71 million	$11.71 million
Apples – existing crops (producers with lower levels of water security)	330.6	541.8	$14.46 million	$26.17 million
Tomatoes – new crops	236.0	777.7	$9.07 million	$35.24 million
Apples – new crops	363.6	1,141.3	$12.32 million	$47.56 million
Apples – existing crops (producers with higher levels of water security)	330.6	1,471.9	$8.67 million	$56.24 million
Wine grapes – new crops	16.4	1,488.2	$0.41 million	$56.65 million
Wine grapes – existing crops	44.6	1,532.8	$0.93 million	$57.58 million
Strawberry runners – new crops	167.2	1,700.0	$2.11 million	$59.69 million

a Cumulative ML supplied refers to total use of water to be supplied by the proposed Emu Swamp Dam (or an alternative supply source). Cumulative ML supplied is calculated by adding the ML supplied to each use as ML are allocated to each use based on the return per ML. For example, cumulative ML supplied after allocation to existing apple crops (producers with lower levels of water security) is equal to 541.8 ML (211.2 ML to new strawberry crops plus 330.6 ML to existing apple crops (low water security)).

Note: Green vegetable crops were excluded based on the level of consultation that was able to be undertaken with producers due to lack of availability.

Source: Synergies modelling.

It is acknowledged that, in practice, different producers of the same crop will derive different returns from additional irrigation water, subject to a range of factors associated with their current production practices, levels of water security, etc. The merit order presented above is therefore intended to provide an illustration of the likely take-up of additional volumes of irrigation water and hence the on-farm return from additional irrigation water use.

It is important to note that the estimates contained in the above table do not take into account annual water infrastructure and supply charges or up-front costs that would need to be incurred for producers to make use of additional irrigation water delivered to the farm gate (e.g. additional pipe infrastructure).

In order to compare the return to additional irrigation water to the capital cost of a proposed supply augmentation, such as the Emu Swamp Dam or an alternative option, it is necessary to make an allowance for these costs. This is because the estimates of total return per ML do not take into account future costs to be incurred by the producer in securing access to the irrigation water. To the extent that the producer is to incur additional costs, such as annual water infrastructure charges, the total return to the irrigation water will be reduced.

For example, if annual water infrastructure and supply charges are expected to total $500 per ML and producers needed to invest, on average, $2,500 per ML in on-farm infrastructure improvements in order to access their additional water entitlements (e.g.

additional pipeline connections to existing on-farm storages), it would be necessary to reduce the estimates for the total return by $7,500 per ML.[3]

Based on an estimated yield for the proposed Emu Swamp Dam of approximately 1,700 ML, this equates to a total reduction of $15.0 million, lowering the average return per ML from $35,100 per ML to $27,600 per ML (for the scenario excluding green vegetable crops). It is this value that should be assessed against estimates for the capital cost per ML for any supply augmentation options.

It is important to note that the above estimates have been derived based on the assumption that entitlements are 'high reliability' (i.e. >95 per cent). The value of additional irrigation water to producers is for application to existing crops during periods of water shortage to avoid crop yield and product quality losses and for application to newly established crops. Both of these uses require producers to be confident in the reliability of supply. If the water entitlements to be made available from the proposed Emu Swamp Dam, or any other supply augmentation, were to be of a lower level of reliability, an adjustment would need to be made to the estimated returns to additional irrigation water.

Finally, it is important to note that this assessment is not intended to provide a recommendation as to the price at which additional irrigation water should be supplied to producers (or the prices that producers would actually agree to pay). Rather, the purpose of the assessment is to estimate the financial return to additional irrigation water at the farm level (i.e. the most that producers would be willing (or have capacity) to pay for additional irrigation water) to enable the cost of supply augmentation options to be compared to the farm-level return to additional volumes of irrigation water. There are a range of factors that impact on the price that producers will actually pay for irrigation water, several of which are unrelated to the farm-level return to irrigation water, including irrigation prices in other areas.

Sensitivity analysis was conducted on three key variables – discount rate; crop prices; and incidence of 'dry' years. Whilst all variables had a significant impact on the average per ML return to irrigation water, the impact was most significant for crop prices, with a 10 per cent reduction in future crop prices resulting in a reduction in the average per ML return from $35,100 per ML to $20,400 per ML (in Present Value terms). This is significant and demonstrates the extent to which producers' expectations regarding future crop price fluctuations will impact on the price that producers are prepared to pay for additional irrigation water entitlements.

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[3] Based on a discount rate of 10 per cent. It is important to note that these are indicative estimates intended to demonstrate the impact of these costs on the value of additional water entitlements.

Industrial water demand

Several past studies have projected future industrial demand for water in Stanthorpe. The demand projections from these studies are widely divergent. Synergies therefore sought to understand the basis for the differences and come to an informed view about whether water is indeed a constraint to future industrial activity in the region. We did not attempt to forecast actual volumes of industrial water demand as this was not within project scope.

The assessment involved the following steps:

- review of relevant, previous studies containing demand projections including:
  - the 2016 *Regional Water Supply Security Assessment* for Stanthorpe, prepared by Department of Energy and Water Supply (DEWS);
  - a report by Sinclair Knight Mertz (SKM) titled "*Stanthorpe Shire Water Opportunities - Urban Water Needs Analysis;*
  - the 2008 Environmental Impact Statement (EIS) prepared by SKM for Emu Swamp Dam;
- consultation with DEWS to confirm assumptions underpinning their 2016 demand assessment; and
- consultations with the Granite Belt Chamber of Commerce and Industry (GBCCI), the SDRC and horticultural producers in the region to gain perspectives around the potential for an agrifood processing industry to become established in Stanthorpe should a new, reliable supply of water become available.

DEWS examined Stanthorpe's urban water needs over the next 30 years. At present, Stanthorpe is supplying, on average, 590 ML per year, of which about 30 per cent (177 ML) is for non-residential use (i.e. industrial, commercial and municipal). By 2036, total urban demand is projected to grow to between 740 ML and 858 ML per year. DEWS assumed that there would be no change to the proportion of non-residential use (i.e. 30 per cent) as it had no strong evidence to indicate that major, new industrial/commercial projects would develop in Stanthorpe.

SKM, in its previous forecasting, arrived at a significantly different conclusion and assumed that industrial demand would outstrip residential demand by 2020, reaching about 500 ML in that year. Synergies notes that in 2017, just three years short of 2020, actual industrial water use (as estimated by DEWS) is just 177 ML.

The GBCCI identified Emu Swamp Dam as its number one priority for promoting economic development in the Stanthorpe region. It believes that there is considerable scope to attract agrifood processors to Stanthorpe if a reliable source of treated water could be made available. By way of example, the GBCCI pointed to the trend towards pre-packaging of fruit and vegetables and preparation of "ready to cook" sliced and diced vegetables prior to supply to supermarkets. It was said that this activity could be done more efficiently and at a larger scale in town if a reliable source of treated, reticulated water was available for washing and hygiene purposes.

Our discussions with horticultural producers in the region found that not all share GBCCI's optimism for locally-based value adding. Even if an additional reticulated water source became available, few producers we spoke to raised any interest in shifting to food processing, as they are currently securing good returns from supplying fresh produce to Brisbane and northern Queensland markets.

In our assessment, it is unlikely that an agrifood processing industry will become a major new demand driver for additional water in Stanthorpe. The reason for this is twofold:

- the volumes of additional water capable of being supplied by the proposed Emu Swamp Dam are relatively small, so would only allow a marginal increase in horticultural output and unlikely to be of sufficient scale to underpin a major, local food processing hub; and
- Stanthorpe producers currently have the option of transporting their produce to nearby Warwick for processing, where there is no water constraint and better access to major transport routes and labour. However, there is little evidence of this occurring, so we are cautious of claims that a new water source for Stanthorpe would attract more local processing.

While non-residential water demand is expected to increase over time, it is Synergies' view that there is insufficient evidence to support a forecast that would have industrial demand outstripping residential demand in the foreseeable future or exhibiting a 'step change' in economic development if a new bulk water supply was developed.

Contents

Figures and Tables

Synergies
ECONOMIC CONSULTING

1 Introduction

GHD has been engaged by the Southern Downs Regional Council (SDRC) to undertake a Final Feasibility study into the proposed Emu Swam Dam. As part of this work, GHD has engaged Synergies Economic Consulting (Synergies) as their sub-consultants to undertake an assessment of the agricultural and industrial water demand that could potentially be met by the proposed Emu Swamp Dam.

This analysis is part of the Strategic Assessment of the project, the purpose of which is to inform the decision on whether a Preliminary Business Case (PBC) is to be undertaken. The Strategic Assessment will also involve a review of urban water supply requirements for Stanthorpe, however this is not within the scope of this analysis.

The Emu Swamp Dam has been subject to several previous assessments, including a 2007 Environmental Impact Statement (EIS) and a business case funding assessment in 2016. The project received planning and environmental approval from the Coordinator-General in September 2014.

Several previous studies have assessed the demand for water within proposed irrigation distribution system coverage area (dam supply footprint),[4] including for irrigation use. These assessments have typically been survey-based approaches that have attempted to derive estimates of the total volume of demand for additional irrigation water and producers' willingness to pay for water. The assessment of industrial water demand in past studies has been limited.

The purpose of this report is to provide a robust assessment of agricultural and industrial demand for water within the dam supply footprint. The approach to assessing irrigation demand is based on assessing the net financial value of current irrigation water use (and increased use) at the farm level. This includes assessing on-farm returns from the use of additional volumes on existing crops and for the establishment of new crops.

The assessment of industrial demand is based on reviewing previous analysis and consulting with key stakeholders to ascertain the extent to which access to reliable water represents a constraint on future industrial activity in the region.

4 The dam footprint refers to the area within which properties could be supplied by the proposed Emu Swamp Dam, based on the initial configuration of the pipeline designed to supply irrigation users whom had expressed an interest in the project. The analysis has been conducted based on this footprint.

The report is structured as follows:

- section 2 sets out the background information relevant to the project, including providing an overview of agricultural production and industrial activity in the region;
- section 3 describes the current water supply-demand situation in relation to agriculture in the region and our approach to undertaking the demand assessment;
- section 4 describes the current industrial demand for water in the region and our approach to identifying potential, future industrial water demand;
- section 5 reviews the available water market data and assesses the implications for the demand assessment;
- section 6 discusses the consultation process undertaken in relation to agricultural and industrial water users;
- section 7 identifies the crop systems on which modelling was conducted, including the key inputs and parameters for each crop;
- section 8 sets out the modelling results; and
- section 9 summarises the findings from the analysis and the implications for the Strategic Assessment.

The report includes the following attachments:

- Attachment A contains a summary of previous demand assessments relevant to the proposed Emu Swamp Dam;
- Attachment B contains a list of the documents that were provided by SDRC and reviewed as part of the assessment; and
- Attachment C contains the survey template provided to crop producers.

2 Background

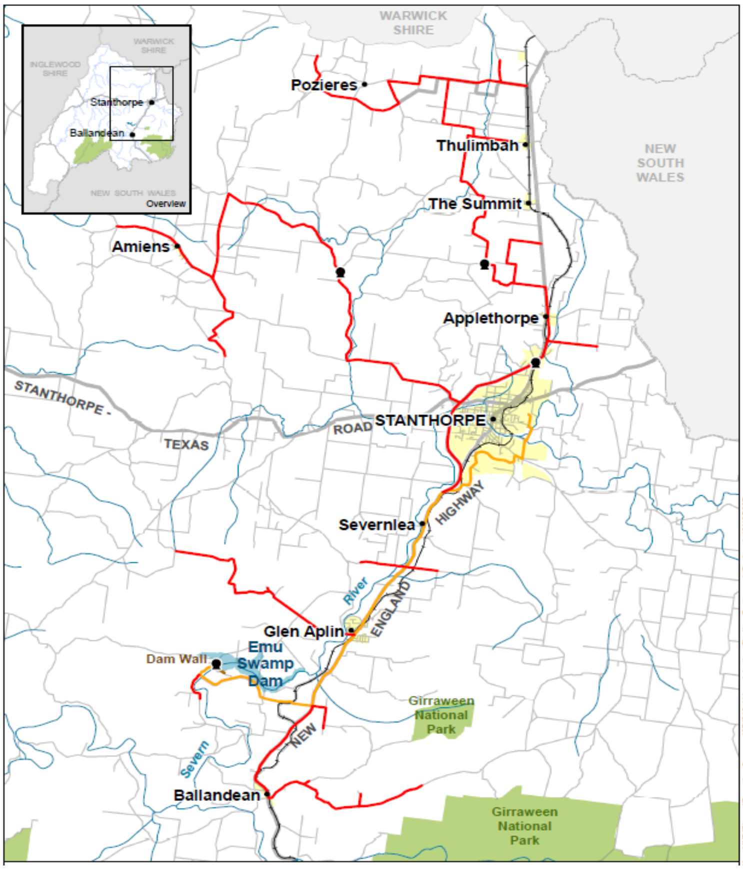
This section presents the background information relevant to the demand assessment, including an overview of past assessments and their relevance to this analysis.

2.1 Emu Swamp Dam

The water supply situation in the Southern Downs region has been subject to several assessments dating back thirty years. The Emu Swamp Dam itself has been under investigation since 2006.[5]

The site for the proposed Emu Swamp Dam is approximately 15 km south-west of Stanthorpe on the Severn River (see Figure 1).

Figure 1 Map of the proposed Emu Swamp Dam



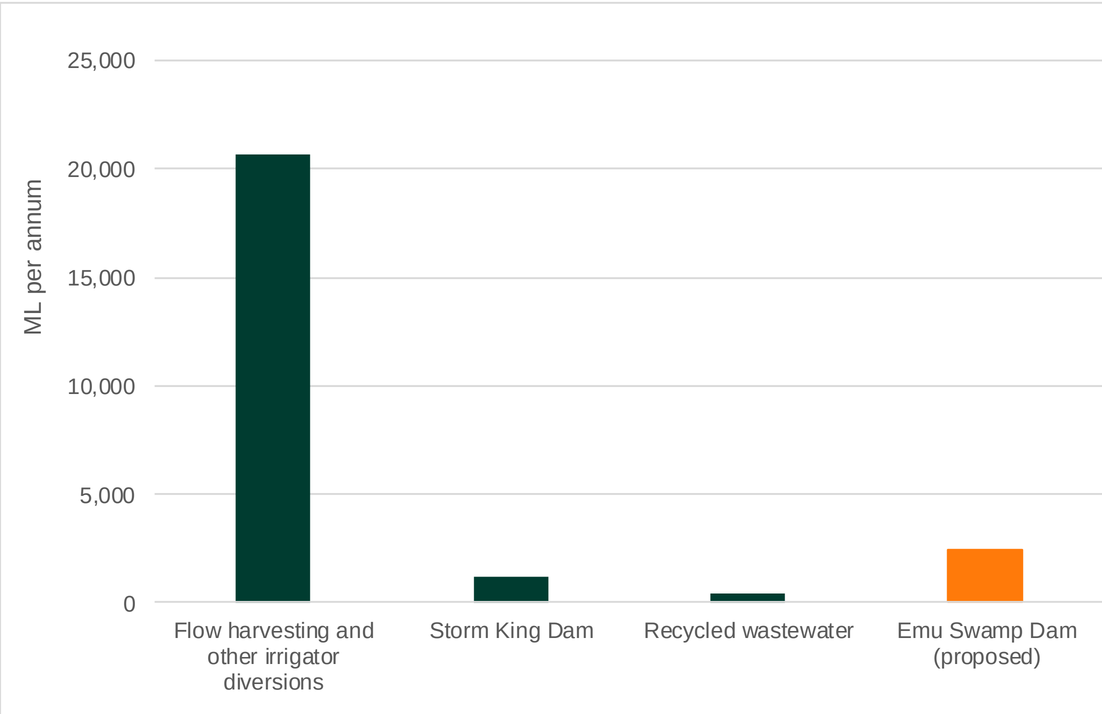
Source: Coordinator-General (2014). Emu Swamp Dam Environmental Impact Statement. Queensland Government.

5 T Sargent Services (2013). The Economic Impact of the Emu Swamp Dam.

The dam, which received planning and environmental approval from the Coordinator-General in September 2014,[6] has an estimated storage capacity of approximately 10,500 ML, to be used for either urban, industrial and/or irrigated agricultural production. It is understood that a preliminary estimate of approximately 2,418 ML per annum has been derived for the annual yield from the dam (approximately 1,700 ML of which is to be used for irrigation).[7] The EIS for the project estimated a capital cost for the dam of $76 million, in addition to noting the potential for a pipeline network to be constructed to link the dam to irrigation properties in the region. A review of previous capital cost estimates for the dam and other options, and the pipeline network, is to be completed as part of the Strategic Assessment.

Figure 2 shows the potential yield from the proposed Emu Swamp Dam relative to the other major sources of water supply in the region.

Figure 2 Water supply sources in the Stanthorpe region



Note: Yield estimate for the proposed Emu Swamp Dam of 2,418 ML per annum is based on information provided by GHD.

Data source: DEWS (2016). Stanthorpe Regional Water Security Supply Assessment; SKM (2007). Emu Swamp Dam Project – Planning Report; GHD.

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6 'Emu Swamp Dam Project'. Department of State Development; DOA: 30 March 2017; See: http://statedevelopment.qld.gov.au/assessments-and-approvals/emu-swamp-dam-project.html

7 Preliminary estimate provided by GHD.

It is important to note that the additional water that would be made available for irrigated agricultural production from the proposed Emu Swamp Dam (1,700 ML) represents a relatively small proportion (less than 10 per cent) of the water currently diverted for irrigated use in the region (noting the estimate for irrigation diversions was derived in 2007).

2.2 Agricultural production in the region

Agriculture is one of the largest industries in the Southern Downs region, with its contribution of $182.7 million to Gross Regional Product (GRP) in 2014/15 second only to transport, postal and warehousing ($191.2 million).[8]

As of January 2016, there were approximately 245 horticultural producers within the dam supply footprint. The key crops grown in the region include:

- tree crops, predominantly apples and stone fruits
- brassicas (i.e. cabbages, broccoli, cauliflower)
- wine grapes
- tomatoes and capsicums
- strawberries
- strawberry runners
- other green vegetables, including peas and beans, cucurbits, lettuce, celery, parsley and herbs, etc.

2.3 Industrial activity

The main water-using industries currently located in and around Stanthorpe can be broadly categorised into one of three types:

- commercial, retail and offices (including health care, social assistance, financial and insurance services, rental, hiring and real estate services);
- municipal activities (e.g. public parks and gardens, golf course, bowling greens, etc.); and
- light industry (e.g. machinery repair workshops, warehouses, stockfeed merchants etc.).

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8 AEC Group (2016). Southern Downs Socio-Economic Profile.

There is no heavy industry within the dam supply footprint.

Commercial, retail and offices are not water-intensive industries and the demand for water by this user group tends to change in line with population, as these businesses typically provide services for the local community as opposed to producing outputs for export out of the region.

2.4 Summary of previous demand assessments

The demand for additional water in the Stanthorpe area has been subject to several previous assessments. Attachment A summarises several of these assessments. We provide an abridged summary of the key outcomes here.

2.4.1 Agricultural demand

For agricultural water demand:

- previous assessments of demand for irrigation water have involved survey-based approaches whereby producers were asked whether they required access to additional volumes of irrigation water; the proposed application of the water (i.e. new or existing crops); and their willingness to pay;
- owing to the thinness of water trading markets in the region, there is little market price information for water (which would otherwise reveal how much producers are prepared to pay for water) (see section 5);
- the survey-based approaches referred to above have found that there is interest in material volumes of additional irrigation water for horticultural production within the dam supply footprint across a wide range of crops;
- it has been reported that additional volumes of irrigation water would be used for both existing crops and to expand crop production in the area;[9]
- the most recent demand study was conducted via an internet-based survey in December 2015. A total of 19 producers were surveyed with all stating they would attempt to purchase additional water entitlements at a one-off purchase price of $5,979 per ML and annual fixed charges of $241 per ML and annual variable charges of $139 per ML. In total, survey respondents indicated a total demand of 1,210 to 1,325 ML, with volume demanded ranging from 5 ML to 300 ML per annum;[10] and

[9] This is consistent with the fact that the volume of water that would be made available from the proposed Emu Swamp Dam represents a small proportion of total irrigation water use within the dam footprint area.

[10] Jacobs (2016). Emu Swamp Dam – Business Case, Final Report (Funding Submission).

- in 2013, 90 interviews were undertaken, with the vast majority of producers indicating strong support for the project based on the growth it would enable. The study found that, of the 48 producers interviewed that would be able to access water from the project, 40 stated that they needed additional water.[11]

2.4.2 Industrial demand

For industrial water demand:

- in 2006, Sinclair Knight Mertz (SKM) prepared a report for the Shire of Stanthorpe titled "*Stanthorpe Shire Water Opportunities - Urban Water Needs Analysis*". The report formed one of series of reports prepared by SKM on the status of water demand and supply in the region. In relation to industrial demand, the report concluded that an improved water supply would provide opportunities to support and attract more diverse value adding businesses. Non-domestic water demand was forecast to increase from 250 ML per annum (as at 2005) to between 600 and 800 ML per annum by 2015;[12]
- in 2008, an Environmental Impact Statement (EIS) by SKM was prepared for the Emu Swamp Dam project, including a benefit-cost analysis (BCA) of the project. The BCA assumed that, over time, industrial water demand would exceed residential demand due to the changing character of Stanthorpe where the urban population is constrained (by young people leaving for education and services sector employment opportunities) while growing tourism and agriculture value-adding are increasing water demand in these sectors;
- the EIS forecast that industrial demand would outstrip residential demand by 2020 and that total urban demand would exceed 1,000 ML per annum by 2025. This is considerably higher than that assumed by a more recent demand assessment by DEWS, which is summarised below;
- DEWS recently completed a Regional Water Supply Security Assessment (RWSSA) for Stanthorpe[13], which found that:
  - the combined industrial, commercial and municipal water use in Stanthorpe constitutes, on average, about 30 per cent of the town's total water demand. All

[11] T Sargeant Services (2013). The Economic Impact of the Emu Swamp Dam. Southern Downs Regional Council.

[12] SKM based their forecast on an appraisal of new business and industrial developments expected to establish in Stanthorpe region (classified as either "almost certain", "likely" and "possible").

[13] DEWS (2016). Stanthorpe Regional Water Supply Security Assessment.

industrial water users in the region are currently serviced by the reticulated water network;

– the main industries in Stanthorpe are in the areas of agricultural support industries; health care and social assistance; financial and insurance services; construction; retail; and rental, hiring and real estate services. These businesses are generally of a smaller scale, consistent with most urban areas, and there are no major industrial users of water in Stanthorpe;

– SDRC holds a water licence with a volumetric limit of 1,150 ML per annum for extracting water from Storm King Dam, and uses this to supply Stanthorpe's urban water demand. Over a seven-year period (2008-2015), Council has drawn an average of 590 ML annually to supply the reticulated network;

– DEWS forecast total urban demand (including industrial) to increase to between 740 ML and 858 ML per annum by 2036 (with the higher forecast based on extended dry periods). Industrial demand was assumed to grow in proportion to population growth;

– based on these forecasts, the report concluded that between now and 2036 there is only a very low risk of Stanthorpe experiencing a supply shortfall (once in 350 years), provided water restrictions are applied as dam levels fall; and

- DEWS did not assess the potential for new industrial demand for water outside of the reticulated network (the focus of the study was on the capacity of Storm King Dam to meet the needs of customers that have demand for treated, scheme water).

2.5 Current status of the project

As noted above, the proposed Emu Swamp Dam received planning and environmental approval from the Coordinator-General in September 2014. Commonwealth Government funding was allocated to conduct a feasibility study for the dam in 2016.[14]

The most recent feasibility study for the proposed Emu Swamp Dam was undertaken by Jacobs in 2016. However, the robustness of the analysis conducted, particularly in relation to the demand for irrigation water, was not sufficient to enable a decision to be made on whether to proceed with the construction of the dam (or pursue an alternative option), largely due to the absence of any detailed assessment of the on-farm return from the use of additional irrigation water.

[14] 'Palaszczuk Government cleans up Barnaby's mess on Qld water projects'; Queensland Government Media Statements; 25 October 2016; DOA: 30 March 2017; See: http://statements.qld.gov.au/Statement/2016/10/25/palaszczuk-government-cleans-up-barnabys-mess-on-qld-water-projects

The purpose of this report is to provide a robust assessment of agricultural and industrial water demand within the dam supply footprint. If deemed necessary, the assessment will be followed by a Preliminary Business Case (PBC), which will build upon this analysis to assess the financial and economic feasibility of the proposed Emu Swamp Dam (or alternative option) in greater detail.

3 Agricultural water demand

This section summarises our approach to assessing agricultural water demand and summarises the current irrigation supply-demand situation in the region.

3.1 Approach

3.1.1 Overview

There are a range of approaches that can be applied to assess irrigation water demand, including deriving estimates based on water market data or historical growth rates, willingness to pay surveys and on-farm financial assessments.

As discussed in the preceding section, the previous assessments of irrigation demand relevant to the project have predominantly involved producers being surveyed on how much additional water they would request, the price they would be willing to pay for the water and the most likely use of the water (i.e. existing crops or expansion).

Each of the approaches listed above have strengths and weaknesses. In our view, assessing irrigation water demand based solely on survey responses (or views expressed by stakeholders through other means), whilst informative, is not sufficiently robust to enable a decision to be made on the feasibility of a water supply augmentation. More robust demand assessments can be undertaken using multiple approaches to triangulate the expected value of irrigation water, including through stakeholder consultation and farm-level financial modelling.

As such, our approach is based on assessing the level of demand for additional irrigation water by conducting farm-level financial modelling for individual crops. Whilst stakeholder consultation is important in terms of identifying inputs for the farm-level financial modelling, this approach enables a more robust assessment of the level of demand for irrigation water compared to methodologies that are solely reliant on stakeholder input.

The principle underpinning our methodology is as follows: For those crops that are identified as likely sources of demand for additional volumes of irrigation water, we estimate the net financial return from the use of additional volumes of irrigation water ($ per ML). This represents the upper bound of what producers would be willing (or have capacity) to pay (in total)[15] for additional irrigation water entitlements, as any

[15] Including the up-front cost of purchasing the water entitlement, any costs associated with accessing the water entitlement and future infrastructure and water supply charges.

amount in excess of this would not be profitable. This method involves demand being assessed separately for:

- the application of additional volumes of water to existing crops, either to increase yield or product quality or to protect against loss of product yield or quality during dry periods; and
- the use of additional water for the purpose of expanding irrigated crop production.

3.1.2 Key steps

The key steps for the agricultural demand assessment are as follows:

Establish the current irrigation water supply-demand situation within the dam footprint

- review of relevant documentation provided by SDRC (see Attachment B for a list of the documents reviewed);
- review of other publicly available information relevant to the assessment, including:
  - data and information on irrigated crop production within the dam supply footprint, irrigation water application rates, and additional land available for irrigated crop production;
  - data and information on the nature and quantum of current irrigation water use on agricultural properties in the region;

Review financial crop production information

- review information available on the financial break-down of the production of crops that are produced in the region (e.g. gross margin analysis, reports assessing the value of crop production in the region, etc.);

Consultation with producers

- a web-based survey asking producers to respond to questions regarding the impact of irrigation water use on crop yield, potential uses of additional volumes of irrigation water, potential area for expansion of irrigated crop production, etc.;
- focus groups with irrigators to obtain information to inform the development of farm-level models and to gain additional information on the on-farm impacts of increased irrigation water availability (e.g. increased yield or crop quality, avoiding loss of yield, etc.) and potential for additional volumes of irrigation water to enable the expansion of irrigated crop production within the dam supply footprint;

- one-on-one consultation with producers over the duration of the consultation period as required, primarily via telephone interviews;

Develop farm-level financial models

- based on the information derived from the consultation process, combined with information obtained from the review of documentation and publicly available information, financial models were developed for individual crops identified as being potential sources of demand for additional irrigation water (through consultation with producers);
- conduct modelling to derive estimates for several outputs for each crop, including the on-farm net return from the application of additional volumes of irrigation water, both to existing crops and newly established crops; and

Develop demand forecasts and scenarios for additional water

- derive estimates for the level of demand for additional volumes of irrigation water within the dam supply footprint based on assumptions regarding the potential for additional irrigation water to be applied to new and existing crops, to be informed by consultation with producers.

Demand assessments for water supply augmentations intended for irrigation supply normally require an analysis of the feasibility of the establishment of greenfield enterprises. However, for this analysis, given that the water to be made available from the proposed Emu Swamp Dam (see Figure 2) represents a relatively small increase in total irrigation water use in the region (less than 10 per cent), we consider that the additional irrigation water would be used to supplement existing on-farm water supplies currently maintained by producers, either for established crops or for incremental expansion of irrigated crop production. This view concurs with feedback received from irrigators through our consultation process. As such, greenfield producers were not considered in this assessment. The appropriateness of this approach was reaffirmed through consultation with producers.

3.2 Current supply-demand situation

Our findings from the first step of the assessment process are reported below. These form a picture of the water supply-demand situation, which is important for the farm-level financial assessment of the on-farm return from the use of additional irrigation water.

3.2.1 Supply

There is currently no supplemented water supply available for irrigation use in the region other than through use of recycled water which represents approximately half of Stanthorpe's urban supply volumes. Producers obtain water for irrigation by harvesting overland flow run-off and by extracting water from tributaries of the Severn River. Producers have developed on-farm storages (i.e. farm dams) to store water obtained from these sources.[16] There are also a small number of licences authorising the taking of small volumes of water for irrigation use from the catchment area of Storm King Dam.[17]

In a previous assessment of the proposed Emu Swamp Dam, annual irrigation diversions by producers in the region were estimated at approximately 20,700 ML per annum.[18] Based on the estimated annual yield to be made available for irrigation of 1,700 ML, the proposed Emu Swamp Dam would represent a relatively marginal increase in total irrigation water use in the region (estimated at less than 10 per cent).[19]

This is consistent with the assessment conducted by Unidel in 2011, which found that producers were primarily reliant on on-farm storages for irrigation water and that the primary purpose of a supplemented water supply would be to provide additional water security to producers.[20] This is significant as it means that any supplemented water supply (such as the proposed Emu Swamp Dam) would be used to supplement existing on-farm storages, meaning that additional up front capital expenditure incurred by producers to access and utilise additional volumes of irrigation water would be minimal.

It is important to note that producers in the region have been subject to a moratorium on the development of on-farm water storages since the year 2000. Producers have therefore been constrained in their ability to obtain access to additional volumes of water for irrigation use. The Border Rivers Water Plan contains an unallocated strategic water reserve for irrigation and associated industries within the Stanthorpe Water Management Area of 3,000 ML.[21] The Water Plan is currently under review, with a revised Draft Water Plan to be released for comment in January 2018.[22]

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16 T Sargeant Services (2013).

17 DEWS (2016).

18 SKM (2007). Emu Swamp Dam Project – Planning Report.

19 It is also important to note that the estimate of 20,700 ML did not include on-farm run-off that is collected by producers and applied to crops.

20 Unidel (2011). Emu Swamp Dam Report – Southern Downs Regional Council Stanthorpe Water Project.

21 Water Plan (Border Rivers).

22 Based on advice provided by GHD.

Some producers within the dam supply footprint are also supplied with recycled water under an agreement with the SDRC. The scheme was initially commissioned in 2006, with irrigators paying a consumption charge of $108 per ML. In 2015/16, 397 ML of recycled wastewater was supplied to users. The SDRC recently released its decision to increase the consumption charge to $190.14 per ML from 1 July 2017.[23]

3.2.2 Demand

There are two key factors that provide horticultural producers in the Southern Downs with an advantage over competing producers in other regions:

- the microclimate in the Southern Downs enables producers to grow crops over periods during which they are not able to be grown in other regions (e.g. strawberry runners grown over the summer for supply during the winter season); and
- close proximity to the Brisbane market presents producers in the Southern Downs with a cost and time in transit advantage over producers in New South Wales and Victoria.

Current production of irrigated crops

A detailed assessment of the breakdown of horticultural production, both in the Southern Downs region and the dam supply footprint, was undertaken by Orchard Services in 2013.[24] Table 1 summarises the data from this report in terms of the production area attributable to each crop.

Table 1 Breakdown of area of crop production in Southern Downs and dam supply footprint (2013)

Crop	Area in Southern Downs region (ha)	Area in Emu Swamp Dam footprint (ha)	Proportion of total area within footprint (%)	Proportion of total crop area within footprint (%)
Apples	1,204	1,202	99.8	44.0
Stonefruit	202	121	59.9	4.4
Pears	22	22	100.0	0.8
Other tree crops	18	16	88.9	0.6
Wine grapes	481	161	33.5	5.9
Table grapes	23	14	60.9	0.5
Strawberries	34	33	97.1	1.2
Strawberry runners	85	85	100.0	3.1
Other berries	5	5	100.0	0.2

[23] Information provided by the Southern Downs Regional Council.

[24] Orchard Services (2013). Report on horticultural production in the proposed footprint of the Emu Swamp Dam in Queensland's Southern Downs Region.

Crop	Area in Southern Downs region (ha)	Area in Emu Swamp Dam footprint (ha)	Proportion of total area within footprint (%)	Proportion of total crop area within footprint (%)
Tomatoes	153	65	42.5	2.4
Capsicums	168	125	74.4	4.6
Brassicas	526	241	45.8	8.8
Lettuce	179	67	37.4	2.5
Baby leaf	123	103	83.7	3.8
Celery	39	39	100.0	1.4
Peas and beans	342	254	74.3	9.3
Cucurbits	58	19	32.8	0.7
Heavy vegetables	408	20	4.9	0.7
Parsley and herbs	30	29	96.7	1.1
Other vegetables	69	67	97.1	2.5
Euphorbia	29	29	100.0	1.1
Turf	12	12	100.0	0.4
Totals	**4,210**	**2,729**	**64.8**	**100**

Note: Area in Emu Swamp Dam footprint is based on dam footprint as at 2013.

Source: Orchard Services (2013). Report on horticultural production in the proposed footprint of the Emu Swamp Dam in Queensland's Southern Downs Region.

To inform this analysis, Orchard Services has updated the area of production estimates for the dam supply footprint for the major crop categories. The revised estimates and commentary provided are summarised in Table 2.

Table 2 Areas of crop production within the dam supply footprint (April 2017)

Crop	Area within dam footprint (ha)	Details
Tree fruit	1,315	• Area of orchard crops has decreased as stone fruit trees continue to be removed due to over-production. • New apple crops continue to be established, predominantly new varieties.
Grapes	170	• Small overall decrease in area under wine grape production within the dam footprint. • Most new plantings are limited to new varietals.
Strawberries and other berries	180	• 160 ha of strawberries and 20 ha of raspberries and blackberries • Several strawberry producers have made significant capital investments in hydroponic production systems.
Strawberry runners	170	• Significant growth in production over the past four years. • Production is dominated by two major producers, one of whom has also expanded into other regions.
Vegetables	1,005	• Little change over the past four years, with area of production and number of producers remaining relatively static within the dam footprint.
Speciality crops	41	• Mushrooms, vegetable seedlings, turf. • Areas under production have remained unchanged over the past four years.
Total	**2,881**	• 152 ha (5.6 per cent) increase in total crop production within the dam footprint over the past four years.

Source: Orchard Services (2017). Updated Granite Belt data.

The above table shows that apples remain the dominant crop within the dam supply footprint and there has been significant growth in the production of strawberries and strawberry runners over the past four years. Areas of production for grapes and vegetables have remained relatively static, whilst production of other tree fruits has decreased.

Current irrigation water use

Producers in the Southern Downs are efficient water users, having adopted water efficient technologies such as micro-sprays, drip irrigation and soil moisture monitoring systems. In addition, some producers have implemented (or are considering implementing) measures to reduce evaporation and seepage losses from on-farm storages.[25]

Irrigation application rates (i.e. the number of ML of irrigation water applied to crops per hectare) vary considerably across different crops. Table 3 contains some of the previous estimates derived for volumes of irrigation water use by crop in the Southern Downs.

Table 3 Overview of past estimates of irrigation water use in the Southern Downs

Source	Crop/cropping system	Estimated irrigation water use
Unidel (2011). Emu Swamp Dam Report – Southern Downs Regional Council Stanthorpe Water Project.	Tomatoes and capsicums	3-5 ML per ha
	Celery and cabbage	6.5 ML per ha
	Salad vegetables	8 ML per ha
	Apples	6 ML per ha
	Capsicums and broccoli	9 ML per ha
Orchard Services (2002). Comparison of the water use efficiencies of Stanthorpe Shire's Horticultural Crops and Selected Field Crops.	Fruit	6-6.5 ML per ha
	Vegetables	6-12 ML per ha
Orchard Services (2001). Horticultural Production & Water Use in the Stanthorpe Shire.	Apples/pears	6 ML per ha
	Vegetables	6-12 ML per ha
	Stone fruit	6.5 ML per ha
	Grapes	3 ML per ha

Source: Various.

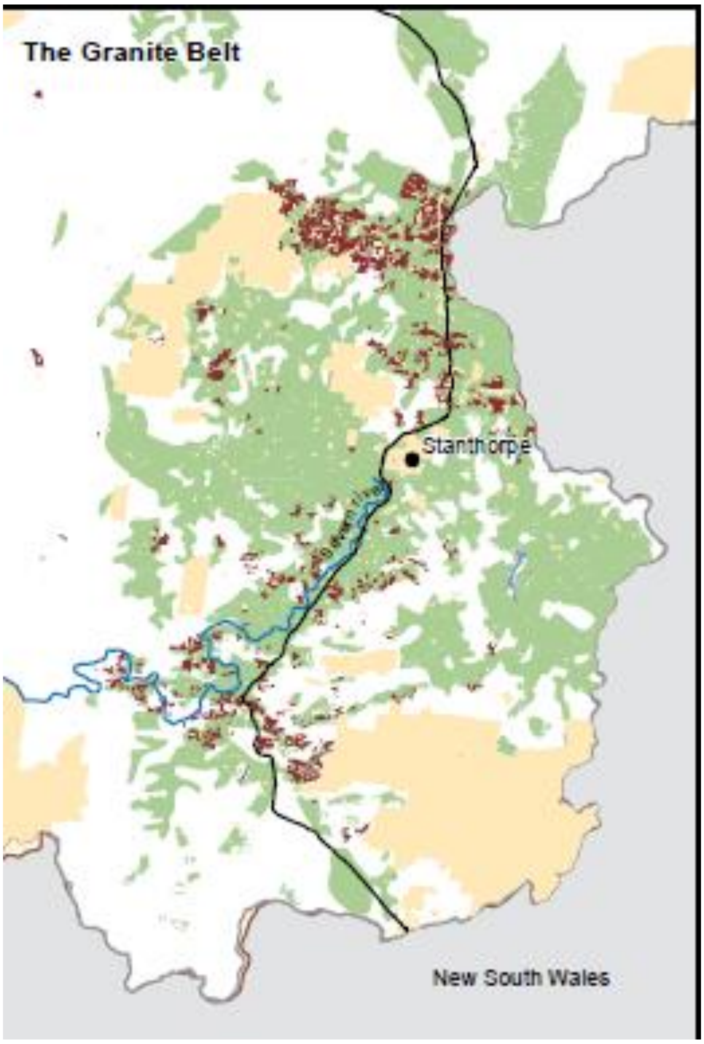
Current irrigation application rates were discussed with producers as part of the consultation process (see section 6).

25 SKM (2007). Emu Swamp Dam Environmental Impact Statement; 'Tax break boost for Granite Belt farmers'; Sunshine Coast Daily, 1st September 2015; See: https://www.sunshinecoastdaily.com.au/news/tax-break-a-boost-for-business/2758367/

Land available for increased irrigated crop production

It is also important to note that availability of suitable land for crop production is not considered to be a constraint on crop production in the Southern Downs. The most recent Queensland Agricultural Land Audit[26] found that there was a significant amount of land in and around Stanthorpe that could potentially be used for horticulture production that was not under production (see Figure 3).

Figure 3 Land potentially suitable for horticulture production in the Southern Downs



Note: Areas shaded in green were defined as 'potential perennial horticulture' whilst areas in brown represent current perennial horticulture.
Source: Department of Agriculture, Fisheries and Forestry (2013). Queensland Agricultural Land Audit.

Whilst the land audit did not take into account a range of factors including labour availability and market constraints, it is clear from this assessment that access to suitable

26 Department of Agriculture, Fisheries and Forestry (2013). Queensland Agricultural Land Audit.

land is unlikely to be a constraint on the expansion of crop production within the dam supply footprint, particularly given any expansion would be marginal due to the relatively small volume of additional water to be made available for irrigation use in the region.

3.3 Summary

We make the following observations of current irrigation water supply and use in the Southern Downs:

- producers are currently reliant upon on-farm storages and the harvesting of overland flows and the intersection of near-surface groundwater resources for irrigation water supply;
- the yields from water harvesting are unequally distributed across the Stanthorpe Water Management Area, with water security presenting more of a problem for some producers than for others;
- the volume of irrigation water to be made available by the construction of the proposed Emu Swamp Dam would represent a relatively marginal increase (less than 10 per cent) in total irrigation water use in the region and as such is more likely to supplement water supplies of established producers as opposed to being used by greenfield producers to meet base water requirements;
- there is significant variability in irrigation application rates across crops produced in the region (3 to 12 ML per ha); and
- access to suitable land is unlikely to represent a constraint on the expansion of crop production within the dam supply footprint, noting that any expansion of area of production will be marginal due to the relatively small increase in irrigation water to be made available.

4 Industrial water demand

This section summarises our approach to assessing industrial water demand in and around Stanthorpe, and provides context in relation to demand drivers.

4.1 Approach

4.1.1 Overview

The assessment of industrial water demand was conducted based on a two-stage process:

- consultation with DEWS on the Stanthorpe RWSSA conducted in 2016 to gain a comprehensive understanding of the key drivers of the analysis of future industrial water demand; and
- targeted consultation with key stakeholders relevant to future industrial water demand in the region, as identified through discussions with DEWS and other stakeholders.

It is important to note that the focus of this assessment is on identifying whether the lack of a new bulk water supply, of the magnitude of Emu Swamp Dam, is constraining new industrial activity from establishing in Stanthorpe. It is not the purpose of this analysis to forecast actual volumes of industrial water demand for the region.

4.1.2 Key steps

For the industrial demand assessment, the key steps are as follows:

- review of documentation provided by the Council, focusing on the RWSSA for Stanthorpe conducted by DEWS in 2016;
- consultation with DEWS to understand the key assumptions and analysis underpinning the assessment of future industrial water use for the region;
- identification of key stakeholders in relation to industrial water use in the region, based on discussions with the SDRC and DEWS; and
- consultation with key stakeholders to determine the extent to which water availability is likely to constrain future industrial activity in the region.

If it is determined, based on this analysis, that water availability is likely to be a constraint on industrial activity in the region, a financial analysis will be undertaken, based on available information, of the identified industrial activity or activities to determine the financial impact of additional volumes of water being made available by the proposed Emu Swamp Dam during stage 2 (Preliminary Business Case) of this project.

4.2 Current supply-demand situation

As part of its RWSSA for Stanthorpe, DEWS assessed water usage from 2008/09 to 2014/15. This assessment found that average water demand during this period was approximately 324 litres per capita per day, or 590 ML annually. This total includes all water supplied by the Stanthorpe reticulation network, including residential, commercial, municipal and industrial use.

The non-residential component was estimated to comprise about 30 per cent of the town's total water demand. There are no major industrial water users in the region that are supplied with water through the reticulation network.

DEWS' assessment concluded that any future growth in demand for industrial water use is expected to be approximately proportionate to population growth.[27] It reached this conclusion because the industrial demand component is expected to come from businesses providing services to the town, as opposed to value-adding industries producing output for export out of the region. We concur with this assessment given the lack of existing water intensive industry in the region and from our experience of similar communities elsewhere in rural Queensland.

4.3 Future demand growth

Synergies consulted with the Granite Belt Chamber of Commerce and Industry (GBCCI) and a number of agricultural producers in the region to canvas views on the scope for agrifood processing industries to develop in Stanthorpe should additional water become available.

The GBCCI has identified the Emu Swamp Dam as its number one priority for promoting economic development in the Stanthorpe region. It believes that there is considerable scope to attract agrifood processors to Stanthorpe if a reliable source of treated water could be made available. By way of example, it pointed to:

27 Department of Energy and Water Supply (2016).

- one industrial user, who is currently using 3-4 ML per annum and is looking to increase this to 8-10 ML next year and up to 50 ML longer term (water is used as both a food additive and for processing);[28]
- the trend towards pre-packaging of fruit and vegetables and preparation of "ready to cook" sliced and diced vegetables prior to supply to supermarkets. It was said that at least two growers in Stanthorpe are already value-adding in this way, with the post-harvest packaging and processing of capsicums and carrots being done on-farm. The GBCCI believes that this activity could be done more efficiently and at a larger scale in town if a reliable source of treated, reticulated water was available (water is used for washing and hygiene purposes); and
- the strong interest by agrifood processors in Brisbane to relocate their operations to regional areas, closer to the primary feedstock (e.g. fruit and vegetables) and where land is cheaper.

Our discussions with producers in the region found that not all share GBCCI's optimism about the potential for an agrifood processing industry in Stanthorpe. Even if an additional reticulated water source became available, few producers we spoke to raised any interest in value-adding to their produce.

In our assessment, it is unlikely that a prospective new agrifood processing industry could be attracted to Stanthorpe because the volumes of additional water capable of being supplied by the proposed Emu Swamp Dam are relatively small, so would only allow a marginal increase in horticultural output and unlikely to be of sufficient scale to underpin a major, local food processing hub.

Furthermore, to the extent that processing of Stanthorpe's horticultural produce is profitable (relative to the supply of fresh produce direct to market), we would expect to see a greater proportion of Stanthorpe's produce being transported to nearby Warwick for processing, where there is no water constraint and better access to major transport routes and labour. As there is little evidence of this occurring, we are cautious of claims that a new water source for Stanthorpe would attract more local processing.

4.4 Conclusion

While non-residential water demand is expected to increase over time, it is Synergies' view that there is insufficient evidence to support a forecast that would have industrial demand outstripping residential demand over the next five years or exhibiting a 'step

[28] It is noted that this increase in water use would entail a very large expansion of production. The feasibility of such an expansion was not assessed as part of this analysis.

change' in economic development if a new bulk water supply was developed (as was assumed for the EIS). We conclude that the forecast used in the EIS was unrealistic as other factors, aside from water, would limit the attractiveness of Stanthorpe as a location to base new industrial activity.

5 Water market analysis

Water market data can provide a useful indication of the economic value for water under different seasonal conditions and across different locations. This data can be useful for making a comparative assessment of the market willingness to pay for additional water, relative to the cost of making water available through development of new supply sources.

Water markets are now well-established in the southern Murray Darling Basin and there is reasonably good price information to draw insights into factors affecting market values for water. However, with the exception of several water supply systems, water trading in Queensland is still relatively immature. As such, the conclusions that can be drawn from Queensland water market data are often limited by the relatively low volumes traded in these markets.

This section reviews data available on water trading (permanent and temporary trades), with a focus on price information that is relevant to the project. In Queensland, there is no legislative requirement for buyers or sellers to disclose price information for temporary trades (i.e. seasonally assigned water). Therefore, it is not possible to examine market prices for this water product. Furthermore, temporary trade volumes are only reported at an aggregate level, as opposed to volumes of individual trades. Better information is available for permanent trading of water allocations, as it is a legislative requirement to disclose both the volume and price of a permanent trade and to maintain a public register of these trades.

5.1 Water trading in Stanthorpe

The permanent trade of unsupplemented water allocations and "temporary trade" of seasonal assignments is permitted in the Stanthorpe Water Management Area, subject to trading rules contained in the Border Rivers Resource Operations Plan (ROP). These rules also set out the relevant zones within which (and between which) trading is permitted.

Table 4 summarises the permanent trades that have occurred in Stanthorpe since 2011-12. The market is very thin, with only one or two trades occurring each year over the period 2011-12 to 2014-15. This is most likely explained by the restrictive trading rules that exist in Stanthorpe (for hydrological reasons), as opposed to a lack of appetite for water trading. Trading activity was somewhat higher in 2015-16, with a total of six trades in that period. In the year to date (2016-17) only one trade has occurred.

Since 2011-12, prices have varied between $1,000 per ML and $6,250 per ML. Several trades are recorded as having zero consideration. This is potentially due to transfers of water allocation between related parties, or between two legal entities operating within the same farm business.

Table 4 Permanent trading of unsupplemented water allocation – Stanthorpe Water Management Area

Period	Number of trades	Volume (ML)	Price ($/ML)
2011 - 2012	1	12	0
2012 - 2013	1	23	2,500
2013 - 2014	1	20	0
2014 - 2015	2	12 ML and 10 ML	4,000 and 5,000
2015 - 2016			
July 2015	1	33	2,500
Sept 2015	1	8	6,250
Nov 2015	1	14	0
Dec 2015	1	6	1,000
Jan 2016	1	1	1,000
June 2016	1	10	0
2016 – 2017			
Nov 2016	1	14	2,500

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

5.2 Water market information from other areas

Water market prices observed in other areas nearby to Stanthorpe may provide some additional insights as to the traded value of water. However, these prices need to be treated with caution given the different agricultural crops grown in these areas, potentially lower water supply constraints, and the different type of water products being traded.

5.2.1 Border Rivers region

The volume of trades and prices achieved in the Border Rivers and Macintyre water supply schemes is shown in Table 5. These data relate to the permanent trade of medium priority supplemented surface water allocations.

While the number of trades is quite small, prices indicate that irrigators are prepared to pay in the order of $500 per ML to $2,000 per ML, depending on season.

Table 5 **Permanent water trades in the Border Rivers and Macintyre Brook WSS**

Water Supply Scheme	Priority group	Number of transfers	Volume transferred (ML)	Volume turnover (%)	Weighted average price ($/ML)
2013/14					
Border Rivers	Medium	18	6,247	8	2,181
Macintyre Brook	Medium	6	1,350	6	1,075
Totals		*24*	*7,597*	*7*	*2,101*
2014/15					
Border Rivers	Medium	5	1,748	2	2,175
Macintyre Brook	Medium	13	1,116	5	1,180
Totals		*18*	*2,864*	*3*	*1,816*
2015/16					
Border Rivers	Medium	6	4,872	6	332
Macintyre Brook	Medium	6	1,053	4	1,752
Totals		*12*	*5,925*	*5*	*586*

Source: Water Market Information - Permanent Water Trading Reports, Business Queensland www.business.qld.gov.au/industries/mining-energy-water/water/water-markets/marketinformation

5.2.2 Moreton region

Table 6 summarises permanent water trades of supplemented surface water for several water supply schemes within the Moreton ROP, which borders the Border Rivers Water Management Area. Average prices vary from $400 per ML to $500 per ML depending on season.

Table 6 Permanent trades of supplemented water entitlements in the Moreton ROP

Water Supply Scheme	Priority group	Number of transfers	Volume transferred (ML)	Volume turnover (%)	Weighted average price ($/ML)
2013/14					
Central Brisbane River	Medium	1	32	<1	500
Total		*1*	*32*	*<1*	*500*
2014/15					
Central Brisbane River	High class A	4	278,725	100	0
Central Brisbane River	Medium	6	593	8	460
Lower Lockyer Valley	Medium	5	207	2	550
Pine Valleys	High class A	1	59,000	100	0
Warrill Valley	Medium	6	525	2	0
Totals		*22*	*339,050*	*85*	*402*
2015/16					
Central Brisbane River	Medium	26	1,112	16	754
Lower Lockyer Valley	Medium	11	518	4	403
Warrill Valley	Medium	11	1,028	4	18
Totals		*48*	*2,658*	*<1*	*434*

Source: Water Market Information - Permanent Water Trading Reports, Business Queensland
www.business.qld.gov.au/industries/mining-energy-water/water/water-markets/marketinformation

5.2.3 Water markets in southern Murray Darling Basin

While the agricultural production systems in southern Murray Darling Basin are very different to those in Stanthorpe, it is nevertheless valuable to examine how water market prices respond to changing seasonal conditions and the maximum prices that have been observed over the past decade. Previous experience from the southern Murray Darling Basin has shown that irrigators of permanent horticultural and viticultural crops are typically willing to pay the most for water in periods of drought, and it is common for water to be temporarily traded out of regions that support annual crops such as rice and irrigated pastures – to orchards and grape vines.[29]

Permanent trades

In 2015-16, high security water entitlements traded at an average of $2,179 per ML in the Murrumbidgee (New South Wales) and $1,442 per ML in the Greater Goulburn region of Victoria. Both these regions support intensive horticulture and viticulture. The majority of high reliability entitlements across the various trading zones in the southern Murray Darling Basin have doubled in value over the past three years.[30]

29 National Water Commission (2010) Australian water markets: trends and drivers 2007–08 to 2009–10.

30 Aither (2016) Water Markets Report – 2015-16 review and 2016-17 outlook.

Lower reliability entitlements trade at a substantial discount to high security water. For example, in 2015-16, general security entitlement in the Murrumbidgee traded at an average of $1,370 per ML and low reliability entitlement in the Greater Goulburn traded at just $227 per ML.

Temporary trades

The price of temporary water is largely determined by the amount of water available in a given year. Prices therefore tend to fluctuate more than those for permanent water. At the peak of the Millennium drought in 2007, temporary water traded at an average of $925 per ML. Once good rains returned, prices reached their lowest levels in 2011 at $25 per ML.[31] Over the course of 2015-16, average prices ranged between $200 per ML to $250 per ML.[32]

Compared to prices for permanent water entitlements, prices for temporary trades tend to equalise between regions. This is because there are generally few constraints on temporary trade between regions and trading zones within the southern Murray Darling Basin.

5.3 Conclusion

Based on the above water market data, the prices observed for permanent water trades of unsupplemented water allocation in the Stanthorpe Water Management Area are similar to prices being paid for high security entitlements in the southern Murray Darling Basin. This indicates that water is a highly valued resource in Stanthorpe, particularly given the fact that unsupplemented water allocation is considerably less reliable than high priority supplemented water allocation (the latter being approximately similar to a high security entitlement). Furthermore, prices of up to $6,250 per ML have been observed in Stanthorpe – which is additional evidence of high willingness to pay for water.

31 ABARES (2015) Australian Water Markets Report – 2013-14, report prepared for the Department of Agriculture and Water Resources, Canberra.

32 Aither (2016) Water Markets Report – 2015-16 review and 2016-17 outlook.

6 Consultation with agricultural water users

This section summarises the consultation undertaken with agricultural producers and how it informed the financial modelling of the on-farm returns to additional irrigation water use.

6.1 Engagement process

As discussed in section 3.1, consultation with agricultural producers was undertaken through three streams:

- focus groups with producers to discuss the implications of increased water availability for crop production (both existing and new crops);
- an internet-based survey requesting that producers provide information on crop production, yield estimates, current irrigation water application rates, and the impacts of increased irrigation water availability; and
- one-on-one telephone interviews with producers over the duration of the consultation period.

6.1.1 Focus groups

Producers were recruited to participate in two focus groups held in Stanthorpe on 19th April. Email invitations were sent to all stakeholders on the SDRC stakeholder list in addition to adverts being placed in local media and public service broadcasts commissioned. In addition, information on the focus groups and registration forms were placed on the Emu Swamp Dam Feasibility Project public website and Facebook page.

The purpose of the irrigator focus groups was to discuss:

- the nature of the assessment with producers and communicate the data and information required;
- key production characteristics, including yield, operating costs, on-farm revenue;
- the characteristics of producers' current irrigation water use, including:
  - application of irrigation water;
  - additional water requirements;
  - the potential impact of increased water availability on yield or product quality; and

- the potential for increased water availability to enable producers to expand crop production and the extent to which factors other than water availability represent a constraint on increased crop production.

The focus groups were attended by seven producers, including producers of wine grapes, tomatoes and capsicums, strawberry runners and specialty crops (i.e. vegetable seedlings). The information derived from the focus groups was used, in combination with information and data obtained from other sources, to inform the development of the crop models and evaluation of the on-farm return to additional irrigation water use.

6.1.2 Web-based survey

A web-based survey was also released to enable producers unable to attend the focus groups to provide information to assist with the assessment. The survey was emailed to all producers in the SDRC stakeholder database. The survey template is provided in Attachment C.

The information requested in the survey included:

- crops produced and farm area
- current irrigation water application rates and yields
- interest in accessing additional volumes of irrigation water
- the impact of increased water availability on crop yield/quality
- the potential for expansion of area under production with additional water.

Ten producers responded to the web-based survey, with wine grapes the most common crop produced by respondents. Other crops included tomatoes and capsicums, apples, other tree fruits, mixed vegetables, and specialty crops such as mushrooms and vegetable seedlings.

The key outcomes from the web-based survey responses were as follows:

- the majority of respondents (six of ten) expressed a desire to obtain additional irrigation water;
- several producers stated that with additional irrigation water they would be able to expand their area of irrigated crop production; and
- several respondents reported that shortfalls in irrigation application rates had significant adverse impacts on crop yield (e.g. producers reported that a 10 per cent shortfall could result in yield losses of 10 to 30 per cent).

6.1.3 One-on-one consultation

One-on-one consultation, including phone interviews and email exchanges, was also conducted with producers throughout the consultation phase. Discussions were focused on similar issues as those discussed in the focus groups (i.e. information on current production and water application, yield impacts of increased water availability, potential for crop expansion, etc.). One-on-one consultation was conducted with seven producers. Crops produced by these producers included apples, stone fruits, wine grapes, strawberries and strawberry runners.

6.2 Key findings

The key outcomes from the consultation with producers (including the focus groups, survey results and one-on-one consultation) were as follows:

- water availability is a significant constraint on the expansion of crop production in the region, particularly in relation to tomatoes, strawberries and strawberry runners;
- market factors are the other major constraint on production, particularly for apples, other tree fruits, wine grapes and a range of vegetable crops;
- consistent with the results of the 2013 land audit (see section 3.2.2), producers confirmed that they have access to significant areas of additional land for the expansion of crop production, both on existing properties and nearby land available at minimal cost. This land could be used for the expansion of crop production, subject to other constraints being addressed;
- additional volumes of irrigation water, either from a dam or other means (e.g. increased water harvesting) would be used to supplement existing irrigation water supply sources in the region (i.e. on-farm storages) rather than to underpin greenfield developments;
- there is a significant desire for additional volumes of irrigation water from producers of a wide range of crops, including apples, tomatoes and capsicums, strawberries, wine grapes, strawberry runners, green vegetables and specialty crops (e.g. vegetable seedlings, mushrooms); and
- water shortages resulting in the reduced application of irrigation water has a significant negative impact on crop yields, particularly for apples and wine grapes.

7 Farm-level crop models

This section identifies the crops on which financial modelling was undertaken and sets out the key inputs and parameter estimates.

7.1 Crops modelled

Crops were included in the analysis based on:

- a review of available information in relation to crop production and water use within the dam supply footprint; and
- the outcomes of consultation with producers.

The crops included in the analysis can be separated into two categories – 'annual' crops, for which producers are able to vary their levels of production periodically (e.g. tomatoes and capsicums, green vegetables) and 'permanent' crops, which require significant up-front capital investments with minimal scope for varying production levels over time (e.g. apples and wine grapes). There are important differences between these two crop types that have a significant impact on the nature of producers' demand for additional irrigation water. These differences include:

- the sunk costs of establishing crops – whilst pre-harvest costs associated with some 'annual' crops can be significant (e.g. tomatoes), these costs are incurred every time a crop is established. Therefore, producers are able to vary production levels based on a range of factors, including market conditions and water availability, without incurring significant sunk costs. For producers of 'perennial' crops, production requires significant sunk capital investments (e.g. for apple producers, apple trees, hail netting), the cost of which must be recovered over the lifetime of the crop;
- time period for production decisions – as they are not required to incur significant sunk capital costs, producers of 'annual' crops are able to make periodic decisions regarding their levels of production in accordance with changing circumstances (e.g. reduced demand, lower water availability), whilst producers of 'permanent' crops are required to sustain their capital investment (i.e. their permanent plantings), which reduces their capacity to alter production levels based on changing circumstances; and
- water reliability needs – access to a highly reliable water supply over the long term is more important for producers of 'permanent' crops than producers of 'annual' crops, as the former does not have the option of scaling production based on water availability and must have access to a minimum volume of water to maintain their permanent plantings.

Based on the documentation reviewed and consultation conducted, the following sources of demand for additional irrigation water within the dam supply footprint were identified:

- apple producers, predominantly for increased water security for existing crops in addition to small scale incremental expansion of cropping area;
- tomato and capsicum producers, for the expansion of crop production, predominantly for tomatoes;
- strawberry producers, for the expansion of crop production;
- wine grape producers, predominantly for application to existing crops, but also to facilitate small scale expansion of crop production; and
- strawberry runner producers, for the expansion of crop production.

Due to limited availability of green vegetable producers to take part in the consultation process, less consultation was undertaken with producers of green vegetables than with producers of other crops. However, it is understood, based on the outcomes of previous studies and anecdotal information provided by producers of other crops, that green vegetable producers are also likely to be a source of demand for additional irrigation water. Green vegetables have therefore been included in the farm-level financial analysis.[33]

Additional information regarding the nature of demand for additional irrigation water for producers of these crops is provided in section 8.

Whilst it is acknowledged that producers of other crops may purchase additional volumes of irrigation water, it is considered that producers of the crops identified above are likely to account for the vast majority of demand for additional irrigation water. Modelling outputs based on these crops is therefore considered sufficient to enable a robust assessment of irrigation water demand within the dam supply footprint.[34]

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33 Although due to the minimal consultation conducted, green vegetable crops have been excluded from the base demand assessment.

34 Whilst it would have been advantageous to confirm these assumptions through a more comprehensive survey of crop producers within the Emu Swamp Dam footprint, this was not possible within the timeframe allocated to the Strategic Assessment. It is recommended that this be undertaken in the event the project proceeds to a Preliminary Business Case.

7.2 Data and information sources

The information used to inform the parameter estimates for the crop models were as follows:

- yield estimates and irrigation application rates are based on publicly available data and consultation with producers;[35]
- price estimates were based on pricing data for the last 15 months for the Brisbane market obtained from Market Information Services.[36] The applicability of this price data to producers in the Southern Downs was confirmed through the consultation process; and
- on-farm operating costs, including pre-harvest, harvest and post-harvest costs, are based on publicly available cost estimates, primarily for crop production in southern Queensland, with estimates being refined based on consultation with producers.[37]

7.3 Apples

In 2013, apples were estimated to account for 1,204 hectares of production in the Southern Downs, with 1,202 hectares located within the dam supply footprint (44 per cent of the total area of production within the dam supply footprint).[38] Whilst the number of apple producers in the region has decreased over the past four years, the total area of apple production within the dam supply footprint has remained relatively constant, with some producers planting new apple crops (predominantly new varieties).

Consultation with apple producers indicated, consistent with findings from previous studies, that there is demand for additional volumes of irrigation water from apple producers to provide additional security for established crops, with some producers also seeking additional water to expand production, predominantly to enable them to plant new varieties.

35 Primary sources of data were Orchard Services (2013) and consultation with producers in the Southern Downs.

36 'MIS Sample Market Price Reports'; Market Information Services in association with Brisbane Market Produce Surveyors. See: http://www.marketinfo.com.au/index.php?page_id=17

37 Department of Primary Industries and Fisheries (2004). Brassica Growers Handbook; Gross Margin Information – Agricultural Gross Margin Calculator (http://agmargins.net.au); New South Wales Department of Primary Industries – Farm budget and costs (http://www.dpi.nsw.gov.au/agriculture/budgets); Queensland Government – Agbiz tools – Plants – Vegetables (https://publications.qld.gov.au/dataset/agbiz-tools-plants-vegetables); Water for Profit, Benchmark – Irrigating Strawberries, Growcom; Van Putten, I. (1996). Apple gross margins by variety in Tasmania – Final Report, Horticultural Research & Development Corporation.

38 Orchard Services (2013).

Table 7 sets out the key operating characteristics and costs of apple production within the dam supply footprint. This is based on a desktop review of data and information derived through consultation with producers.

Table 7 Representative crop system for apple producers

Parameter	Measure	Estimate
Yield	tonnes/ha	**55**
Irrigation application rate	ML/ha	5.5
Farm revenue		
Price	$/tonne	$1,800
Operating revenue	**$/ha**	**$99,000**
Farm operating costs		
Pre-harvest costs (FORM, canopy maintenance, fertiliser, chemicals)	$/ha	$30,000
Irrigation costs	$/ha	$2,750
Harvesting and post-harvest costs	$/ha	$33,000
Total variable growing costs	**$/ha**	**$65,750**
Gross margin per hectare	**$/ha**	**$33,250**
Gross margin per ML	**$/ML**	**$6,045**

Note: Estimates derived from a review of available data and information and based on consultation with producers. It is noted that some parameters, in particular yield and farm operating costs, are likely to vary significantly across producers.

Source: Synergies modelling. Data obtained from data and information sources and stakeholder consultation.

7.4 Tomatoes and capsicums

In 2013, tomatoes and capsicums accounted for 153 hectares and 168 hectares of crop production within the Southern Downs regions respectively. Within the dam supply footprint, the areas of production were 65 hectares and 125 hectares respectively (2.4 per cent and 4.6 per cent of the total production area in the dam supply footprint).[39] Tomatoes and capsicums were modelled as a combined crop system as it is common for producers to grow both crops.

Based on consultation with producers, it is concluded there is significant demand for additional water from tomato and capsicum producers. The nature of production of these crops means that producers ensure that they have sufficient water available to meet their yield and quality targets for each crop (i.e. producers determine their production levels having regard to their future water availability). As such, additional irrigation water would be used to expand crop production (rather than being applied to existing crops).

[39] Orchard Services (2013).

Table 8 sets out the key characteristics of the production of tomatoes and capsicums within the dam supply footprint. These characteristics were developed based on a desktop review of data and information and through consultation with producers.

Table 8 Representative crop system for tomato and capsicum producers

Parameter	Tomatoes		Capsicums	
	Measure	Estimate	Measure	Estimate
Yield	Per ha	70 tonnes	Per ha	40 tonnes
Irrigation application rate	Per ha	5.5 ML	Per ha	5.0 ML
Farm revenue				
Price	Per kg	$1.70	Per kg	$1.75
Operating revenue	**Per ha**	**$119,000**	**Per ha**	**$70,000**
Farm operating costs				
Pre-harvest costs (FORM, canopy maintenance, fertiliser, chemicals)	Per ha	$42,000	Per ha	$25,000
Irrigation costs	Per ha	$2,750	Per ha	$2,500
Harvesting and post-harvest costs	Per ha	$50,000	Per ha	$35,000
Total variable costs	**Per ha**	**$94,750**	**Per ha**	**$62,500**
Gross margin per hectare	**Per ha**	**$24,250**	**Per ha**	**$7,500**
Gross margin per ML	**Per ML**	**$4,409**	**Per ML**	**$1,500**

Note: Estimates derived from a review of available data and information and based on consultation with producers. It is noted that some parameters, in particular yield and farm operating costs, are likely to vary significantly across producers.

Source: Synergies modelling. Data obtained from data and information sources and stakeholder consultation.

7.5 Strawberries

Strawberry production in the Southern Downs has increased significantly in recent years. Within the dam supply footprint, the area of production has increased from 33 hectares in 2013 to 160 hectares (1.2 per cent and 5.9 per cent of the total production area in the dam supply footprint). This growth has predominantly been driven by large producers from other regions (e.g. north coast of Queensland) establishing operations in the Southern Downs to take advantage of the region's microclimate and market advantages.[40]

However, despite these advantages, strawberry producers in the Southern Downs are subject to significant competitive pressure from producers in New South Wales and Victoria. The water-intensive nature of strawberry production and the need to maintain

[40] 'Queensland strawberry growers take crops to cooler Granite Belt climate to survive tough market conditions, establish year-round supply'. ABC News; A. Edwards; 29 April 2015; DOA: 4 April 2017; See: http://www.abc.net.au/news/2015-04-29/qld-strawberry-growers-take-crops-to-cooler-granite-belt-climate/6419394

product yield and quality levels means that strawberry producers in the region need to ensure that they have sufficient water security for their established crops.

Whilst strawberry producers would seek additional volumes to expand production, it is understood that expansion of strawberry production from the region will be constrained by market forces, primarily competition from southern strawberry growing regions. One major producer advised that an increase in production of above 15 per cent would likely result in a significant reduction in price. It was also advised that one producer had recently terminated operations due to a lack of profitability.

Table 9 sets out the operating characteristics, revenues and costs of strawberry production within the dam supply footprint. These characteristics were developed based on a desktop review of data and information and through consultation with producers.

Table 9 Representative crop system for strawberry producers

Parameter	Measure	Estimate
Yield	Per ha	150,000 punnets
Irrigation application rate	ML/ha	8.0
Farm revenue		
Price	Per punnet	$2.50
Operating revenue	**Per ha**	**$375,000**
Farm operating costs		
Pre-harvest costs (FORM, canopy maintenance, fertiliser, chemicals)	$/ha	$101,415
Irrigation costs	$/ha	$4,000
Harvesting and post-harvest costs	$/ha	$194,585
Total variable costs	**$/ha**	**$300,000**
Gross margin per hectare	**$/ha**	**$75,000**
Gross margin per hectare per ML	**$/ML**	**$9,375**

Note: Estimates derived from a review of available data and information and based on consultation with producers. It is noted that some parameters, in particular yield and farm operating costs, are likely to vary significantly across producers.

Source: Synergies modelling. Data obtained from data and information sources and stakeholder consultation.

7.6 Wine grapes

In 2013, grape production in the Southern Downs totalled 504 hectares, with only 175 hectares located within the dam supply footprint (6.4 per cent of the total production area in the dam foot print).[41] Wine grape production has remained relatively static, both in the region and within the dam supply footprint, over the past four years. However,

41 Orchard Services (2013).

whilst the area under production has not increased, producers are continuing to plant new varieties based on market trends.

The consultation process revealed significant variation across wine grape producers in several key production characteristics, including crop yield, irrigation application rates and operating costs. For some producers, the key consideration with regards to water availability was ensuring the long-term viability of their vines, whilst other producers are seeking additional volumes of irrigation water to increase yields and expand production. Irrigation application rates are typically lower for wine grapes than for the other crops produced in the region.

It is important to note that the return to additional irrigation water for wine grape producers has been estimated based on the wholesale value of wine grapes, rather than the value-added products produced from wine grape production (i.e. bottles of wine). The latter requires capital equipment and production costs that have not been considered in this analysis. Furthermore, these value-adding processes are not directly related to the application of irrigation water. In order to ensure that the analysis appropriately reflects the return from the application of additional volumes of irrigation water for the production of wine grapes, the parameter values applied for yield and price have been based on upper range estimates.

Table 10 sets out the key operating characteristics, revenues and costs of wine grape production within the dam supply footprint. These characteristics were developed based on a desktop review of data and information and through consultation with producers.

Table 10 Representative crop system for wine grape producers

Parameter	Measure	Estimate
Yield	Per ha	10 tonnes
Irrigation application rate	Per ha	1.75 ML
Farm revenue		
Price	Per tonne	$1,500
Operating revenue	**Per ha**	**$15,000**
Farm operating costs		
Pre-harvest costs (FORM, canopy maintenance, fertiliser, chemicals)	Per ha	$1,200
Irrigation costs	Per ha	$875
Harvesting and post-harvest costs	Per ha	$5,000
Total variable costs	**Per ha**	**$7,075**
Gross margin per hectare	**Per ha**	**$7,925**
Gross margin per hectare per ML	**Per ML**	**$4,529**

Note: It is important to note that there is significant variation in several of these key production parameters across wine grape producers in the region. The estimates set out in this table are considered reflective of this distribution, based on consultation with wine grape producers in the region and a review of available documentation.

Source: Synergies modelling. Data obtained from data and information sources and stakeholder consultation.

7.7 Strawberry runners

Production of strawberry runners accounts for 170 hectares of production within the dam supply footprint (6.2 per cent of the total production area in the dam supply footprint), having increased considerably over the past four years (from 85 hectares in 2013).[42] This has been driven by strong growth in strawberry production and the favourable climate in the Southern Downs that enables producers to grow strawberry runners to satisfy demand during the winter season.

Consultation was undertaken with both of the major strawberry runner producers in the region. Both producers expressed a desire to gain access to additional irrigation water to facilitate the expansion of production.

Table 11 sets out the key operating characteristics, revenues and costs of strawberry runner production within the dam supply footprint. Due to the limited data available, these estimates were based primarily on consultation with producers.

Table 11 Representative crop system for strawberry runner producers

Parameter	Measure	Estimate
Irrigation application rate	Per ha	10 ML
Operating revenue	**Per ha**	**$100,000**
Irrigation costs	Per ha	$5,000
Pre-harvest, harvesting and post-harvest costs	Per ha	$75,000
Total variable costs	**Per ha**	**$80,000**
Gross margin per hectare	**Per ha**	**$20,000**
Gross margin per hectare per ML	**Per ML**	**$2,000**

Note: Due to the lack of publicly available price data and production and cost information on strawberry runner production, inputs and parameter estimates are high-level based on discussions with producers.

Source: Based on consultation with producers within the dam footprint.

7.8 Green vegetables

As shown in Table 1, a wide range of green vegetables are produced in the Southern Downs and within the dam supply footprint, including broccoli, cabbage, lettuce, baby-leaf, celery, parsley and herbs, peas and beans, and cucurbits. The area of vegetable crop production in the region has remained relatively static in recent years.[43]

As noted previously, whilst less consultation was undertaken with green vegetable producers that with other producers due to lack of availability of green producers to take part, the crop has been included in the analysis based on past assessments and anecdotal

[42] Orchard Services (2017).

[43] Orchard Services (2017).

information indicating green vegetable producers may be a potential source of demand for additional irrigation water.

Table 12 sets out the key operating characteristics, revenues and costs of the production of green vegetable crops within the dam supply footprint. These characteristics were developed based on a desktop review of data and information.

Table 12 Representative crop system for green vegetable producers

Parameter	Measure	Estimate
Yield	Per ha	25 tonnes
Irrigation application rate	Per ha	5.0 ML
Farm revenue		
Price	Per kg	$3.00
Operating revenue	**Per ha**	**$75,000**
Farm operating costs		
Pre-harvest costs (FORM, canopy maintenance, fertiliser, chemicals)	Per ha	$12,838
Irrigation costs	Per ha	$2,500
Harvesting and post-harvest costs	Per ha	$41,790
Total variable costs	**Per ha**	**$57,128**
Gross margin per hectare	**Per ha**	**$17,872**
Gross margin per hectare per ML	**Per ML**	**$3,574**

Note: Estimates derived from a review of available data and information. It is noted that some parameters, in particular yield and farm operating costs, are likely to vary significantly across producers.

Source: Synergies modelling. Data obtained from data and information sources.

8 Modelling framework and results

This section sets out our key assumptions about how additional irrigation water would be used by crop producers. This is informed through our consultation with producers in the region. We then present value estimates for additional water, derived from the results of the farm-level modelling conducted for each crop. As previously stated, these estimates represent the upper bound of what producers would be willing (or have capacity) to pay (in total) for additional irrigation water.

8.1 Beneficial uses of irrigation water

There are two potential uses of additional irrigation water for crop producers within the dam supply footprint – application to existing area under crop and the expansion of the area of production. We examine each of these opportunities below.

8.1.1 Application to existing cropped area

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

- increased yield or product quality by increasing irrigation application rates; or
- the avoidance of the loss of yield or product quality in 'dry' years, through being able to maintain water application rates necessary to maximise yield and quality.

Based on our consultations, the dominant response to additional water for application to existing crops would be the second of these two actions – i.e. few producers (possibly with the exception of some wine grape producers) would increase their 'normal year' irrigation rates (as these rates are already optimised for maximum net economic output). The typical benefit of additional irrigation water to producers would be to serve as a buffer against 'dry' years, and thus avoid losses in crop yield or product quality. This is particularly valuable for permanent crops (e.g. apples and wine grapes) where there is no opportunity to vary the size of the area under crop on an annual basis depending on seasonal conditions.

Table 13 summarises our key findings regarding the likelihood of additional irrigation water being applied to existing crops for each crop.

Table 13 Likelihood of additional water being applied to established crops

Crop	Likelihood of application to existing crops	Rationale
Apples	High	Apple producers experience significant reductions in yield and potentially product quality as a result of water shortages. Several producers expressed a strong interest in securing additional volumes of irrigation water to prevent loss of yield and hence revenue in dry years. Water security is also important to apple producers due to the need to maintain irrigation to permanent crops (protect sunk investment). Unlike growers of annual crops, apple growers do not have the flexibility of being able to reduce their area of plantings to match seasonal conditions.
Tomatoes and capsicums	Low	Due to the annual nature of crop production, the significant planting costs incurred, and the significant reductions in revenue received for lower grade tomatoes and capsicums, producers typically scale production based on expected future water availability (i.e. producers ensure they have enough water to meet their water supply needs for the area of planted crop). Rather than reduced yields, lower water availability therefore manifests as a reduction in area of crop production.
Strawberries	Low	The water-intensive nature of strawberry production, significant up-front and ongoing costs of production and importance of maintaining product yield and quality mean that strawberry producers ensure they have sufficient water security for existing crops. The dominant driver of demand for additional volumes of irrigation water sought by strawberry producers would be to expand area of production.
Wine grapes	High	Whilst water requirements and irrigation application rates vary significantly across wine grape producers, several producers consulted with stated that their primary use of additional irrigation water would be for application to established crops, either to increase yield or for increased water security to avoid yield losses or to protect vines during dry periods. However, some producers noted that they had no desire for additional volumes of irrigation water.
Strawberry runners	Low	As with tomatoes, capsicums and strawberries, producers of strawberry runners scale production based on their water availability due to the need to meet crop yield and quality requirements. As such, producers would therefore not seek additional volumes of irrigation water for their current levels of production, but rather to expand areas of production.
Green vegetables	Medium	It is understood based on discussions with other crop producers and previous assessments that producers of these crops are likely to have the capacity to apply additional water during dry periods to reduce loss of yield or product quality, noting that vegetable producers will also scale production based on the volume of irrigation water that is available.

Source: Based on consultation with producers.

8.1.2 Expansion of area under irrigated production

An increase in the availability of irrigation water has the potential to result in an increase in the area under crop production. However, in order for the return to irrigation water to be calculated based on the expansion of area under crop production, it must be the case that access to sufficient volumes of irrigation water is the primary constraint on expanding production.

The key factors, other than access to irrigation water, that can constrain the expansion of crop production in a region are:

- availability of suitable land;
- the incidence of 'lumpy', fixed costs that make expansion cost-prohibitive (e.g. machinery, sprinkler equipment, trellising, on-farm water storage); and
- market factors (i.e. demand for additional quantities of production, labour costs).

As discussed in section 3.2.2, the most recently completed Agricultural Land Audit indicates it is unlikely that access to suitable land represents a constraint on the expansion of crop production within the dam supply footprint. This was reiterated through consultation with producers, all of whom expressed the view that factors other than land (primarily water availability and market constraints) were constraining production. This is likely to be the result of the fact that crop profitability in the Southern Downs region is not necessarily driven by fertile soils, but rather by the favourability of the microclimate in the region in terms of the seasonality of crop production and the freight cost and transit time advantage afforded to producers due to the region's relative close proximity to Brisbane.[44]

Several producers noted that market factors are a constraint on increased production. This was particularly the case for apples, wine grapes and some vegetable crops (e.g. lettuce, baby-leaf).[45] A crop is constrained in terms of its expansion potential in a region where the market for that crop is such that there is no demand in the market for additional production at a price that is commercially viable for producers (i.e. an expansion of crop production will result in a reduction in net revenue to producers).

In addition, as noted in section 3.2.1, additional water supplied to irrigated crop producers within the dam supply footprint would be used to supplement existing on-farm water storages. The estimated yield for irrigation purposes from the proposed dam of around 1,700 ML represents a marginal increase in total irrigation water use in the region. Hence, to the extent that additional water was to be used to facilitate new crop production, this will predominantly occur through incremental expansion of existing operations, as opposed to largescale greenfield development.

Table 14 sets out the extent to which each of the above factors represent a constraint on crop production within the dam supply footprint, based on consultation with producers and a review of relevant documentation.

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44 The microclimate in the Southern Downs region provides producers with a seasonal advantage over some other major crop growing regions, as producers are able to meet market demand during periods when other regions are constrained. This is particularly relevant for tomatoes and capsicums, strawberries and strawberry runners.

45 Whilst minimal consultation was conducted with green vegetables, it is understood anecdotally that most vegetables produced in the Southern Downs region are also likely to be subject to market constraints.

Table 14 Constraints on expansion of crop production in the Southern Downs region

Crop	Water availability	Land availability	Market factors
Apples	• Main impact of shortages of water is a loss of yield from existing crops during dry periods. • Other factors more of a constraint on expansion of production however additional water could enable some growers to expand plantings and expand into new varieties.	• Land availability is not considered a constraint on production – apple producers have purchased additional land where there are water rights attached. • There is spare land available for production, however land without water rights is of little value to producers.	• Market factors are a major constraint on future expansion of apple production in the region. Lack of growth in the market is a major factor preventing growers from investing significant up-front capital required for crop expansion. • Main area of growth is in new varieties – results in new plantings of these varieties to replace outgoing varieties.
Tomatoes and capsicums	• Water availability is the major constraint on production, particularly in relation to tomatoes. • Producers are constraining their area of production based on available water. • Producers have invested heavily to ensure they have the necessary level of water security to maintain their existing levels of production.	• Land availability is not considered a constraint on production. • In addition to there being additional land available, tomato and capsicum producers have the ability to plant an additional crop on existing land subject to other constraints being addressed.	• Whilst market factors are a constraint on production, producers advised that there is scope for material growth (20-30 per cent) in tomato production from the Southern Downs region before it is anticipated that producers would see a material reduction in price. • This is largely due to the seasonal advantage the Southern Downs holds with respect to tomato and capsicum production relative to other regions.
Strawberries	• Whilst producers have invested heavily in enhancing their water security, water availability is a constraint on increased production in the region.	• Land availability is not considered to be a constraint on production – strawberry production has expanded significantly in the region in recent years.	• Strong growth in demand in the strawberry market in recent years has led to significant increases in strawberry crop production in the region. • Only scope for incremental expansion of production area from the current level – major producer estimated that an increase in output from the region of over 15 per cent would result in a material reduction in average prices.
Wine grapes	• Water availability is not the key constraint on the expansion of wine grape production in the region. • Whilst some wine grape producers have a desire for additional volumes of water to increase security for existing crop production, there is only likely to be incremental growth in wine grape production as a result of an increase in water availability.	• Land availability is not considered to be a constraint on production. Wine grape producers have existing land that is not currently being produced on or have access to additional areas of land at relatively low cost.	• Market factors are a significant constraint on the growth of wine grape production in the region. • Despite an increase in export market opportunities for wine grape producers in the region, the area of land used for wine grape production in the region has decreased in recent years. • Several producers noted that market factors were the primary constraint on increasing wine grape production in the region.
Strawberry runners	• Water availability is the major constraint on production. • Producers have invested heavily in water use efficiency measures. • One of the two major producers has invested in crops outside of the region	• Land availability is not considered to be a constraint on production. Both major producers stated that they have existing land available that is currently not being used for production and have access to additional areas of nearby land at relatively low cost.	• There is strong growth in the market for strawberry runners, particularly during the season of production for the Southern Downs region. • Subject to other constraints being addressed, it is likely that producers would expand

Crop	Water availability	Land availability	Market factors
	due to better water availability.		production of strawberry runners significantly (e.g. 20-30 per cent).
Green vegetables	• Limited ability to consult with producers means it is difficult to reach a conclusion on the extent to which water availability represents a constraint on green vegetable production.	• Based on the 2013 agricultural land audit, it is unlikely that land availability represents a constraint on green vegetable production in the Southern Downs.	• Based on anecdotal information provided by other crop producers, market factors are considered a constraint on the production of some green vegetables (e.g. lettuce, baby-leaf).

Source: Based primarily on consultation with producers.

8.2 Value estimates for additional irrigation water

The following sections present the results of the modelling of the on-farm return to additional irrigation water for each crop and intended use. It is important to note that the estimates derived for the total return to additional irrigation water are based on the assumption that entitlements will be 'high reliability'. The value of additional irrigation water to producers is for application to existing crops during periods of water shortage to avoid crop yield and product quality losses and for application to newly established crops. Both of these uses require producers to be confident in the reliability of supply. If the irrigation water entitlements to be made available from the proposed Emu Swamp Dam, or any other supply augmentation, were to be lower than 'high reliability' (i.e. reliability of around 95 per cent), an adjustment would need to be made to the estimated returns to additional irrigation water.

8.2.1 Apples

The key findings from consultation with producers with respect to the impact of increased irrigation water availability on apple production within the dam supply footprint were as follows:

- consistent with the findings from previous assessments, demand for additional volumes of irrigation water from apple producers is likely to be in relation to producers seeking additional water security for established crops, primarily to avoid loss of yield or product quality during dry years;
- some producers may be constrained from expanding crop production due to a lack of water availability, however market factors are considered to be the more significant constraint; and
- several apple producers have made significant investments in order to increase their on-farm water resources in recent years, including purchasing properties with water harvesting rights.

Application to established crops

As noted above, the main driver of demand for additional irrigation water from apple producers is for increased water security for existing crops. In particular, apple producers would use additional volumes of water to avoid product yield or quality losses during 'dry' years.

The value of additional irrigation water for use on established apple crops will vary across producers based on the frequency with which producers' experience water shortages. For example, one grower may experience yield loss due to water shortages once every five years, whilst a producer with better water security may only experience yield loss once every ten years. Additional irrigation water will therefore be of greater value to the former.

To account for this variation across apple producers, the return to additional volumes of irrigation water to be applied to established crops was estimated separately for:

- producers with lower water security, for whom it was assumed additional volumes of irrigation water would be applied to established crops one in every four years (on average); and
- producers with higher water security, for whom it was assumed additional volumes of irrigation water would be applied to established crops one in every six to seven years (on average).[46]

Based on consultation with apple producers, the following assumptions were also applied:

- during an average 'dry' year, producers typically experience a shortfall in water application rates of around 10 per cent; and
- this water shortage results in a loss of product yield or quality that translates to a revenue loss of around 15 per cent.

It is acknowledged that in some 'dry' years producers will experience more significant water shortages and hence greater revenue losses, however the above assumptions are considered appropriate based on consultation with producers.

46 It is important to acknowledge that, even within these categories, the incidence of the application of additional volumes of irrigation water and hence the return to additional irrigation water will vary across producers. For example, some producers within the first group may require access to additional volumes of irrigation water one in every two to three years. However, based on consultation with apple producers, it is considered that this categorisation of demand for additional irrigation water from apple producers is appropriate.

Table 15 shows the impact of revenue losses in 'dry' years for apple producers within the dam supply footprint.

Table 15 Impact of 'dry' year on apple producers

Year	Revenue per ha	Growing costs per ha	Gross margin per ha
'Normal' year	$99,000	$65,800	$33,300
'Dry' year	$84,200	$60,500	$23,600
Differential	**-$14,800**	**-$5,300**	**-$9,700**

Source: Synergies modelling. Based on consultation with producers. Estimates are rounded to the nearest $100.

As shown above, in an average 'dry' year, it is estimated that apple producers experience a loss of gross margin of $9,700 per hectare. As this loss of gross margin is attributable to a water shortage of around 0.55 ML (i.e. 10 per cent of 5.5 ML), for each additional ML of irrigation water, the average apple producer could avoid a loss of $17,500 in a 'dry' year.

Based on the incidence rates set out above, the annual value of additional irrigation water for application to established apple crops is estimated at:

- $4,400 per ML for apple producers with lower water security
- $2,600 per ML for apple producers with higher water security.

Applying a discount rate of 10 per cent equates to a total return associated with this additional irrigation water of $44,000 per ML and $26,000 per ML respectively (in Present Value terms).[47]

Expansion of crop production

As discussed above, market factors (i.e. insufficient demand) rather than water availability is the primary constraint on the expansion of apple production in the Southern Downs region. This was confirmed through consultation with apple producers and is evidenced by the lack of growth in the area of apple production in the region in recent years (noting other crops have experienced significant growth). This is also consistent with the outcomes from the survey undertaken by T Sargeant Services in 2013, which found that only 14 per cent of apple producers were looking to expand their area of production.[48]

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47 As discussed later in this report, it is important to note that this estimate does not take into account any additional costs associated with the future supply of the additional irrigation water (e.g. water infrastructure and delivery charges) or any up-front expenditure required to access and utilise the additional volumes.

48 T Sargeant Services (2013). The Economic Impact of the Emu Swamp Dam.

Whilst noting this, some apple producers did express a desire to expand their area of production, including the planting of new varieties. As such, whilst it is considered that the primary use of additional irrigation water by apple producers would be for application to established crops, an increase in water availability is also likely to facilitate the incremental expansion of apple production within the dam supply footprint.

Table 16 sets out the key inputs required to determine the on-farm return to additional volumes of irrigation water used for new apple crop production within the dam supply footprint.

Table 16 Inputs and assumptions for assessing return to irrigation water for new apple crop production

Input/Assumption	Estimate
Gross margin per ML	$6,045 per ML
Cost of establishing new crops	$100,000 per ha[a]
Average life of newly established crops (i.e. apple trees, hail netting, irrigation equipment, etc.)	20 years[a]
Irrigation water requirement for establishment of new crops	6.1 ML per ha[b]

a Based on consultation with apple producers.

b Includes a 'security water' component of 10 per cent the base irrigation application rate.

Source: Estimates derived through consultation with producers.

There is a significant cost associated with establishing additional apple crops (estimated at $100,000 per hectare based on stakeholder consultation). This is due to the significant costs associated with the purchase and planting of new apple trees, irrigation equipment, and hail netting.

It is also noted that the irrigation water requirement assumed for the establishment of an additional hectare of apple trees is greater than the average irrigation application rate for existing crops (6.1 ML per ha compared to 5.5 ML per ha). This is based on the observation that in order for producers to have the necessary certainty to establish an additional hectare of crops, they must have access to 'security water' of at least 10 per cent of their average irrigation requirement.[49] This assumption has also been applied for the expansion of other crops.

Based on the above assumptions, the net annual return from newly established apple crops is estimated at $20,500 per hectare.[50] Based on an irrigation water requirement of

49 In the absence of this 'security water', producers would be exposed to significant risk should they encounter 'dry' years, as they will have insufficient irrigation water to apply to their newly established crops. This risk is likely to prevent producers from expanding crop production in the absence of sufficient 'security water'.

50 Calculated based on the gross margin analysis presented above, with establishment costs being annualised over 20 years based on a discount rate of 10 per cent. An additional cost of $1,000 per annum has also been included to account for increased overhead requirements.

6.1 ML per ha, this equates to an annual return of $3,400 per ML. Applying a discount rate of 10 per cent results in a total on-farm return of $34,000 per ML (in Present Value terms).

8.2.2 Tomatoes and capsicums

The key findings from consultation with producers with respect to the impact of increased irrigation water availability on the production of tomatoes and capsicums within the dam supply footprint were as follows:

- tomato production in the Southern Downs region is currently highly profitable, due to the region's climate and seasonality of production and favourable market conditions;
- producers are more focused on expanding tomato production in the current market rather than capsicum production;
- maintaining product yield and quality is of great importance to tomato and capsicum producers as the revenue derived from the sale of low grade product is significantly lower than for high grade product; and
- tomato and capsicum producers therefore make planting decisions based on the amount of water they have available (in addition to consideration of other factors).

Based on the outcomes of consultation, the analysis was focused on tomato production, as it was considered that producers would use additional irrigation water on tomato production were it to become available. In addition, due to the nature of tomato crop production and decisions in terms of planting areas and water use, the return to irrigation water for tomato production was only assessed for application to new crops, as it is unlikely that producers would seek additional volumes for existing crops (due to producers making decisions on the area of crop to plant based on water availability).

Expansion of crop production

As discussed in section 8.1.2, water availability is considered the primary constraint on tomato production within the dam supply footprint. Several producers stated that with increased water availability, they would seek to expand tomato production. In addition, due to the relatively low volumes of production in the region relative to the overall market for tomatoes, it is considered the market could accommodate a material expansion in tomato production from the region (estimated by producers at 20 to 30 per cent of the region's current production).

Table 17 sets out the key inputs required to determine the on-farm return to additional volumes of irrigation water used for new tomato crop production.

Table 17 Inputs and assumptions for assessing return to irrigation water for new tomato production

Input/Assumption	Estimate
Gross margin per ML	$4,409 per ML
Cost of establishing new crops	NA (annual crop, no additional costs incurred, only annual planting costs)
Average life of newly established crops (i.e. apple trees, hail netting, etc.)	NA
Irrigation water requirement for establishment of new crops	6.05 ML per ha[a]

a Includes a 'security water' component of 10 per cent the base irrigation application rate.
Source: Estimates derived through consultation with producers.

Unlike for apples, no establishment costs have been included for the expansion of tomato production.[51] This is a result of all costs of establishing tomato crops being reflected in producers' pre-harvest costs (estimated at $42,000 per hectare). These costs are incurred in relation to each tomato crop, including land preparation, planting and the installation of trellising and irrigation equipment.

A similar assumption has been adopted regarding the 'security water' requirement of 10 per cent in order for tomato producers to expand crop production. This results in an irrigation water requirement of 6.05 ML per hectare as opposed to 5.5 ML per hectare. This is consistent with views expressed by producers that water security is an important requirement for the establishment of new tomato crops (due to the significant loss of revenue resulting from product quality shortfalls due to water shortage).

Based on the above assumptions, the net on-farm return from newly established tomato crops is estimated at $23,300 per hectare.[52] Based on an irrigation water requirement of 6.05 ML per annum, this equates to an annual return of $3,800 per ML. Applying a discount rate of 10 per cent results in a total on-farm return of $38,000 per ML.

8.2.3 Strawberries

The key findings from the consultation with producers with respect to the impact of increased irrigation water availability on the production of strawberries within the dam supply footprint were as follows:

- there has been significant growth in strawberry production in the region in recent years, driven primarily by growers establishing operations to the region to take

51 However, additional overhead costs of $1,000 per hectare per annum were included.

52 This estimate is the same as that derived for existing tomato crops (minus additional overhead costs) due to the annual nature of tomato crop production and the absence of additional costs to establish new tomato crops.

advantage of the favourable climatic conditions and subsequent market advantages;

- the importance of water to strawberry production, the significant up-front and ongoing costs associated with crop production, and importance of meeting market requirements with regards to yield and product quality means that producers place a high level of importance on having sufficient water for application to existing crops; and
- whilst water availability is a constraint on the expansion of strawberry production in the region, future expansion is constrained by market factors, in particular competing suppliers in the New South Wales and Victorian growing regions. As a result, future expansion in strawberry production in the region is likely to be incremental.

Based on the outcomes of consultation with strawberry producers, the return to irrigation water was only assessed for application to new crops, as due to the factors identified above, producers only establish strawberry crops with high levels of water security. Hence, additional irrigation water is likely to be used to establish new crop production, as opposed to being applied to existing crops.

Expansion of crop production

The recent expansion in strawberry production in the Southern Downs has been underpinned by significant capital investments by producers, including investing in water security and efficiency measures. Whilst access to sufficient water supply is a constraint on strawberry production in the region (see section 8.1.2), one major producer commented that a material increase in production from the region would likely result in a reduction in prices and noted that a producer had recently terminated production due to a lack of profitability.

Based on the outcomes of consultation with producers, it is considered that an increase in irrigation water supply would facilitate incremental growth in strawberry production in the region. The assumption has been applied (informed by consultation) that additional water supply would facilitate the expansion of strawberry production within the dam supply footprint by 15 per cent.

Table 18 sets out the key inputs required to determine the on-farm return to additional volumes of irrigation water used for new strawberry production.

Table 18 Inputs and assumptions for assessing return to irrigation water for new strawberry production

Input/Assumption	Estimate
Gross margin per ML	$9,375
Cost of establishing new crops	$200,000[a]
Average life of newly established crops (i.e. irrigation equipment, tunnels, etc.)	30 years[a]
Irrigation water requirement for establishment of new crops	8.8 ML per hectare[b]

a Based on consultation with producers.

b Includes a 'security water' component of 10 per cent the base irrigation application rate.

Source: Estimates derived through consultation with producers.

An estimate for the cost of establishing an additional hectare of strawberry production of $200,000 has been applied. This up-front cost covers the cost of land clearing and preparation, procuring and installing tunnelling infrastructure, irrigation piping, pumps, filters and other devices and other necessary equipment.[53] It has been assumed that this infrastructure and equipment has a life of approximately 30 years.[54] Including a 10 per cent security component, the irrigation requirement for new strawberry crops is 8.8 ML per hectare.

Based on the above assumptions, the net annual return from newly established strawberry crops is estimated at $48,800 per hectare.[55] Based on an irrigation water requirement of 8.8 ML per annum, this equates to a per ML return of $5,500 per ML. Applying a discount rate of 10 per cent results in a total on-farm return of $55,000 per ML.

8.2.4 Wine grapes

The key findings from the consultation with producers with respect to the impact of increased irrigation water availability on the production of wine grapes within the dam supply footprint were as follows:

- there is significant variability across wine grape producers in the region in terms of key production characteristics, including crop yield, irrigation application rates, and on-farm revenue and operating costs. For example, producers consulted with reported crop yields ranging from 5 to 10 tonnes per hectare;

53 Based on consultation with producers.

54 Note that some equipment is likely to have a longer life, however 30 years is considered an appropriate average.

55 Based on a useful life of infrastructure and equipment of 30 years and using a discount rate of 10 per cent. An additional cost of $1,000 per annum has also been included to account for increased overhead requirements.

- there was also variability in terms of producers' views as to whether water availability is a key constraint on wine grape production in the region. Whilst some producers considered water to be a key constraint, others identified market-based factors (i.e. insufficient demand) as the key constraint on production. It is noted that despite an increase in access to export markets for some producers, production of wine grapes in the Southern Downs has contracted slightly in recent years (noting that some producers continue to establish new vines, particularly alternative varietals);
- wine grape producers within the dam supply footprint can be categorised as follows with respect to their water requirements:
  - producers that apply relatively low volumes of irrigation water to their grape vines (i.e. 0.5 ML per hectare) and maintain irrigation water supply to protect grape vines during very dry periods; and
  - producers that apply higher volumes of irrigation water to their grape vines (i.e. 1.5 to 3 ML per hectare) and would use additional irrigation water to increase crop yields, particularly in 'dry' years, and (to a lesser extent) to establish new grape vines.

Based on the outcomes of consultation with producers, the analysis has focused on the second category of producers, as it is unlikely the first category will account for material demand for additional irrigation water. The farm-level analysis of the return to additional irrigation water has therefore been modelled for producers in the second category, both in terms of application of the water to established grape vines and also for the expansion of wine grape production.

Application to established crops

As noted above, a proportion of wine grape producers in the region would, were they able to access additional irrigation water, apply additional volumes to established crops to improve crop yield. As with apple producers (see section 8.2.1), the value of additional irrigation water for use on established grape vines will vary across producers based on:

- the frequency with which producers apply additional volumes to the vines (this will depend on a range of factors, including current level of water security and target crop yield); and
- the yield improvement/avoided loss of yield achieved through the application of the additional volumes.

For example, a producer with lower water security may seek to apply additional volumes on a regular basis to improve their crop yield, whilst another producer with better water security or a lower yield target may only apply additional volumes in very dry years.[56] The first of these two producers will place a higher value on additional irrigation water.[57]

Based on consultation with wine grape producers, the following assumptions were applied to estimate the return to irrigation water for application to established vines:

- on average, wine grape producers would apply additional irrigation water to established vines one in every two to three years;
- in these years, producers would apply an additional 0.5 ML of irrigation water per hectare (30 per cent of current average application rate); and
- the revenue shortfall due to loss of yield as a result of lower irrigation application rates (or increase due to application of additional irrigation water) is 30 per cent.[58]

It is acknowledged that some wine grape producers with lower water security would apply additional volumes of irrigation water more often than once every two to three years (and that the application of additional volumes of irrigation water could have more significant yield impacts than the estimates applied), however the above assumptions are considered appropriate based on consultation with wine grape producers in the region.

Table 19 shows the financial impact of a shortfall in irrigation application in years in which wine grape producers within the dam supply footprint could achieve higher crop yields by applying additional irrigation water to established grape vines.

Table 19 Impact of shortfalls in irrigation application to existing crops on wine grape production

Year	Revenue per ha	Growing costs per ha	Gross margin per ha
'Normal' year	$15,000	$7,100	$7,900
'Dry' year	$10,500	$5,300	$5,200
Differential	**-$4,500**	**-$1,800**	**-$2,700**

Source: Synergies modelling. Based on consultation with producers.

The above table shows that, in years where wine grape producers are unable to apply a sufficient volume of irrigation water to achieve their target crop yield, the loss of gross

56 It is noted that wine grape producers place a very high value on water that is necessary to keep wine grape vines alive during very dry periods. However, throughout the consultation process, no wine grape producer expressed the view that they required additional volumes of irrigation water for this purpose.

57 One wine grape producer consulted with stated that they would seek to apply additional irrigation water to their existing vines almost every year in order to improve yield.

58 There were significant differences expressed by producers in relation to this variable, with some reporting lower and others much higher yield impacts of water shortages.

margin per hectare is estimated at $2,700. As this loss of revenue is attributable to a water shortage of 0.52 ML (i.e. 30 per cent of 1.75 ML), each additional ML of irrigation water corresponds to an avoided loss of revenue of $5,200 per ML (for those years in which additional irrigation water would have been applied).

Based on the assumption that producers would seek to apply additional irrigation water to avoid loss of yield once every two to three years, the annual value of additional irrigation water for application to established wine grape vines is estimated at $2,100 per ML. Applying a discount rate of 10 per cent equates to a total on-farm return associated with additional irrigation water of $21,000 per ML (in Present Value terms).

Expansion of crop production

As noted in section 8.1.2, market factors are the primary constraint on wine grape production in the Southern Downs. This was confirmed by the wine grape producers consulted with and is evidenced by the fact that the area under production has remained static whilst production of other crops (e.g. strawberries and strawberry runners) has increased significantly in recent years. It is also consistent with the outcomes of the survey undertaken by T Sargeant Services in 2013, which found that only 11 per cent of wine grape producers were looking to expand their area of production.[59]

However, several producers reported they have land available for expansion and some expressed a desire to expand production were additional volumes of water to be made available. As such, whilst any increase in production is likely to be marginal, it is likely that an increase in water availability would facilitate the incremental expansion of wine grape production by existing producers within the dam supply footprint. For the purpose of this assessment, it has been assumed that an increase in the availability of irrigation water would facilitate a 5 per cent increase in the area under wine grape production within the dam supply footprint (i.e. 8.5 hectares of additional production).

Table 20 sets out the key inputs required to determine the on-farm return to additional volumes of irrigation water used for new wine grape production.

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59 T Sargeant Services (2013).

Table 20 Inputs and assumptions for assessing return to irrigation water for new wine grape production

Input/Assumption	Estimate
Gross margin per ML	$4,529 per ML
Cost of establishing new crops	$20,000 per ha[a]
Average life of newly established crops (i.e. grape vines)	40 years[a]
Irrigation water requirement for establishment of new crops	1.93 ML per ha[b]

a Based on consultation with wine grape producers.

b Includes a 'security water' component of 10 per cent the base irrigation application rate.

Source: Estimates derived through consultation with producers.

Based on the assumptions set out above, the net on-farm return from newly established wine grape vines is estimated at $4,900 per hectare.[60] Based on an irrigation water requirement of 1.93 ML per hectare, this equates to an annual return of $2,500 per ML. Applying a discount rate of 10 per cent results in a total on-farm return of $25,000 per ML (in Present Value terms).

8.2.5 Strawberry runners

The key findings from the consultation with producers with respect to the impact of increased irrigation water availability on the production of strawberry runners within the dam supply footprint were as follows:

- both of the major strawberry runner producers within the dam supply footprint have sufficient water resources to maintain existing production, with both seeking additional irrigation water to expand production;
- in addition, the importance of maintaining crop yield and quality in order to maintain market share means there is little scope for producers to accommodate shortfalls in yield or quality due to insufficient water application. Hence, producers ensure they have sufficient water available to produce existing crops;[61]
- production of strawberry runners in the region has increased significantly in recent years (from 85 hectares to 170 hectares),[62] due predominantly to growth in strawberry production across several areas throughout Australia and the favourable seasonality of production in the Southern Downs. Both major producers

[60] Calculated based on the gross margin analysis presented above, with establishment costs being annualised over 40 years based on a discount rate of 10 per cent. An additional cost of $1,000 per annum has also been included to account for increased overhead requirements.

[61] Both major producers expressed the view that they have invested significantly in ensuring they have the required level of water security to guarantee production of their existing crops.

[62] Orchard Services (2017).

expressed the view that there is the potential for further expansion of strawberry runner production in the region; and

- one producer has expanded production in other regions where water resources are more readily available.

Based on these outcomes, the analysis was concentrated on the potential for additional irrigation water to facilitate the expansion of strawberry runner production, as opposed to additional volumes being applied to existing crops.

Expansion of crop production

As discussed in section 8.1.2, water availability is the primary constraint on production of strawberry runners in the Southern Downs, with both major producers seeking additional volumes to expand their areas of production. The strong demand for strawberry runners produced in the region means the market is likely to be able to accommodate a material expansion in production from the region. This is supported by one of the major producers in the region investing in expanding production in northern New South Wales, where water is more readily available. For this assessment, it has been assumed that were the constraint imposed by insufficient water supply to be alleviated, production of strawberry runners within the dam supply footprint could increase by 25 per cent (i.e. an additional 42.5 hectares of production).

Table 21 sets out the key inputs required to determine the on-farm return to additional irrigation water used for new strawberry runner production within the dam supply footprint.

Table 21 Inputs and assumptions for assessing return to irrigation water for new strawberry runner production

Input/Assumption	Estimate
Gross margin per ML	$2,000 per ML
Cost of establishing new crops (i.e. land clearing and preparation, irrigation installation)	$50,000[a]
Average life of newly established crops (i.e. irrigation mains)	40 years[a]
Irrigation water requirement for establishment of new crops	11 ML per ha[b]

a Based on consultation with strawberry runner producers.

b Includes a 'security water' component of 10 per cent the base irrigation application rate.

Source: Estimates derived through consultation with producers.

Based on the assumptions set out above, the net on-farm return from newly established strawberry runner crops is estimated at $13,900 per hectare.[63] Based on an irrigation water requirement of 11 ML per hectare, this equates to an annual return of $1,300 per ML. Applying a discount rate of 10 per cent results in a total on-farm return of $13,000 per ML (in Present Value terms).

8.2.6 Mixed green vegetables

Less consultation was undertaken with green vegetable producers than with other producers due to the lack of availability of green vegetable producers at the time of consultation. However, through discussions with other crop producers, it was determined that, should additional water become available, green vegetable producers could represent a source of demand. On this basis, farm-level analysis was conducted for green vegetable crops based on publicly available information on crop production, including yields, irrigation application rates, production costs, and the impact of increased water availability on crop production.

However, it is important to note that producers also expressed the view that market factors did represent a material constraint on green vegetable production in the region (noting that water availability may also be a material constraint).

Application to established crops

As with other crops, there will be considerable variation across green vegetable producers in terms of the frequency with which producers require access to additional irrigation water to avoid losses in relation to crop yield or product quality.

The limited availability of green vegetable producers to take part in the consultation process made it necessary to rely on publicly available information on production of green vegetables in framing the assumptions for the analysis. Based on a review of available information (including past assessments undertaken in relation to the proposed Emu Swamp Dam), the following assumptions were applied to estimate the on-farm return from the use of additional irrigation water on existing green vegetable crops:

- on average, green vegetable producers experience a ‘dry’ year one in every five years;

[63] Calculated based on the gross margin analysis presented above, with establishment costs being annualised over 40 years based on a discount rate of 10 per cent. An additional cost of $1,000 per annum was also included to account for increased overhead requirements.

- during the average 'dry' year, producers experience a shortfall in water application rates of 10 per cent; and
- the water shortage results in a loss of product yield or quality that translates to a revenue loss of 20 per cent.

Table 22 shows the impact of revenue losses in 'dry' years and hence the on-farm return to additional volumes of irrigation water for green vegetable producers within the dam supply footprint (noting the indicative nature of the analysis).

Table 22 Impact of 'dry' year on green vegetable producers

Year	Revenue per ha	Growing costs per ha	Gross margin per ha
'Normal' year	$75,000	$57,128	$17,872
'Dry' year	$60,000	$48,520	$11,480
Differential	**-$15,000**	**-$8,608**	**-$6,392**

Source: Synergies modelling. Analysis is indicative only.

As shown in the above table, in an average 'dry' year, it is estimated that green vegetable producers experience a loss of gross margin of $6,400 per hectare. As this loss of gross margin is attributable to a shortfall of 0.5 ML (i.e. 10 per cent of 5 ML), for each additional ML of irrigation water, the average green vegetable producer could avoid a loss of $12,800 (in those years in which producers would seek to apply additional volumes).

Based on an incidence rate of one 'dry' year every five years, the annual value of additional irrigation water for application to established green vegetable crops is estimated at $2,600. Applying a discount rate of 10 per cent equates to a total on-farm return associated with this additional irrigation water of $26,000 per ML (in Present Value terms).

Expansion of crop production

As discussed above, whilst less consultation was undertaken with green vegetable producers that with other producers, it is considered that, were additional irrigation water to be made available, producers of some green vegetables would seek to expand production (noting the presence of other constraints). This is supported by the survey undertaken by T Sargeant Services in 2013, which found that 71 per cent of vegetable producers were seeking to expand their area of production.[64] However, given the absence of consultation with producers, it has only been assumed that the area of green vegetable crop production within the dam supply footprint would increase by 5 per cent as a result of additional water supply (i.e. an additional 25 hectares of production).

[64] T Sargeant Services (2013).

Table 23 sets out the key inputs required to estimate the on-farm return to additional irrigation water used in new green vegetable crop production.

Table 23 Inputs and assumptions for assessing return to irrigation water for new green vegetable production

Input/Assumption	Estimate
Gross margin per ML	$3,574 per ML[a]
Cost of establishing new crops	NA (annual crop, no additional costs incurred, only annual planting costs)
Average life of newly established crops (i.e. irrigation mains)	NA
Irrigation water requirement for establishment of new crops	5.5 ML per ha[b]

a Based on publicly available information for a range of crops, including green beans, cabbages, lettuce, broccoli and broccolini.

b Includes a 'security water' component of 10 per cent the base irrigation application rate.

Source: Estimates are indicative only – based on publicly available information on crop production, irrigation application rates, etc.

Based on the above assumptions, the net on-farm return from newly established green vegetable crops is estimated at $16,900 per hectare.[65] Based on an irrigation water requirement of 5.5 ML per hectare, this equates to an annual return of $3,100 per ML. Applying a discount rate of 10 per cent results in a total on-farm return of $31,000 per ML (in Present Value terms).

[65] As with other crops, this takes into account an additional cost of $1,000 per hectare per annum to take into account increased overhead requirements.

9 Key findings and implications

The preceding section set out the results of the farm-level modelling conducted on the identified crops. This section summarises the key findings, for both irrigation and industrial water demand, and the implications for the Strategic Assessment.

9.1 Irrigation water demand

9.1.1 Summary of modelling results

Table 24 presents a summary of the results of the crop-by-crop analysis of the returns from the increased availability of irrigation water within the dam supply footprint.

Table 24 Summary of modelling results

Crop	Approx. area of production within dam footprint (ha)	Total return for existing crops (Present Value per ML)	Total return for new crop production (Present Value per ML)
Apples (lower water security producers)	1,202	$44,000	$34,000
Apples (higher water security producers)		$26,000	
Tomatoes	65		$38,000
Strawberries	160		$55,000
Wine grapes	170	$21,000	$25,000
Strawberry runners	170		$13,000
Green vegetables	500	$26,000	$31,000

Note: Areas of production are based on the assessment undertaken by Orchard Services in 2013, informed by an updated assessment undertaken by Orchard Services in April 2017. Areas are approximations only. Estimates have been rounded.

For apples, the two categories refer to those producers with lower levels of water security (i.e. experience a higher incidence of yield/quality losses due to water shortage) and those producers with higher levels of water security (i.e. experience a lower incidence of yield/quality losses due to water shortage).

Source: Synergies modelling.

In order to assess the likely uses of additional irrigation water within the dam supply footprint it is necessary to apply assumptions for:

- the extent to which existing producers of each crop would seek additional volumes to apply to established crops; and
- the extent to which the supply of additional irrigation water would facilitate the expansion of the area of production for each crop.

Sections 8.1.1 and 8.1.2 have detailed the key findings from the consultation process regarding the extent to which additional water is likely to be applied to established and new crops for each crop type. Table 25 sets out, based on these findings, the potential demand for additional irrigation water by crop type and use. The estimates for the percentage expansion in area by crop type were developed by Synergies based on an assessment of recent trends in crop production in the region and through consultation with producers.

Table 25 Demand for additional irrigation water by crop type and use

Crop	Area within dam footprint (ha)	Demand for existing crop production		Demand for new crop production			
		Demand per ha	Total demand	% expansion in area	Additional area of crop production (ha)	ML/ha required for expansion	Total demand
Apples (lower water security)	1,202	0.55 ML	330.5 ML	5	60	6.05	363.5 ML
Apples (higher water security)		0.55 ML	330.5 ML				
Tomatoes	65			60	39	6.05	236 ML
Strawberries	160			15	24	8.80	211 ML
Wine grapes	170	0.53 ML (to 50% of ha)	45 ML	5	8.5	1.93	16.5 ML
Strawberry runners	170			25	42.5	11.00	467.5 ML
Green vegetables	500	0.5 ML (to 50% of ha)	125 ML	5	25	5.50	137.5 ML

Notes: Assumed that 50 per cent of apple producers have lower water security and 50 per cent have higher water security.

For wine grapes and green vegetables, it has been assumed that only 50 per cent of producers will demand access to additional irrigation water for application to existing crops (based on consultation with stakeholders and past reports and studies).

Source: Synergies modelling.

Based on the above table, the estimates of demand for additional irrigation water within the dam supply footprint are as follows:

- 2,000.5 ML (for all crops without green vegetables)
- 2,263 ML (for all crops including green vegetables).

It is necessary to report these two estimates separately as the estimates for green vegetable production are indicative, based on publicly available data and information due to the unavailability of green vegetable producers to take part in the consultation process.

Based on these volume estimates, Table 26 sets out estimates for the total return to additional irrigation water by crop type and use.

Table 26 Total return from additional irrigation water

Crop	Total ML of additional water	Per ML return for existing crops	Per ML return for new crops	Total return from additional water
Apples	1,024.5 ML	$44,000 (low security) $26,000 (high security)	$34,000	$35.46 million
Tomatoes	236 ML	-	$38,000	$9.07 million
Strawberries	211 ML	-	$55,000	$11.71 million
Wine grapes	61.5 ML	$21,000	$25,000	$1.35 million
Strawberry runners	467.5 ML	-	$13,000	$5.90 million
Green vegetables	262.5 ML	$26,000	$31,000	$7.41 million
Totals	**2,263 ML**			**$70.90 million**

Note: Totals may not add due to rounding. Per ML estimates have been rounded.
Source: Synergies modelling.

9.1.2 Implications for Strategic Assessment

Merit order of water demand

As previously stated, an indicative estimate of 1,700 ML per annum has been developed for the yield from the proposed Emu Swamp Dam that is to be used for irrigation purposes.[66] As it is likely that demand for additional irrigation water exceeds this estimate, it is anticipated that water entitlements would be allocated to the highest value use until the additional supply is fully allocated.

Table 27 presents a merit order for the likely take-up of the estimated yield from the proposed Emu Swamp Dam, based on the outcomes of this assessment.

[66] The estimates derived for the farm-level return to additional irrigation water are based on 'high reliability' water entitlements. If entitlements were to have a lower level of reliability, corresponding adjustments would need to be made to the estimated returns.

Table 27 Illustrative demand take-up for additional volumes of irrigation water (without green vegetables)

Use	ML used	Cumulative ML supplied[a]	Total returns (Present Value)	Cumulative returns (Present Value)
Strawberries – new crops	211.2	211.2	$11.71 million	$11.71 million
Apples – existing crops (producers with lower levels of water security)	330.6	541.8	$14.46 million	$26.17 million
Tomatoes – new crops	236.0	777.7	$9.07 million	$35.24 million
Apples – new crops	363.6	1,141.3	$12.32 million	$47.56 million
Apples – existing crops (producers with higher levels of water security)	330.6	1,471.9	$8.67 million	$56.24 million
Wine grapes – new crops	16.4	1,488.2	$0.41 million	$56.65 million
Wine grapes – existing crops	44.6	1,532.8	$0.93 million	$57.58 million
Strawberry runners – new crops	167.2	1,700.0	$2.11 million	$59.69 million

a Cumulative ML supplied refers to total use of water to be supplied by the proposed Emu Swamp Dam (or an alternative supply source). Cumulative ML supplied is calculated by adding the ML supplied to each use as ML are allocated to each use based on the return per ML. For example, cumulative ML supplied after allocation to existing apple crops (producers with lower levels of water security) is equal to 541.8 ML (211.2 ML to new strawberry crops plus 330.6 ML to existing apple crops (low water security)).

Note: Green vegetable crops were excluded based on the level of consultation that was able to be undertaken with producers due to lack of availability.

Source: Synergies modelling.

Due to the lack of availability of green vegetable producers to engage in the consultation process, this crop was not included in the above merit order. If green vegetable crops are included in the demand profile, no additional water is allocated to strawberry runner or wine grape production (despite total demand estimates of 467.5 ML and 61.5 ML being derived for these crops respectively). This is a result of the lower per ML return from strawberry runner and wine grape production over, say, green vegetables, which means that the inclusion of crops with higher per ML returns (such as green vegetables) results in ML being diverted from strawberry runners and wine grapes to higher value applications. When green vegetables are included in the demand profile, the cumulative return over 1,700 ML of additional supply increases from $59.69 million to $62.77 million.

It is acknowledged that, in practice, different producers of the same crop will derive different returns from additional irrigation water, subject to a range of factors associated with their current production practices, levels of water security, etc. The merit order presented above is therefore intended to provide an illustration of the likely take-up of additional volumes of irrigation water and hence the on-farm return from additional irrigation water use.

Implications for supply augmentations

The results detailed in the preceding sections provide estimates for the total return from the use of additional irrigation water. However, these estimates do not take into account:

- annual water infrastructure and supply charges (i.e. charges that would be recovered from producers to cover the cost of water delivery and ongoing operating and maintenance expenditure associated with the water storage and pipeline infrastructure); and
- up-front costs that would need to be incurred for producers to make use of additional irrigation water delivered to the farm gate.

In order to compare the return to additional irrigation water to the capital cost of a proposed supply augmentation, such as the Emu Swamp Dam or an alternative option, it is necessary to make an allowance for these costs. This is because the estimates of total return per ML do not take into account future costs to be incurred by the producer in securing access to the irrigation water. To the extent that the producer is to incur additional costs, such as annual water infrastructure charges, the total return to the irrigation water will be reduced.

For example, if annual water infrastructure and supply charges are expected to total $500 per ML and producers needed to invest, on average, $2,500 per ML in on-farm infrastructure improvements in order to access their additional water entitlements (e.g. additional pipeline connections to existing on-farm storages), it would be necessary to reduce the estimates for the total return by $7,500 per ML.[67]

Based on an estimated yield for the proposed Emu Swamp Dam of 1,700 ML (for irrigation), this equates to a total reduction of $15.0 million, lowering the average return per ML from $35,100 per ML to $27,600 per ML (for the scenario excluding green vegetable crops). It is this value that should be assessed against estimates for the capital cost per ML for any supply augmentation options.

Finally, it is important to note that this assessment is not intended to provide a recommendation as to the price at which additional irrigation water should be supplied to producers (or the prices that producers would actually agree to pay for water entitlements). Rather, the purpose of the assessment has been to estimate the financial return to additional irrigation water at the farm level (i.e. the most that producers would be willing (or have capacity) to pay for additional irrigation water) to enable the cost of supply augmentation options to be compared to the farm-level return to additional irrigation water. There are a range of factors that impact on the price that producers will

[67] Based on a discount rate of 10 per cent. It is important to note that these are indicative estimates intended to demonstrate the impact of these costs on the value of additional water entitlements.

actually pay for irrigation water, several of which are unrelated to the farm-level return to irrigation water, including irrigation prices in other areas.[68]

9.1.3 Sensitivity analysis

Due to the inherent uncertainty associated with estimating the farm-level return to additional irrigation water, it is necessary to conduct sensitivity analysis on key assumptions and parameters to identify the extent to which the estimates for the farm-level return to additional irrigation water is affected by changes to key variables.

Sensitivity analysis was conducted on the following variables:

- discount rate
- crop prices
- incidence of 'dry' years.

Table 28 sets out the results from the sensitivity analysis.

Table 28 Results of sensitivity analysis

Parameter	Present value of returns without green vegetables ($ per ML)	Present value of returns with green vegetables ($ per ML)
Base results	$35,100	$36,900
	Discount rate	
Low (7.5%)	$48,700 (+38.7%)	$51,000 (+38.0%)
High (12.5%)	$26,900 (-23.4%)	$28,400 (-23.0%)
	Crop prices	
Lower crop prices (-10%)	$20,400 (-41.8%)	$21,900 (-41.8%)
Higher crop prices (+10%)	$49,800 (+41.8%)	$52,000 (+41.8%)
	Incidence of 'dry' years	
Less regular (-50%)	$28,000 (-20.2%)	$29,400 (-20.3%)
More regular (+50%)	$42,200 (+20.2%)	$44,400 (+20.3%)

Source: Synergies modelling. Estimates are rounded to the nearest $100.

As shown in the above table, changes to all three parameters resulted in significant changes to the estimated average return to additional irrigation water, particularly in relation to the discount rate and crop prices. Of most significance is the impact of a

68 For example, farm debt levels can impact on the willingness of producers to expand production and invest in additional water supply. This has not been taken into account in assessing the farm-level return to additional irrigation water for producers within the dam supply footprint.

reduction in crop prices on the average return per ML, with a 10 per cent reduction in prices resulting in a reduction in the return to irrigation water of over 40 per cent.

This result demonstrates the impact of crop price fluctuations on both profitability and thus the farm-level return to irrigation water. As an example, were crop prices to fall by 10 per cent,[69] the total on-farm return to irrigation water from the proposed Emu Swamp Dam (based on an estimated yield of 1,700 ML per annum) would fall from $59.69 million to $34.73 million.[70]

It is important to note that multiple parameters may vary under the same scenario. For example, under the scenario in which both crop prices and the incidence of 'dry' years fell by 10 per cent, the average return to additional irrigation water (assuming a yield of 1,700 ML to be made available for irrigation purposes) would fall from $35,100 per ML to $19,200 per ML (a decrease of 45.2 per cent), corresponding to a reduction in the total return to irrigation water to be supplied by the proposed Emu Swamp Dam from $59.69 million to $32.70 million.

This is an important consideration in relation to the price that producers are willing to pay for additional irrigation water. As discussed in section 9.1.2, there are a range of factors that can impact on the price that producers are willing to pay for additional water entitlements. This sensitivity analysis shows that producers' expectations regarding future crop price fluctuations and appetite for risk will have a significant impact on the price producers are prepared to pay for additional irrigation water entitlements.

9.2 Industrial water demand

9.2.1 Summary of assessment

Previous assessments have reached significantly different conclusions regarding future industrial water demand in the Stanthorpe region. Through consultation, the GBCCI identified the proposed Emu Swamp Dam as its number one priority for promoting economic development in the Stanthorpe region. According to the GBCCI, the primary source of growth is likely to be agrifood processing operations. The GBCCI stated that this activity could be done more efficiently and at a larger scale in town if a reliable source of treated, reticulated water was available for washing and hygiene purposes.

69 It should also be acknowledged that were crop prices to fall by an average of 10 per cent, it is likely that producers of some crops would reduce their areas of production, increasing the water available for crop production and potentially resulting in further reductions to the per ML return to additional irrigation water.

70 Calculated based on the scenario in which green vegetable crops are excluded from the analysis.

Our discussions with horticultural producers in the region found that not all share GBCCI's optimism for locally-based value adding. Even if an additional reticulated water source became available, few producers we spoke to raised any interest in shifting to food processing, as they are currently securing good returns from supplying fresh produce to Brisbane and northern Queensland markets.

In our assessment, it is unlikely that an agrifood processing industry will become a major new demand driver for additional water in Stanthorpe. The reason for this is twofold:

- the volumes of additional water capable of being supplied by the proposed Emu Swamp Dam are relatively small, so would only allow a marginal increase in horticultural output and unlikely to be of sufficient scale to underpin a major, local food processing hub; and
- Stanthorpe producers currently have the option of transporting their produce to nearby Warwick for processing, where there is no water constraint and better access to major transport routes and labour. However, there is little evidence of this occurring, so we are cautious of claims that a new water source for Stanthorpe would attract more local processing.

9.2.2 Implications for Strategic Assessment

While non-residential water demand is expected to increase over time, it is Synergies' view that there is insufficient evidence to support a forecast that would have industrial demand outstripping residential demand in the foreseeable future or exhibiting a 'step change' in economic development if a new bulk water supply was developed.

A Summary of previous demand assessments

This attachment summarises some of the previous agricultural demand assessments undertaken for the proposed Emu Swamp Dam.

Jacobs (2016). Emu Swamp Dam – Business Case.

As part of the business case, Jacobs conducted a survey of 19 crop producers. The survey responses indicated strong support for at least 1,300 ML of demand for water from the project across a wide range of horticultural crops, including vegetables, wine grapes, apples and stone fruit, and strawberries. All 19 growers supported the project based on a proposed one-off purchase price for water entitlements of $5,979 per ML and annual fixed and variable charges of $241 and $139 per ML respectively. The volumes of water required by irrigators ranged from 5 to 300 ML per annum.

The report concluded that horticultural production in the region would increase significantly as a result of the project by unlocking underutilised land that is suitable for horticultural production.

T Sargeant Services (2013). The Economic Impact of the Emu Swamp Dam.

A total of 90 interviews were undertaken with growers, the majority of whom indicated their strong enthusiasm for the project based on the growth opportunities it would enable. A small proportion of growers were not supportive of the project on the basis that extra production would have a downward effect on prices.

The majority of the growers interviewed were seeking improved water security and additional water to accommodate planned development. The growers interviewed for this process accounted for 26 per cent of all growers operating within the Emu Swamp Dam footprint. Of these growers, 83 per cent were seeking additional water for either security or development purposes. Based on responses from these growers, over 4,000 ML per annum was sought. The report noted that given only 26 per cent of growers within the dam footprint were surveyed, the total demand for additional water was likely to be significantly greater than 4,000 ML.

Unidel (2011). Emu Swamp Dam Report – Southern Downs Regional Council Stanthorpe Water Project.

This study included a questionnaire and online survey, supported by field verification based on discussions with a sample group of irrigators. The key outcomes from the survey were as follows:

- 61 per cent of growers indicated that they usually have enough water each year;
- 22 per cent of growers' total water requirement is 'security water';
- growers will not plant crops without water supply certainty;
- water availability was considered to be a key constraint on increased production;
- an increase in the volumes of water available would result in an increase in production from current cropping areas and an expansion of farm footprints;
- growers indicated that 'high security water' was required; and
- for growers that did not foresee growth in production, demand for additional volumes of water related to stability and the benefits from increased water security.

Unidel also conducted commercial modelling of seven farming enterprises in the region.[71] The consultation undertaken as part of this process found that there seemed to be less interest in expansion opportunities than for 'security water' however it was concluded this was likely directly related to the lack of water security.

The report concluded that whilst there was no single position to reflect the views and level of support for a water storage scheme from the growers consulted with, there was recognition of the potential benefits of increased water supply security. Water security was seen as more important than providing opportunities for an increase in production. Based on limited discussions with growers, delivered water costs of more than $2,000 per ML were considered uneconomic.

SKM (2007). Emu Swamp Dam Project – Planning Report.

This study reported that agricultural water was required to improve farming security, not to increase farming area. This conclusion was drawn based on the distribution of requested irrigation water volumes as set out in the table below.

Table A.1 Distribution of requested irrigation water volumes (from SKM report)

Requested volume (ML per annum)	Number of irrigators	Proportion of irrigators
300-100	2	4%
99-50	5	10%
49-20	25	51%
19-10	7	14%
9 and less	10	21%

[71] The crops produced by the seven farming enterprises were as follows: capsicums and tomatoes (three systems); celery and cabbage; salad vegetables; apples; and capsicums and broccoli.

Total	49	100%

Source: SKM (2007). Emu Swamp Dam Project – Planning Report.

The distribution presented in the above table indicated that 86 per cent of irrigators consulted with requested less than 50 ML per year. The report concluded that this indicated that water was required for higher security rather than to increase the cropped area. The report also noted that the irrigation allocation of 1,740 ML per year represented only an 8 per cent increase in total irrigation water use in the region (based on an estimate for existing entitlement mean annual irrigation diversions of 20,700 ML).

Orchard Services (2001). Potential Demand for Water in the Stanthorpe Shire.

This report was commissioned to investigate projected irrigation, urban and industrial water use in the Stanthorpe Shire over the next 5 to 10 years. Irrigation water demand was assessed based on a survey of 30 producers, which accounted for 11 per cent of total horticultural producers in the Stanthorpe Shire. Key findings from the survey responses were as follows:

- survey responses indicated that during every year of the past five years, at least 50 per cent of respondents claimed that crop production or quality levels were limited due to water availability;
- around 30 per cent of producers indicated that water security was a major concern regarding continuation and expansion of their production;
- only 30 per cent of producers indicated that they usually had enough water; and
- 26 of the 30 producers indicated they would expand production if they had access to additional volumes of water, with the intended expansion averaging 24.3 ha and totalling (across the 26 producers) 730 ha, with a total additional water requirement of 5,155 ML per annum.

Macro Agricultural Consultants (1996). The Granite Belt Water Supply Steering Committee's submission to the Water Infrastructure Task Force.

The purpose of this report was to assess the economic benefits derived from additional horticultural development in the Stanthorpe Shire as a result of the development of the Broadwater Dam.

The report found that the provision of an additional ML of irrigation water could increase production on existing apple orchards by 50 per cent in drought years; 20 per cent in normal years; and 10 per cent in wet years. This equates to an overall net effect of an additional 23 per cent of yield.

The report also found that additional horticulture from the proposed irrigation scheme would generate farm profiles ranging from $4,000 to $6,000 per ML of irrigation water. However, the report stated that apple producers' capacity to pay for additional volumes of irrigation water was limited by significant on-farm capital investment incurred in recent years due to the need for the Queensland apple industry to restructure and the cost of developing new orchards in order to use the additional irrigation water.

B List of documents reviewed

Table B.1 List of documents reviewed for agricultural and industrial demand assessment

Author	Year	Document title
Munro Johnson & Associates	1983	Preliminary Report on the Effects of Upstream Land Use on Storm King Dam
Queensland Water Resources Commission	1988	Report on Granite Belt Investigation
Tancred, S.J.	1996	An Assessment of the Economic Benefits Deriving from Additional Horticultural Development in the Stanthorpe Shire as a result of the Construction and Utilisation of the Broadwater Dam
Sinclair Knight Merz	1998	Proposed Dam near Ballandean on the Severn River
Orchard Services	2001	Horticultural Production and Water Use in the Stanthorpe Shire
Orchard Services	2001	Potential Demand for Water in the Stanthorpe Shire
Orchard Services	2002	Comparison of the water use efficiencies of Stanthorpe Shire's Horticultural Crops and Selected Field Crops
Sinclair Knight Merz	2006	Stanthorpe Shire Council Emu Swamp Dam Project – Initial Advice Statement
Stanthorpe Community Reference Panel	2006	Granite Belt Water Grid Proposal
Capital Strategies	2007	Stanthorpe Irrigation Water Project
Sinclair Knight Merz	2007	Stanthorpe Shire Council Emu Swamp Dam Project – Planning Report
Unidel	2011	Emu Swamp Dam Report
Orchard Services	2013	Report on Horticultural Production in the Proposed Footprint of the Emu Swamp Dam in Queensland's Southern Downs Region
T Sargeant Services Pty Ltd	2013	The Economic Impact of the Emu Swamp Dam
Coordinator-General, Department of State Development, Infrastructure and Planning	2014	Emu Swamp Dam Project: Coordinator-General's Evaluation Report on the Environmental Impact Statement
Jacobs	2016	Emu Swamp Dam – Business Case
Department of Energy and Water Supply	2016	Stanthorpe Regional Water Supply Security Assessment

Synergies ECONOMIC CONSULTING

C Survey template

Background

We are conducting an independent study to assess the Business Case for the Emu Swamp Dam as a water supply source and as growth-enabling infrastructure. As part of this assessment, we are seeking to understand the current demand of irrigation water and conduct an analysis of the benefits that additional irrigation water can potentially bring to farms in the area.

Why are we doing this?

Understanding the financial benefits and impacts of irrigation use is important to assessing the Business Case of the Emu Swamp Dam, as irrigated agriculture is the primary regional water use in the Southern Downs region, and is expected to be the largest source of demand for water from the Emu Swamp Dam.

We want your feedback

As our methodology is based on consultation with irrigators, we would appreciate if you could respond to this survey. With your help, we want to build an understanding of the reality of the current demand for irrigated water and the potential benefits this may have on your farm and region.

We want to hear from as many people as possible, from all different producers and cropping systems. This will assist us to ensure that our study is based on an accurate representation of the crops and farming systems that are likely to be supplied by the proposed dam.

1. Your details

Name

Email address

Phone number

Farm address

2. Farm details

Total farm area

Total irrigated area

Irrigated crops/produce grown on your farm

3. Are you interested in getting additional irrigation water?

- Yes
- No

4. Do you have information on the annual production costs for the crops you currently grow that you would be prepared to share or discuss with the study team? Any cost estimates provided will be aggregated and used for internal modelling purposes. No cost estimates provided would be provided to any external parties.

- Yes
- No

If yes, could you please contact Daniel Culpitt at d.culpitt@synergies.com.au.

5. What is the operating cost of applying irrigation? ($/ML) (e.g. electricity, repairs and maintenance of pumps, etc.)

[ ]

6. What irrigation crops/produce do you currently grow on your farm?

- [ ] Tomatoes and capsicums
- [ ] Strawberries
- [ ] Apples and other tree fruits
- [ ] Brassicas (cabbages, broccoli, broccolini, cauliflower)
- [ ] Wine Grapes
- [ ] Other (beans, sprouts, lettuce, cucumbers, etc.)

7. Could you indicate, for each irrigated crop you grow (up to a max. of 3 crops) your target water application rate (ML/ha).

Crop 1____________ ______ML/ha

Crop 2____________ ______ML/ha

Crop 3____________ ______ML/ha

8. What is your crop yield at the target water application rate (tonnes/hectare)?

Crop 1____________ ______t/ha

Crop 2____________ ______t/ha

Crop 3____________ ______t/ha

9. What is the impact on your crops from a 10% shortfall in water application rate, as a percentage of yield (%)?

Crop 1____________ ______%

Crop 2____________ ______%

Crop 3____________ ______%

10. What is the impact on your crops from a 20% shortfall in water application rate, as a percentage of yield (%)?

Crop 1____________ ______%

Crop 2____________ ______%

Crop 3____________ ______%

11. What is the impact on your crops from a 30% shortfall in water application rate, as a percentage of yield (%)?

Crop 1____________ ______%

Crop 2____________ ______%

Crop 3____________ ______%

12. Do you have access to irrigable land that is currently not being used for irrigated cropping?

(•) Yes

( ) No

13. If yes, please indicate how many hectares are available that are not currently being used.

____

____

14. If more water became available, how much additional water would you apply to grow your crops? (ML/ha)

Crop 1____________ ______ML/ha

Crop 2____________ ______ML/ha

Crop 3____________ ______ML/ha

15. What is an estimate of the cost of establishment and installation of irrigation infrastructure on your land ($/ha)?

$____________

Appendix E - Strategic review of Stanthorpe historical population and urban water demand forecasts

Appendix E.1 Introduction

The issue of urban water supply to Stanthorpe has been critical to all the previous planning, economic and approval documents relating to the construction of Emu Swamp Dam. There is a significant variation in both the necessity and timing of the need for a supplementary water supply for Stanthorpe within the historical documents reviewed. Expected population growth has been a critical dependency identified in previous studies. The purpose of this section of the report is to review issues regarding expected population growth in Stanthorpe and subsequent urban water demand.

Appendix E.2 Population growth

The discovery of tin and the subsequent tin rush led to a rapid rise in population in Stanthorpe. The population rose from 1500 in 1872 to 4000 in 1873. More recent population demographics in the time-period since 2006 are presented in the following table.

Table E-1 – Population of Stanthorpe by year (actual)

Year	Population	Annual Population Change
2006	4770	-
2007	4845	+75
2008	4888	+43
2009	4946	+58
2010	5002	+56
2011	5086	+84
2012	5125	+39
2013	5135	+10
2014	5186	+51
2015	5174	-12
2016	5159	-15

Source: Queensland Government Statisticians Office – Estimated resident population by urban centre and locality, Queensland 2006 – 2016.

Population growth has been relatively minor over the past ten years and exhibited a negative trend in last two years.

The 1997 Water Headworks Strategy Study for Stanthorpe developed by SKM presented the following population projections that are presented for comparative purposes.

Table E-2 – SKM (1997) Stanthorpe population projections

Year	Projected Population
1996	5,085
2005	5,845
2015	6,824
2025	7,996

Source: SKM (1997) Water Headworks Strategy Study for Stanthorpe and Wallangarra Final Report.

The projected population of 6,824 in 2015 was 32% greater the actual population figures. The initial advice statement regarding Emu Swamp Dam prepared by SKM in 2006 presented the following urban water supply projections.

Table E-3 – SKM (2006) Initial advice population projections

Year	Low Growth Scenario	Medium Growth Scenario	High Growth Scenario
2005	5,485	5,484	6,160
2010	5,692	5,956	6,727
2020	6,105	6,642	7,583
2030	6,521	7,455	8,566
2040	6,938	8,361	9,642
2050	7,359	9,390	10,841

Source: SKM (2006) Emu Swamp Dam Initial Advice Statement

The medium and high growth population scenarios were considered conservative (on the low side p.35) on the basis that they were constructed on a declining growth rate rather than the higher annual growth rate that was occurring at the time the report was delivered. The high population growth projection for 2010 was 34% higher than the actual population in that year (SKM 2006).

Projections of population growth by Queensland Government Statisticians Office for the Stanthorpe Statistical Area Level 2 (SA2) which takes in area slightly larger than the town boundaries indicates that of the 30 June 2016 the estimated resident population was 5,596 persons and that projected population of the area is expected to be 6,064 persons in 2036. This population estimate was based on an increase of 0.4% per year over 25 years (Queensland Treasury 2017).

Appendix E.3 Water demand in Stanthorpe

Population growth, average water use per person and the yield from the existing Storm King Dam have been central to the various business cases and planning documents assembled in relation to the urban water supply benefits of the proposed Emu Swamp Dam. The 1997 Water Headworks Strategy Study for Stanthorpe by SKM presented the following table of historical water consumption in Stanthorpe.

Table E-4 – Stanthorpe historical water consumption

Year	Annual Consumption (ML)	Average Day – AD (kL)	Population	AD (L/c/d)
Pre-metered				
1966	664	1820	3,641	500
1971	718	1970	3,602	547
1976	717	1960	3,927	500
Metered				
1981	556	1520	3,966	383
1986	797	2180	4,408	495
1988	695	1900	4,493	423
1992	705	1930	5,150	375

Source: SKM (1997) Water Headworks Strategy Study for Stanthorpe and Wallangarra Final Report.

According the report peak consumption occurred in 1979 when individual water use was estimated at 700 L/c/d. For planning purposes, an average of 500 litres per capita per day was adopted to predict future water demand in Stanthorpe which is presented in the following table.

Table E-5 – Future water demands for Stanthorpe

Year	Population	AD (L/c/d)	AD (kL)	Annual Demand (ML/a)
1996	5,085	500	2,543	929
2005	5,845	500	2,923	1,067
2015	6,824	500	3,412	1,246
2025	7,966	500	3,983	1,454

Source: SKM (1997) Water Headworks Strategy Study for Stanthorpe and Wallangarra Final Report.

Storm King Dam constructed in 1954 with a storage capacity of 2,180 ML has been the major source of water supply for Stanthorpe. The Southern Downs Regional Council holds a water licence with a volumetric extraction limit of 1,150 ML/a (DEWS 2016). The total average volume of water sourced from Storm King Dam to supply Stanthorpe over the 7 years from 2008-09 to 2014-15 averaged 590 ML/a (ranging from 530 ML/a to 696 ML/a) which is 47% of the 2015 demand predicted in the 1997 SKM study. Average per capita usage over the same period was 324 litres per capita (L/c/d) which is 65% of the average demand used in the 1997 study.

The reliability of Storm King Dam and water security for Stanthorpe has been raised in many of the planning and approval documents relating to Emu Swamp Dam. The small storage capacity of Storm King Dam means it is vulnerable to extended dry periods. The Queensland Coordinator General evaluation report of the Environmental Impact Statement for Emu Swamp Dam identified that that Stanthorpe’s projected water demand would exceed the existing Storm King Dam water allocation (reported at 700 ML per annum) by 2016 and continue to increase to 952 ML/a by 2056 (Queensland Coordinator General 2014).

Based on a 2010 DERM investigation the 2014 Coordinator General Report identified that the long-term supply baseline of Storm King Dam was 370 ML per annum at 98 percent reliability and that despite significant (ranging from Permanent (230 L/p/d target), to Extreme (140 L/p/d target)) water restrictions the storage had almost run dry on a number of occasions. The reduced yield of Storm King Dam was then used to predict the likely urban demand from Emu Swamp Dam and used as the basis of calculation of the benefit-cost ratio (BCR). It was concluded that there would be an urban demand of 365 ML/a of Emu Swamp Dam water in 2017. The forecast annual economic benefit was based on the cost saving that accrued to individual water users from not needing to install alternative water supply, in this case rainwater tanks. The cost of rainwater tanks was estimated at $8.31/kL compared to the expected consumption charges of $1.16/kL for water supplied from Emu Swamp Dam. The following table shows the forecast Emu Swamp Dam water consumption and economic benefits.

Table E-6 – Forecast of Emu Swamp Dam water supply consumption and economic benefits

Water consumption	2017	2022	2027	2035	2045
Forecast annual consumption of Emu Swamp Dam water (ML) based on Storm King Yield of 370 ML per annum	365	514	632	684	750
Economic benefit					
Forecast annual economic benefit ($000s) based on per kL cost saving of $7.15	2,608	3,676	4,515	4,891	5,360

Source: Queensland Coordinator General (2014) Emu Swamp Dam project: Coordinator General's evaluation report on the environmental impact statement.

The most recent water supply security assessment for Stanthorpe completed by the Department of Energy and Water Supply presents a divergent position on both the reliability of Storm King Dam and the demand for urban water in Stanthorpe. Key findings from the report are summarised in the dot points below:

- There has been no supply failure to date from Storm King Dam.
- At current water demand levels Storm King Dam can supply Stanthorpe's urban water demands for approximately 20 months.
- Urban water demand is expected to increase to 740 ML/a by 2036.
- Historic modelling (1890-2015) indicted that Storm King Dam would have been capable of meeting a demand of around 600 ML/a (approximately Stanthorpe's current demand) with or without water restrictions. However, the storage would have fallen to low levels on several occasions with only a few months of supply.
- Historic modelling also indicated that Storm King Dam would have been capable of meeting a demand of 740 ML/a without experiencing a shortfall with water restrictions in place. Without restrictions, the storage would have fallen below its minimum storage level on at least three occasions.
- As water demand increases in line with population, the occurrence of high level water will increase in frequency. At current levels of demand, high levels of water restriction are expected to occur approximately once every 10 years. At predicted 2036 levels of demand the frequency of restrictions increases to once every 6.4 years on average . (Department of Energy and Water Supply (2016) Stanthorpe Regional Water Supply Security Assessment)

Appendix E.4 Water restrictions and annual daily usage

Water restrictions are central to the security of supply to Stanthorpe. The following table shows the level of water restrictions imposed at various dam levels.

Table E-7 – Stanthorpe's water restriction levels

Restriction level	Supply trigger levels (% of full supply volume)	Targeted maximum daily residential consumption (L/p/d)
Permanent	75% and above	230
Medium	70% (or below) Relaxed when volume increases to 75%	200
High	50% (or below) Relaxed when volume increases to 55%	170
Extreme	30%(or below) Relaxed when volume increases to 35%	140

Source: Department of Energy and Water Supply (2016) Stanthorpe Regional Water Supply Security Assessment.

Further details of water restriction measures showing permitted and restricted activities are provided on SDRC's web site: http://www.sdrc.qld.gov.au/living-here/water---wastewater/water-restrictions (20170530)

According to DEWS (2016) average water demand per capita was 324 litres per day (L/c/d – includes residential, commercial, municipal and industrial water supplied from the reticulation network, plus any system losses).

The average residential water use over the period 2008-09 to 2014-15 was approximately 213 litres per person per day (L/p/d) (DEWS 2016). The 213 L/p/d is relatively high in comparison to South East Queensland. The following table shows the residential water consumption in various zones in South East Queensland in November 2015.

Table E-8 – Residential water consumption (L/p/d November 2015)

Zone	SEQ	Central SEQ	Gold Coast	Redlands	Scenic Rim	Stanthorpe
Average daily residential consumption (l/p/d)	159	152	183	163	105	213

Source: Seqwater (2016) Water security and consumption update, Seqwater, Ipswich.

Guidelines on the Council website outline allowable activities under each level of restriction and provide a series of fact sheets on water savings. Given the differential between average individual daily water use in Stanthorpe with permanent water restrictions and other comparable areas within South East Queensland with no water restrictions there may be some scope to reduce further individual consumption to maintain storage levels in Storm King Dam and extend supply.

Appendix E.5 Patterns of population growth

Anecdotal information from the region indicates that population changes in Stanthorpe are driven by ageing rural residents moving closer to town for additional services and younger people shifting out of the region to seek greater opportunities. There is some evidence to support this. The latest data from the Queensland Government Statisticians Office (2017) shows that Stanthorpe has a higher number of people in the 65+ age bracket than the rest of Queensland (26.7% Stanthorpe vs 14.4% Queensland). And, a smaller number in the 15-24 age bracket (8.8% Stanthorpe vs 13.6% Queensland). The average age of the population is 44.4 years compared to the average for Queensland of 36.9 years.

According the Southern Downs Planning Scheme (2012) residential development within the town boundaries is dominated by single dwellings on lots ranging from 600 to 1,000 m^2. Occupancy rates per household are expected to decrease significantly as indicated in the following table from the planning scheme.

Table E-9 – Average residential occupancy rates

Category	Occupancy Rates			
	2006	2011	2016	2021
Dwelling House	2.09	2.02	1.95	1.88
Multiple-dwelling including dual occupancy	1.29	1.25	1.21	1.16
Other	1.48	1.43	1.38	1.33

Source: Southern Downs Regional Council (2012) Planning Scheme

The Planning Scheme indicates that there are significant barriers to urban expansion in Stanthorpe. The northeast area of the town provides the only area for residential expansion as the bypass limits development north, west and south and existing rural residential development constrains development to the east (SDRC 2012). The existing planning scheme seeks to protect current rural residential areas from subdivision. The planning scheme establishes small areas of rural residential land that may be connected to existing water services.

According to DEWS (2016) a proportion of population growth is occurring in areas outside the reticulation network on blocks that can provide independent water services. Rates of population growth in the neighbouring rural area surrounding Stanthorpe are estimated at 1.2% annually over the past ten years compared to 0.7% for the Stanthorpe urban area (Queensland Treasury 2017).

There is a significant supply of lots potentially available for rural residential development. There is a very high degree of historic rural land fragmentation across SDRC’s area. According to the Southern Downs Non-Urban Land Study completed by Buckley Vann in 2009, 63% of rural lots (7,000 lots) are less than 20 hectares in size, with 34% (some 3,800 lots) being less than 5 hectares. Most small rural lots occur close to the major urban centres of Stanthorpe and Warwick.

Appendix E.6 Conclusions

- Population growth in urban areas of Stanthorpe has been limited over the past ten years. Population growth has been slightly negative over the past two years.

- Projections of population growth in Stanthorpe undertaken in previous planning and business cases have been overly optimistic in comparison to the actual growth that has occurred.
- Rates of population growth used in previous planning studies (1.5%) have been far greater than actual population growth (0.4%).
- Rates of per capita water usage used to determine future demand (500 L/c/d) are far greater than recent historical averages (324 L/c/d).
- Overall water demand for Stanthorpe has been far less than predicted in previous studies (1,246 ML/a predicted for 2015 versus 590 ML/a actual).
- There are significant variations in the planning and business case documents regarding the reliable long term supply baseline of the existing Storm King Dam (370 ML per annum at 98% reliability versus historical 600 ML/a at 100% reliability).
- The lower bounds of Storm King Dam's water yield reliability have been used in Emu Swamp Dam urban demand projections and associated economic benefit assessments.
- Storm King Dam is a small storage highly reliant on seasonal in-flows and an extended drought may see it drop below operational supply levels.
- Water restrictions are central to meeting supply objectives over the longer term.
- As population increases, the occurrence of water restrictions will also increase.
- Current per person daily usage is higher in Stanthorpe than in other comparable areas in South east Queensland.
- The population in Stanthorpe is ageing and the density of residents per household is decreasing with implications for water supply services.
- Rural residential development is expected to increase due to the high level of land fragmentation and will not be reliant on the urban supply network.

Appendix E.7 Recommendation

It is recommended that a Preliminary Business Case be undertaken that incorporates and examines options for future water supply security in the Stanthorpe urban area. The Preliminary Business Case should:

- Examine in detail options including water restrictions and other water consumption reduction options, infrastructure solutions not including Emu Swamp Dam) and Emu Swamp Dam. The assessment should be based on revised lower bound population projections, revised lower bound individual water usage assessment, revised lower bound economic benefits and emerging patterns of household density and rural residential settlement.

Appendix F - Urban Water Conservation Measures in Relation to the Emu Swamp Dam Project

Appendix F.1 Introduction

This report examines the current approach to minimising water use in the urban area of Stanthorpe and the potential role of water efficiency measures in meeting future demand requirements. The approach is consistent with the principles of least cost planning (LCP) which seeks to determine the most cost effective means of providing water services or alternatively the cheapest forms of water conservation (White and Fane 2007). It contrasts to other approaches identified across the range of planning studies reviewed in relation to Emu Swamp Dam that have focussed mainly on increasing supply to Stanthorpe. Consideration of water efficiency measures is consistent with the Queensland Government Infrastructure Plan and the Building Queensland Guidelines that state a preference for better use of existing resources through demand management rather than constructing new infrastructure.

Appendix F.2 Water restrictions

Water restrictions are recognised as a key component of managing demand in the Stanthorpe urban supply area. The vulnerability of the township to decreasing supply levels is recognised in the range of restrictions that are presented in the following table.

Table F-1 – Stanthorpe's water restriction levels

Restriction level	Supply trigger levels (% of full supply volume)	Targeted maximum daily residential consumption (L/p/day)	Summary of Restricted Activities
Permanent	75% and above	230	Outdoor water use on 3 allocated days except between 10 am and 4 pm. No other restrictions
Medium	70% (or below) Relaxed when volume increases to 75%	200	Restrictions on hours of outdoor water on allocated days (morning and evening only) Topping up of existing pools only Minimal cleaning of paved areas.
High	50% (or below) Relaxed when volume increases to 55%	170	Restrictions on hours of outdoor water on allocated days (evening only). Outdoor sprinkler and irrigation systems not allowed No hose washing of vehicles. No topping up of pools Minimal cleaning of paved areas. No cleaning of buildings

Extreme	30%(or below) Relaxed when volume increases to 35%	140	Further restrictions on hours of outdoor water on allocated days (evening only). No hand-held hosing of gardens and lawns. Outdoor sprinkler and irrigation systems not allowed No hose washing of vehicles. No topping up of pools Minimal cleaning of paved areas. No cleaning of buildings

Source: Southern Downs Regional Council (2017) Water Restrictions

Restrictions have historically been successful in reducing per person per day water use. The following table shows water consumption from Storm King Dam in the years 2003 to 2008 with restrictions equivalent to high or extreme in place.

Table F-2 – Water production from Storm King Dam 2003-2008

Year	Water Production	Residential Water Demand
2003	538.6 ML	163 L/person/day
2004	639.1 ML	204 L/person/day
2005	564.2 ML	170 L/person/day
2006	524.5 ML	151 L/person/day
2007	445.8 ML	137 L/person/day
2008	503.0 ML	150 L/person/day

Source: MWH (2010) South West Queensland Water Demand Analysis

Apart from 2007 average per person per water use was still greater than that in South East Queensland which averaged less than 140 per person per day for the same period.

Appendix F.3 Water restrictions and water efficiency

The focus of the approach in relation to water supply has been on water restrictions backed by enforcement measures rather than a voluntary program of water efficiency that have had success in other parts of Queensland and Australia. Managing water demand is central to water efficiency. According to the Queensland Water Directorate (2017) a permanent reduction in water demand is identical to an increase in supply.

Reducing demand can correspondingly reduce the capital and operational costs of providing water to a community. This will potentially result in lower long-term water costs for consumers. Lower water use is correlated with lower energy use and other environmental benefits such as reduced greenhouse gas emissions and reduced extraction from aquifers and rivers leading to improved river health.

Demand management is defined as the proactive management of end use water consumption. Critically it can contribute to the following outcomes:

- Delaying the need for new bulk water supply infrastructure.

- Reducing peak demand therefore delaying operational and infrastructure investment costs.
- Extending the period before drought response triggers are reached.
- Reducing water business operational costs and pump maintenance.
- Providing customers with greater understanding of their water use and the ability to make informed choices about how they use water.

Appendix F.4 Current water use in Stanthorpe

Permanent restriction levels are based on 230 litres per person per day. The actual average residential water use over the period 2008-09 to 2014-15 in Stanthorpe was approximately 213 litres per person per day (L/p/d) (DEWS 2016). The 213 L/p/d is relatively high in comparison to South East Queensland. In 2015 the average use per person per day in South East Queensland was 159 litres per person per day (Seqwater 2016). Melbourne Water reports that the average per person per day water use over 2016 was 166 litres (Melbourne Water 2016). In the United Kingdom average water consumption is 150 litres per person per day (Fidar et al 2016).

Appendix F.5 Water efficiency and demand management measures

Demand management measures can be categorised into the following categories outlined in the table below:

Table F-3 – Demand management measure categorisation

Category	Description	Example
Increase system efficiency	No change to resource usage by consumers but less system losses.	Leakage detection and repair, change in system operation such as pressure reduction, installing peak balancing capacity.
Increase end use efficiency	Less resource used by the consumer to provide the same service.	Regulating water efficiency in new buildings, financial incentives for water efficient purchase and retrofit efficient equipment.
Promoting distributed sources of supply	Provide services via a locally sourced resource not currently being used.	Household rainwater tanks and greywater reuse systems.
Substitute resource use	Provide same service without use of the resource in question	Planting indigenous plants adapted to local rainfall
Improve the market in resource usage	Inform the consumer about the full costs of their resource use.	Full cost recovery, greater feedback on consumer usage and costs, smart metering, education campaigns, water use audits.

Source: Adapted from White and Fane (2007) Designing Cost Effective Water Demand Management Programs in Australia, Water Science and Technology*, Vol 46, no 6-7.*

The effectiveness of demand reduction strategies was evidenced in South East Queensland during the millennium drought. A study by the Urban Water Security Research Alliance examining residential end use in South East Queensland identified that showering (29%) tap (19%) and clothes washing (21%) comprised the bulk of water consumption. The study identified that in South East replacing low efficiency showerheads with high efficiency reduced usage by 20% and that from loading washing machines used 7% less water than front loaders (UWSRA 2010).

The cost effectiveness of various demand reduction strategies available for implementation within South West Queensland, including Stanthorpe was investigated by MWH in 2010 and selected measure are identified in the following table:

Table F-4 – Cost effectiveness of individual demand management opportunities

Demand Management Opportunity	Total Community Annualised Cost ($ per kL saved)
Residential Education Program	$0.07 to $0.44 per kL
Non-residential education	$2.45 to $13.16 per kL
Permanent Conservation Measures	$0.03 to $0.67 per kL
Rebate – Pool covers	$33.46 to $37.29 per kL
Rebate – Washing Machine	$23.41 to $25.86 per kL
Rebate – Shower Head	$0.47 to 0.54 per kL
Rebate – Dual Flush toilet	$8.70 to $9.89 per kL
Rebate – Internally Plumbed Rain Water Tank	$8.38 to $9.13 per kL
System Water Loss Management	$0.54 to $1.71 per kL
Residential Retrofit Program	$1.58 to $5.73 per kL
Tourist Based Education	$0.79 to $2.14 per kL
Water Efficiency Management Plans	$1.54 to $4.04 per kL
Home Leakage Programs	$11.05 to $20.92 per kL
Installation of Smart Meters	$3.13 to $7.47 per kL

Source: MWH (2010) South West Queensland Water Demand Analysis

The same MWH study identified the effectiveness of demand measures based on their individual economic performance for each individual region including Stanthorpe. Selection of only measures with a total annualised cost equivalent to or less than anticipated marginal supply cost of water (2.00 per kL) was modelled to result in a 9% decrease in water demand per person per day from the baseline.

In broad terms a 9% reduction in average per person water usage in Stanthorpe (213 L/p/d) translates to a 19.2 litres per person per day saving or a change to 193.8 per person per day usage (L/p/d). Across the current population of 5,159 this translates to a potential reduction in water usage of 35.2 ML per year or the equivalent supply demand for an additional 524 residents (based on average daily use of 193.8 L/p/d).

Appendix F.6 Conclusion

Permanent water restrictions have been effective in reducing overall demand in Stanthorpe. The historical success of more restrictive restrictions (up to Extreme – 140 L/p/d target) in reducing per person per day water use indicates a significant elasticity in demand. There appears to be potential to implement cost effective measures to reduce further water demand and consideration should be given to this ‘better use’ approach as part of an options analysis. Demand reduction in this instance can potentially delay the need new infrastructure and the triggering of drought restrictions. Further Stanthorpe specific investigation may identify additional demand reduction measures or supply substitution options.

Central to an understanding of the potential benefits to be gained from implementing water efficiency measures and the type of measures that would be most effective within Stanthorpe is a detailed investigation of end usage. This would provide a basis for estimating the cost effectiveness of the option in comparison to other solutions.

Appendix F.7 Recommendation

It is recommended that water efficiency and demand reduction measures be considered as an option for strategic consideration. If the project is to proceed to the Preliminary Business Case Stage then detailed investigations of current end use pattern, range of demand management measures, cost effectiveness, social acceptability and funding models should be explored.

Appendix G – Options filter

Water supply options identified in earlier work were filtered to identify the candidate projects that will be subject to more detailed feasibility assessment to advance the development of a Preliminary and Detailed Business Case.

It is important to note that the candidate projects are of a concept to pre-feasibility nature only and have been examined with the supported data from previous assessments (including SKM 1997, SKM 2005, SKM 2007, SKM 2008 and SDRC 2010). The historical data supporting each option also varies significantly from different source documents. This is often the result of assumptions made at the time (which may have changed since the original assessment was undertaken).

Four criteria were identified that could be used to reflect the ability of an option to achieve the key project objectives. These were:

1. Project Data
   - Yield:
     - Historical No Failure Yield (HNFY*)
     - Mean Annual Diversion (MAD) – the average volume of water that is available from the river catchment over the analysis period.
   - Data availability to inform comparison of options:
     - Investigation works – survey, geotechnical studies
     - Infrastructure design – pipeline routes, pump stations, indicative costs
     - Accuracy of hydrologic modelling (IQQM)
2. Project Viability
   - Ability to meet the urban water demand by 2050, 844 ML/a are required. Assuming that Storm King Dam can provide a safe yield of 600 ML/a, the minimum required additional safe yield is 250 ML for each option.
   - Capacity to support the expansion of high value irrigation production and industries.
3. Project Costs
   - Costs have been recalculated for all options to updated dollars, where cost data is available, this makes cost comparable between options:
     - Estimate CAPEX to 2017
     - Estimate cost per ML/a of yield
4. Project Risks
   - Environmental and planning approvals status and requirements
   - Social and land acquisition impacts

The results of the options filter are presented below. A summary of outcomes was presented in the table below.

Option	Option Details	Data Availability	Environmental Considerations	Project Viability	Shortlisted
Storm King Dam (urban only)	**Yield:** 652 ML **HNFY* Yield:** 620 ML/a urban, additional yield (SKM 2005a) **MAD**: 1,330 ML/a at 88% (EIS) **Capacity:** 2,180 ML currently; raising walls would create 7,300 ML capacity (SKM 2005a). **CAPEX**: $13.0	Preliminary layout and costing available (SKM 2005) Reported to meet water needs in the short term (to 2030) only (SKM 2005a) All of these yield estimates are based on the assumption that no releases will need to be made from the dam. If releases are required from the raised dam for environmental and compensation purposes, its yield would be significantly reduced (SKM 2005a)	The EIS (SKM 2008a) reports that any change to Storm King Dam would trigger the need to provide for environmental flows, substantially reducing the indicated yields. Approval is unlikely to require an EIS – no significant environmental issues have been reported, but further assessment is necessary.	Sufficient water to meet Stanthorpe urban demand to 2050. For costing purposes, it has been assumed that the existing pipeline is in serviceable condition for the foreseeable future and does not need to be replaced (SKM 2005a). Project cost is viable – though an expensive option per ML	✓ YES
Storm King Dam (Off Stream Storage)	**MAD:** 350 ML/a (94% monthly reliability) **CAPEX**: $18.3	No data available	Limited comparable environmental, social or cultural data with which to compare option.	Down stream of Storm King Dam hence yield projection and reliability questioned	× **NO**
Emu Swamp Dam (urban and irrigation)	**TWS** (SKM 2008a) **MAD**: 696 ML **Capacity**: 5,000 ML **Dam CAPEX**: $56.7 **TWS & Irrigation** (SKM 2014) **MAD:** 742 ML + 1,676 ML **Capacity:** 10,500 ML **CAPEX:** $104.2	Preliminary lay out and costing available	Environmental approval achieved (EIS) (SKM 2008a), subject to conditions including additional studies and investigations, land acquisition, environmental offsets, etc. Second tier (State development) approvals required.	Sufficient water to meet Stanthorpe urban demand to 2050. Cost/ML viable.	✓ YES

Ballandean Dam	**Yield:** 6,370 ML/a (SKM 2005) **MAD:** 1,373 at 90% monthly reliability, based on storage of 8,000 ML (SKM 2008a) **Capacity:** up to 20,000 ML **CAPEX:** $27.9	Preliminary layout and costing available SKM 2005 No data regarding the irrigation pipelines.	No material environmental investigations undertaken. A minimum of 12 months is likely required to undertake environmental investigations to support the development of an EIS and/or other approvals.	Sufficient water to meet Stanthorpe urban demand to 2050 Cost/ML viable.	✓ YES
Connolly Dam Pipeline (urban)	**MAD:** 1,700 ML/a @ 100% (SDRC fact sheet) **CAPEX:** $2.5 million	Exact locations for the pipeline and balancing storage have not been determined in previous report. Pipeline would be longer than 32 km	No environmental assessments available for review. Assuming avoidance through route selection, construction methodology and narrow footprint of impact associated with pipeline – environmental issues unlikely to be significant.	It has the potential to provide a total yield of 2,650 per annum at 98% monthly reliability with SDRC's water restriction regime in place. EIS Chapter 2 (SKM 2008) and SKM 2007 both report the dam is fully committed and cannot currently supply all of Warwick's water supply needs. Option not referenced in the SKM 2005 (#20) options review. Project costs are excessive in relation to pumping requirements.	✓ YES
Leslie Dam	**Yield:** 750 ML	More data required.	No environmental assessments available for review.	Considered to have very little likelihood of securing adequate water supplies. This would also be highly expensive.	POSSIBLY
Demand management water saving measures	Typically generates a 10% reduction in residential water consumption	A specific assessment of Stanthorpe's existing water system would need to be undertaken	Current elements of the demand management are: rain water tanks, water efficient plumbing,	Cost effective and easy to implement – there is potential to reduce Stanthorpe's water consumption.	✓ YES

			leakage management and water pricing.		
Individual on-farm storage, including recycled water beneficial reuse	Current is based on 300-400 ML/a	A specific assessment of irrigators' ability to pay and demand for this option required.	No land access or acquisition requirements.	Cost effective option that could satisfy irrigation demand. Reliability of water supply is a potential issue.	✓ YES
Petries Crossing (urban)	**HNFY:** 230 ML/a (SKM 1997) **MAD:** 300 ML/a at 98% 147 ML/a at 65% (EIS,SKM 2008a) **Capacity:** 370 ML **CAPEX:** $19.8	Preliminary layout and costing available SKM 2005	No material assessment of environmental values outside of RE (16.5 ha of Endangered RE13.3.1 inundated). Potential impact of overflows from Stanthorpe sewage treatment plant and stormwater runoff from Stanthorpe.	Yield insufficient, cannot yield the minimum 250 ML and with no potential to provide supply for irrigation. This option is also very expensive, with high capital cost per ML yield	× **NO**
Quart Pot Creek Dam (*Kyoomba*) (urban and irrigation)	**Yield:** 2,200 ML/a for 20,450 ML capacity – as previously reported between 1980 and 1997 (SKM 2005a) **MAD:** 611 ML/a at 38% monthly reliability for a 40,000 ML storage) SKM 2007b) **HNFY** at 6,500 ML capacity at FSL of 1,500 ML/a based on water balance undertaken by SKM (1997)(SKM 2005a) **MAD:** MAD 298 ML/a at 58% monthly reliability for a 6,500 ML storage (SKM 2007b) **Capacity:** up to 20,450 ML from previous investigations	Preliminary layout and costing available SKM 2005	No material environmental investigations, assessment or reporting undertaken or documented within data reviewed for this Stage 1 scope. Issues may include: low reliability, relocation of the existing trunk main from Storm King Dam, impacts on houses, infrastructure and land within the inundation area, and potentially significant flood related impacts.	Could meet Stanthorpe's water supply needs until 2050 with potential to provide supply for irrigation Not viable as very expensive.	× **NO**

	between 1980 and 1997 (SKM 2005a) **CAPEX:** $51.5				
The Broadwater	Yield: "Very limited as original SKM 1996 yield doesn't take account of all on-farm storages. Later reports state yield is very small. CAPEX: $26.7	Site not considered feasible due to large numbers of small on-farm dams having been built in its catchment since the site was originally proposed	Not considered in reports due to limited and uncertain yield – no environmental assessments available for review.	Potential yield is very limited. This would be very expensive in terms of both capital and annual cost.	× **NO**
Kia Ora	Capacity considered to be in range of 20,000 to 30,000 ML Yield: ND CAPEX: $26.7	There is no available information for the option. The dam needs to have higher wall.	Dismissed as site in NSW and community and political opposition to cross border water transfer is considered likely. There is no available flora and fauna information but the site includes riparian vegetation that is likely to be ecologically important. There is no cultural heritage or native title information for the site.	Kia Ora dam site is unlikely to provide the required water supplies for Stanthorpe and that it should not be pursued further (SKM 2007)	× **NO**
Severn River Off Stream Storage at Booth and Somme Lane	**TWS 100% reliability** **Yield**: 748 ML/a each **Capacity**: 5,400 ML each **CAPEX**: $78.66 (Booth Lane), $83.10 (Somme Lane)	No survey or geotechnical data available	Limited comparable environmental, social or cultural data with which to compare option.	Costs assumed to be similar to ESD, plus on-going maintenance costs	× **NO**

	TWS & Irrigation **Yield:** 708 ML (urban) + 1,331 ML (irrigation) each **Capacity:** 4,300 ML each **CAPEX:** $74.32 (Booth Lane), $83.10 (Somme Lane)				
Bookookoorara Dam	No data available	No data - Only preliminary discussions held between Councils across state boarder and no analysis undertaken	No environmental, social or cultural data available. No environmental, social or cultural data with which to compare option. Reaching agreement on cross state boundary water transfer historically problematic	No certainty around water storage i.e. it is not clear whether during a drought all dams will be affected and hence no option to transfer from a 'full' dam to a dam with low levels. Will result in significant pumping costs given terrain	× NO
Lane Weir with pump to Emu Swamp Dam off-stream storage facility	No data available	No data available	No environmental, social or cultural data available.	-	× NO

* based on 2015 SKM report where available, yields for other options may not be HNFY

Appendix H MCA options assessment

The outcomes from the MCA Options Assessment Workshop are detailed in Tables H.1 and H.2. The Measurement Weight multiplies the weightings applied to the criteria and sub-criteria respectively. The Weighted Score multiplies the Measurement Weight by the score (from 1-5) assigned to each sub-criteria by subject matter specialists.

Table H-1 Urban options

Option A1	Criteria	Sub-Criteria	Measurement Weighting	Weighted Score
Raise Storm King Dam (Urban only)	Economic	Capital Cost $(2017)	12.0%	0.24
		Capital Cost $(2017)/ML yield/year	8.0%	0.08
		Levelised costs $(2017)/ML yield	16.0%	0.32
		Enabling industry (excluding irrigation growth)	4.0%	0.16
	Environmental	Impact on water quality	3.0%	0.15
		Impact on environmental flows	4.5%	0.23
		Inundation impact score	3.0%	0.12
		Land use impact	4.5%	0.18
	Social	Reliability of supply to 2050	13.5%	0.54
		Future proofing (supplies beyond 2050)	9.0%	0.18
		Likelihood of community support	4.5%	0.14
		Cultural heritage impact	3.0%	0.12
	Project Deliverability	Likely implementation speed	4.5%	0.14
		Complexity of project delivery	4.5%	0.14
		Risk of project delivery	6.0%	0.18
Option B1	**Criteria**	**Sub-Criteria**	**Measurement Weighting**	**Weighted Score**
	Economic	Capital Cost $(2017)	12.0%	0.12

Emu Swamp Dam (small) (Urban only)		Capital Cost $(2017)/ML yield/year	8.0%	0.08
		Levelised costs $(2017)/ML yield	16.0%	0.16
		Enabling industry (excluding irrigation growth)	4.0%	0.20
	Environmental	Impact on water quality	3.0%	0.15
		Impact on environmental flows	4.5%	0.18
		Inundation impact score	3.0%	0.12
		Land use impact	4.5%	0.12
	Social	Reliability of supply to 2050	13.5%	0.68
		Future proofing (supplies beyond 2050)	9.0%	0.36
		Likelihood of community support	4.5%	0.09
		Cultural heritage impact	3.0%	0.09
	Project Deliverability	Likely implementation speed	4.5%	0.14
		Complexity of project delivery	4.5%	0.14
		Risk of project delivery	6.0%	0.18
Option C1	**Criteria**	**Sub-Criteria**	**Measurement Weighting**	**Weighted Score**
Ballandean Dam (small) (Urban only)	Economic	Capital Cost $(2017)	12.0%	0.12
		Capital Cost $(2017)/ML yield/year	8.0%	0.24
		Levelised costs $(2017)/ML yield	16.0%	0.16
		Enabling industry (excluding irrigation growth)	4.0%	0.20
	Environmental	Impact on water quality	3.0%	0.15

		Impact on environmental flows	4.5%	0.18
		Inundation impact score	3.0%	0.12
		Land use impact	4.5%	0.14
	Social	Reliability of supply to 2050	13.5%	0.68
		Future proofing (supplies beyond 2050)	9.0%	0.36
		Likelihood of community support	4.5%	0.09
		Cultural heritage impact	3.0%	0.09
	Project Deliverability	Likely implementation speed	4.5%	0.05
		Complexity of project delivery	4.5%	0.14
		Risk of project delivery	6.0%	0.18
Option D1	**Criteria**	**Sub-Criteria**	**Measurement Weighting**	**Weighted Score**
Connolly Dam Pipeline (Urban only)	Economic	Capital Cost $(2017)	12.0%	0.54
		Capital Cost $(2017)/ML yield/year	8.0%	0.32
		Levelised costs $(2017)/ML yield	16.0%	0.64
		Enabling industry (excluding irrigation growth)	4.0%	0.12
	Environmental	Impact on water quality	3.0%	0.15
		Impact on environmental flows	4.5%	0.23
		Inundation impact score	3.0%	0.15
		Land use impact	4.5%	0.23
	Social	Reliability of supply to 2050	13.5%	0.14
		Future proofing (supplies beyond 2050)	9.0%	0.09

		Likelihood of community support	4.5%	0.14
		Cultural heritage impact	3.0%	0.12
	Project Deliverability	Likely implementation speed	4.5%	0.18
		Complexity of project delivery	4.5%	0.14
		Risk of project delivery	6.0%	0.18
Option E1	**Criteria**	**Sub-Criteria**	**Measurement Weighting**	**Weighted Score**
IWSM (Urban only)	Economic	Capital Cost $(2017)	12.0%	0.36
		Capital Cost $(2017)/ML yield/year	8.0%	0.40
		Levelised costs $(2017)/ML yield	16.0%	0.80
		Enabling industry (excluding irrigation growth)	4.0%	0.04
	Environmental	Impact on water quality	3.0%	0.15
		Impact on environmental flows	4.5%	0.23
		Inundation impact score	3.0%	0.15
		Land use impact	4.5%	0.23
	Social	Reliability of supply to 2050	13.5%	0.14
		Future proofing (supplies beyond 2050)	9.0%	0.09
		Likelihood of community support	4.5%	0.09
		Cultural heritage impact	3.0%	0.15
	Project Deliverability	Likely implementation speed	4.5%	0.18
		Complexity of project delivery	4.5%	0.18
		Risk of project delivery	6.0%	0.24

Option F1	Criteria	Sub-Criteria	Measurement Weighting	Weighted Score
Leslie Dam Pipeline (Urban only)	Economic	As this option was dismissed early in the MCA process, detailed cost estimates are not provided.		
	Environmental	Impact on water quality	3.0%	0.20
		Impact on environmental flows	4.5%	0.30
		Inundation impact score	3.0%	0.20
		Land use impact	4.5%	0.30
	Social	Reliability of supply to 2050	13.5%	0.08
		Future proofing (supplies beyond 2050)	9.0%	0.06
		Likelihood of community support	4.5%	0.09
		Cultural heritage impact	3.0%	0.12
	Project Deliverability	Likely implementation speed	4.5%	0.24
		Complexity of project delivery	4.5%	0.23
		Risk of project delivery	6.0%	0.16

Table H-2 Urban and irrigation options

Option A2	Criteria	Sub-Criteria	Measurement Weighting	Weighted Score
Raise Storm King Dam (Urban + On-farm Storage)	Economic	Capital Cost $(2017)	12.0%	0.36
		Capital Cost $(2017)/ML yield/year	8.0%	0.24
		Levelised costs $(2017)/ML yield	16.0%	0.32
		Enabling industry (excluding irrigation growth)	4.0%	0.12
	Environmental	Impact on water quality	3.0%	0.15
		Impact on environmental flows	4.5%	0.23
		Inundation impact score	3.0%	0.12
		Land use impact	4.5%	0.18
	Social	Reliability of supply to 2050	13.5%	0.41
		Future proofing (supplies beyond 2050)	9.0%	0.18
		Likelihood of community support	4.5%	0.18
		Cultural heritage impact	3.0%	0.12
	Project Deliverability	Likely implementation speed	4.5%	0.14
		Complexity of project delivery	4.5%	0.14
		Risk of project delivery	6.0%	0.15

Option B2	Criteria	Sub-Criteria	Measurement Weighting	Weighted Score
Emu Swamp Dam (small) (Urban + On-farm Storage)	Economic	Capital Cost $(2017)	12.0%	0.18
		Capital Cost $(2017)/ML yield/year	8.0%	0.19
		Levelised costs $(2017)/ML yield	16.0%	0.16
		Enabling industry (excluding irrigation growth)	4.0%	0.16
	Environmental	Impact on water quality	3.0%	0.12
		Impact on environmental flows	4.5%	0.23
		Inundation impact score	3.0%	0.08
		Land use impact	4.5%	0.12
	Social	Reliability of supply to 2050	13.5%	0.54
		Future proofing (supplies beyond 2050)	9.0%	0.36
		Likelihood of community support	4.5%	0.16
		Cultural heritage impact	3.0%	0.08
	Project Deliverability	Likely implementation speed	4.5%	0.14
		Complexity of project delivery	4.5%	0.11
		Risk of project delivery	6.0%	0.18
Option B3	**Criteria**	**Sub-Criteria**	**Measurement Weighting**	**Weighted Score**
Emu Swamp Dam (large (Urban+ Irrigation)	Economic	Capital Cost $(2017)	12.0%	0.12
		Capital Cost $(2017)/ML yield/year	8.0%	0.08
		Levelised costs $(2017)/ML yield	16.0%	0.22
		Enabling industry (excluding irrigation growth)	4.0%	0.2
	Environmental	Impact on water quality	3.0%	0.12
		Impact on environmental flows	4.5%	0.18
		Inundation impact score	3.0%	0.06
		Land use impact	4.5%	0.14
	Social	Reliability of supply to 2050	13.5%	0.68
		Future proofing (supplies beyond 2050)	9.0%	0.45
		Likelihood of community support	4.5%	0.18
		Cultural heritage impact	3.0%	0.06
	Project Deliverability	Likely implementation speed	4.5%	0.14
		Complexity of project delivery	4.5%	0.14
		Risk of project delivery	6.0%	0.12

Option C2	Criteria	Sub-Criteria	Measurement Weighting	Weighted Score
Ballandean Dam (large) (Urban + Irrigation)	Economic	Capital Cost $(2017)	12.0%	0.14
		Capital Cost $(2017)/ML yield/year	8.0%	0.11
		Levelised costs $(2017)/ML yield	16.0%	0.26
		Enabling industry (excluding irrigation growth)	4.0%	0.20
	Environmental	Impact on water quality	3.0%	0.12
		Impact on environmental flows	4.5%	0.23
		Inundation impact score	3.0%	0.08
		Land use impact	4.5%	0.14
	Social	Reliability of supply to 2050	13.5%	0.68
		Future proofing (supplies beyond 2050)	9.0%	0.45
		Likelihood of community support	4.5%	0.14
		Cultural heritage impact	3.0%	0.06
	Project Deliverability	Likely implementation speed	4.5%	0.05
		Complexity of project delivery	4.5%	0.14
		Risk of project delivery	6.0%	0.12
Option D2	**Criteria**	**Sub-Criteria**	**Measurement Weighting**	**Weighted Score**
Connolly Dam Pipeline (Urban + On-farm Storage)	Economic	Capital Cost $(2017)	12.0%	0.48
		Capital Cost $(2017)/ML yield/year	8.0%	0.32
		Levelised costs $(2017)/ML yield	16.0%	0.64
		Enabling industry (excluding irrigation growth)	4.0%	0.08
	Environmental	Impact on water quality	3.0%	0.15
		Impact on environmental flows	4.5%	0.23
		Inundation impact score	3.0%	0.15
		Land use impact	4.5%	0.23
	Social	Reliability of supply to 2050	13.5%	0.34
		Future proofing (supplies beyond 2050)	9.0%	0.09
		Likelihood of community support	4.5%	0.18
		Cultural heritage impact	3.0%	0.12
	Project Deliverability	Likely implementation speed	4.5%	0.18
		Complexity of project delivery	4.5%	0.09
		Risk of project delivery	6.0%	0.12

Option E2	Criteria	Sub-Criteria	Measurement Weighting	Weighted Score
IWSM (Urban + On-farm Storage)	Economic	Capital Cost $(2017)	12.0%	0.60
		Capital Cost $(2017)/ML yield/year	8.0%	0.40
		Levelised costs $(2017)/ML yield	16.0%	0.80
		Enabling industry (excluding irrigation growth)	4.0%	0.04
	Environmental	Impact on water quality	3.0%	0.15
		Impact on environmental flows	4.5%	0.23
		Inundation impact score	3.0%	0.15
		Land use impact	4.5%	0.23
	Social	Reliability of supply to 2050	13.5%	0.14
		Future proofing (supplies beyond 2050)	9.0%	0.09
		Likelihood of community support	4.5%	0.14
		Cultural heritage impact	3.0%	0.15
	Project Deliverability	Likely implementation speed	4.5%	0.18
		Complexity of project delivery	4.5%	0.18
		Risk of project delivery	6.0%	0.24

Option F2	Criteria	Sub-Criteria	Measurement Weighting	Weighted Score
Leslie Dam Pipeline (Urban + On-farm Storage)	Economic	As this option was dismissed early in the MCA process due to advice from DEWS as to all of available water yield being committed, detailed cost estimates are not provided.		
	Environmental	Impact on water quality	4.0%	0.2
		Impact on environmental flows	6.0%	0.3
		Inundation impact score	4.0%	0.2
		Land use impact	6.0%	0.3
	Social	Reliability of supply to 2050	8.0%	0.24
		Future proofing (supplies beyond 2050)	6.0%	0.12
		Likelihood of community support	3.0%	0.12
		Cultural heritage impact	3.0%	0.12
	Project Deliverability	Likely implementation speed	6.0%	0.24

GHD

145 Ann Street Brisbane QLD 4000
GPO Box 668 Brisbane QLD 4001
T: (07) 3316 3000   F: (07) 3316 3333   E: bnemail@ghd.com

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Revision	Author	Reviewer		Approved for Issue		
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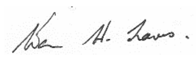
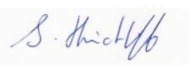
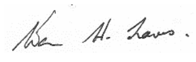
Draft 1		S Hinchliffe		W Traves		26/05/17
Final	S Hinchliffe et al.	S Hinchliffe		W Traves		01/06/17