Queanbeyan-Palerang Regional Council

QUEANBEYAN SEWAGE TREATMENT PLANT UPGRADE PROJECT

Masterplan for Sewage Treatment Plant Upgrade

Document Status

Queanbeyan Sewage Treatment Plant Upgrade Project

Masterplan

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Executive Summary

The Queanbeyan Sewage Treatment Plant (STP), constructed in the mid-1930s, treats effluent from the Queanbeyan Local Government Area (LGA), prior to discharge into the Molonglo River. While maintenance works are regularly undertaken on the STP, the plant is no longer fit-for-purpose. A significant works program is required to address issues including structural failure, equipment obsolescence, maintenance issues and work health and safety issues, as well as refining the process train.

This upgrade project has been instigated as a result of the following drivers for the site:

- Capacity required for current and future population growth
- Much of the existing infrastructure at or approaching end of asset life
- Operability and reliability issues of the STP
- Providing a level of service that conforms to industry best practice for the protection of public health and the environment
- A facility that meets regulator/stakeholder concerns/requirements
- Optimisation of STP design to achieve Infrastructure Sustainability Council of Australia (ISCA) rating of ‘Excellent’ or ‘Leading’.

This Masterplan sets out the design basis for proceeding with the upgrade of the STP, as summarised below.

In conclusion, a 60,000 EP STP is recommended to be constructed on the current site. For future upgrades and additions to the treatment facility, further investigation will be required in accordance with the Road Map (refer Figure 1-1).

Masterplan Element	Design Basis Outcome
***Best for region* Solution**	Queanbeyan’s location on the border of NSW and the ACT puts it in a unique position. The STP is located in the ACT on leased land and ACT Environment and Planning Directorate (EPD) (which includes the Environment Protection and Water Regulation Division), ACT Health and the National Capital Authority (NCA) regulate various aspects of the STP operations. Potential regional opportunities for wastewater management are subject to ongoing discussion with the ACT Government and Icon Water.
Future Growth	Growth is expected to occur in the middle portion of the LGA within the 10 to 25-year horizon. The southern third of the LGA is then expected to grow during the 25 to 50-year horizon. Provision for the first stage of the Queanbeyan STP Upgrade should be for an EP of 60,000. This provides for the 10 to 15-year growth projection. It should be noted that the projections within this Masterplan do not make allowance for any ACT contribution to sewage flows, though depending on timing of actual increases, some flow may be able to be accommodated. The EP calculator was based on average water data for Queanbeyan LGA averaged over 2009-14.

Masterplan Element	Design Basis Outcome
Existing Sewerage Infrastructure	The existing Queanbeyan STP condition currently presents a risk to QPRC with numerous suggestions for both immediate and short-term improvement. Beyond operability and WHS issues, there will be a stronger focus on water quality and environmental discharges. Tighter discharge criteria are likely to be imposed in the future when licence conditions are re-negotiated.
Future Sewerage Infrastructure	• The South Jerrabomberra sewer trunk will need to be upgraded to meet future capacity: – Consider augmentation of the Jerrabomberra Trunk Sewer between manholes W8 and the inlet channel of the STP – Any further augmentation should be delayed until a final service strategy is decided for future development to the south of Queanbeyan – A survey and sewer gauging program should be implemented for the whole length of the trunk sewer (manhole W78 to the STP inlet channel) to enable a more detailed analysis of the sewer • Continue discussions with Icon Water around cross-border arrangements and a regional approach to sewage management. • A septic tank receival station should be included in the new plant.
Environmental Constraints	The following should be considered when determining the location for future STP(s): • Avoid heritage listed sites, scenic protection areas, and quarry buffer zone • Construction within the ANEF affected areas could be considered if appropriate as aircraft noise is unlikely to be an impact on STP operations • Avoid infrastructure within the Q100 flood level without proper flood protection or mitigation measures in place • Avoid bushfire prone areas or provide adequate protections, appropriate to STP operations • Consider and incorporate mitigation of environmental issues on existing site as part of concept design.

<table>
<tr><th>Masterplan Element</th><th>Design Basis Outcome</th></tr>
<tr><td>Water Quality</td><td>Adopt the following effluent discharge criteria and 100% river discharge as the basis of design outcome.
<table>
<tr><th>Parameter</th><th>Units</th><th>Performance</th><th>Statistic</th><th>Proposed Licence Limit (100%ile)</th></tr>
<tr><td>Total Nitrogen</td><td>mg/L</td><td>10
5</td><td>90%ile
50%ile</td><td>10</td></tr>
<tr><td>Total Phosphorus</td><td>mg/L</td><td>0.15
0.1</td><td>90%ile
50%ile</td><td>0.2</td></tr>
<tr><td>Faecal coliforms</td><td>cfu/100mL</td><td>30
200</td><td>Median
90%ile</td><td>60</td></tr>
<tr><td>BOD</td><td>mg/L</td><td>10
5</td><td>90%ile
50%ile</td><td>10</td></tr>
<tr><td>Suspended Solids</td><td>mg/L</td><td>10
5</td><td>90%ile
50%ile</td><td>10</td></tr>
</table></td></tr>
<tr><td>Sustainability</td><td>Set sustainability targets with the goal of obtaining IS design and as-built ratings of Excellent with a score in the range of 65 – 75% or better.

Undertake a recycled water study to determine the viability of reuse in the future which addresses impacts on:
1. Discharge to the Molonglo River
2. Molonglo River yield and downstream environmental flows
3. Aquatic species along the Molonglo River.</td></tr>
<tr><td>Solids Management</td><td>The solid management solution comparison showed that the most beneficial options were:
• Reuse for land reclamation
• Production of fertiliser for animal crops
• Production of fertiliser for human crops
• Use for horticulture and landscaping.

The concept design phase should develop and consider these options further, however if other feasible options become apparent then these may also be considered.

A regional strategy for solids management is required but is outside the scope of this project.</td></tr>
</table>

Masterplan Element	Design Basis Outcome	
Treatment Technologies	**Treatment Step**	**Preliminary Option**
	Preliminary	Inlet works screenings and grit removal to be determined by choice of the secondary treatment process.
	Primary	Equalisation tanks or Primary settling and possible use of mechanical belt sieve.
	Secondary (one of)	BNR Bio-Reactor plus one of • Membrane Bioreactor (MBR) • Conventional Activated Sludge (CAS), e.g. – Sequencing Batch Reactor/ Intermittently Decanted Aerated Lagoons (SBR/IDAL) – Pasveer/Oxidation ditch
	Tertiary (one of)	• Tertiary Filtration • Refurbishing secondary clarifiers
	Disinfection	UV Chlorine (if required for regulatory purposes)
	Solids	Grit and Screenings - Landfill
	Biosolids (one of or a combination of)	• Land reclamation • Animal crop production • Landscaping – Composting Other options may be considered if they can be shown to be feasible through a regional approach.
Upgrade approach	A Multi Criteria Assessment found that a “Build New” upgrade approach was preferred taking into account whole of life cost, constructability, operability, sustainability, future proofing and community acceptance and affordability. All options including build new, refurbishment and reuse options provided a whole of life NPV around $100 M. The total project cost estimate prepared by QPRC using @risk modelling showed a mean estimated project value of $108 M. The assessment of plausible refurbished and reused assets showed no significant capital investment saving compared to the build new option cost estimates. All estimates are preliminary and based on a range of caveats. There is no discernible significant difference within the sensitivity of the cost analysis at a Masterplan level. The selection of treatment technology (BNR – CAS v BNR – MBR) was not significant to the outcome.	

Masterplan Element	Design Basis Outcome
Approvals	*ACT Approvals* Under Schedule 4 of the ACT *Planning and Development Act 2007* (P&D Act) the proposed upgrade to the STP would require an environment impact statement (EIS). A Development Application (DA) would also be required and would likely be assessed under the Impact Track. The completed EIS is required to be submitted with the Development Application submitted under the Impact Track. This applies to the whole site zoned TSZ2: Services and NUZ4: River Corridor (small areas bordering the Molonglo River). *NSW Approvals* NSW approvals will be required for any works within NSW (such as the sewerage collection system). The NSW legislation would similarly require Development Approval and environmental consideration (such as contaminated lands and endangered species). It is possible that the approving authority for this work could be QPRC. Further detail of the scope of any works in NSW would be required to determine this. NSW Department of Primary Industries, Water Department (DPI Water) is required to approve the STP upgrade under Section 60 of the *Local Government Act (1993)*. *Federal Approvals* Any works approval sought needs to consider the *Environmental Protection and Biodiversity Conservation Act 1999*.
	General Comments In 2015 the interim ACT and Region Catchment Management Coordination Group was formed by the ACT Environment Minister. This group includes EPD, and other ACT Government Stakeholders. The function of this committee is to implement an integrated catchment management approach in the ACT and Region, including improving water quality in Lake Burley Griffin. Continued engagement with EPD, ACT Government Stakeholders, NSW EPA and the NCA will be required regarding Lake water quality improvement through an agreed approach and throughout the preparation of the EIS. A framework for a joint approach is agreed. Local Councils are required to produce an Integrated Water Cycle Management (IWCM) plan outlined by NSW DPI Water.

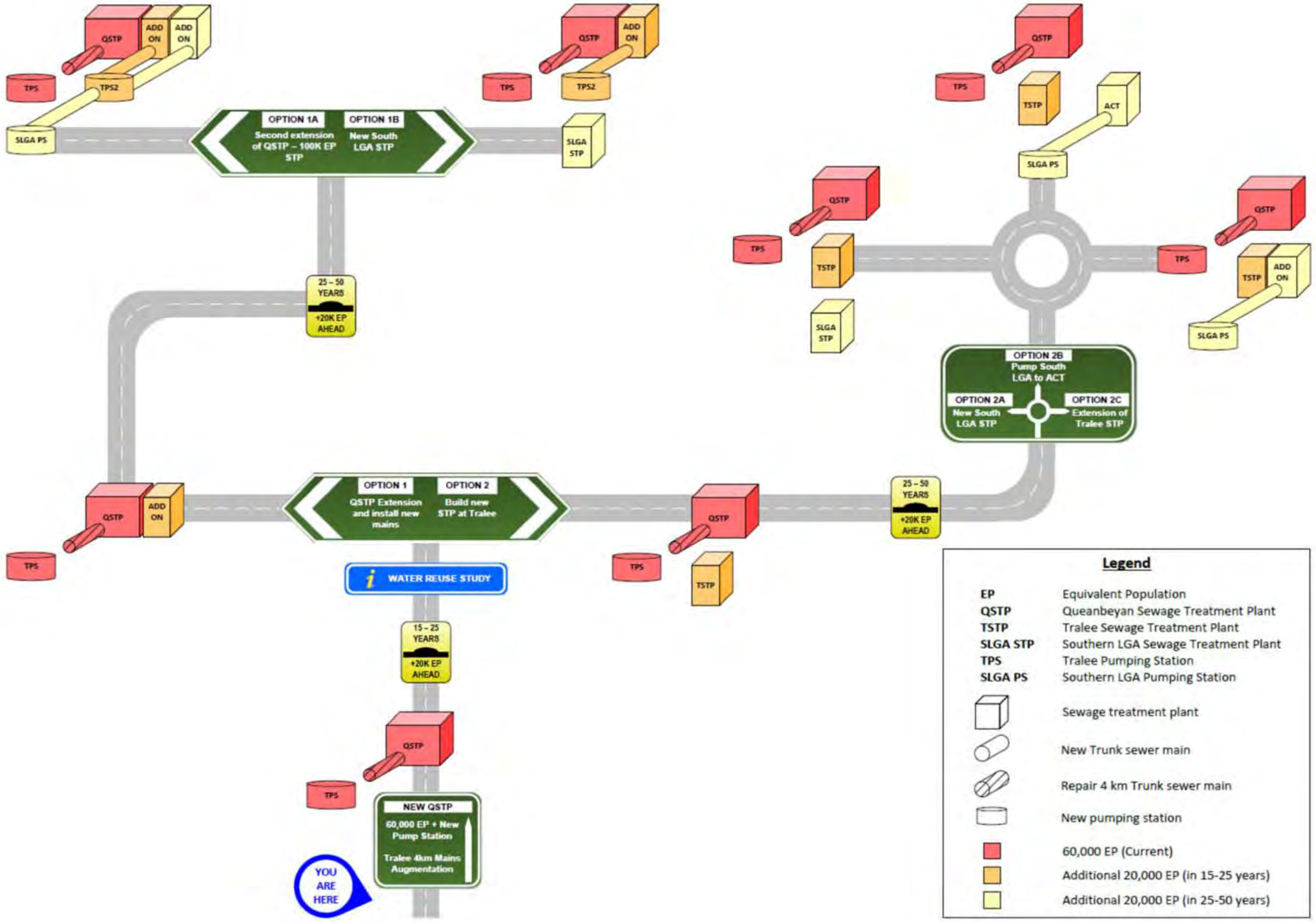

Figure 1-1 Road Map of options

Executive Sign-Off

Position	Name	Signature
QPRC Director of Projects and Assets	Phil Hansen	
QPRC Acting General Manager	Peter Tegart	
QPRC Administrator	Tim Overall	

Abbreviations

Abbreviation	Description
ACT	Australian Capital Territory
ADWF	Average dry weather flow
ANEF	Australian noise exposure forecast
AS	Australian Standard
BNR	Biological nutrient removal
BOD	Biological oxygen demand
Capex	Capital expenditure
Cfu/100 mL	Colony forming units per 100 millilitres
CSS	Canberra Sewage Strategy
DA	Development application
DN	Nominal diameter
DPI Water	Department of Primary Industries Water Department
EIA	Environmental impact assessment
EIS	Environmental impact statement
EP	Equivalent population
EPA	Environmental Protection Authority
EPBC	*Environmental Protection and Biodiversity Conservation Act 1999*
EPD	ACT Government Environmental and Planning Directorate
EPL	Environmental protection licence
EPP	*Contaminated Sites Environmental Protection Policy 2009*
g/EP/d	Grams per equivalent population per day
ha	Hectare
HWA	Hunter Water Australia
IDAL	Intermittently decanted aerated lagoon
IFAS	Integrated fixed film activated sludge
IS	Infrastructure sustainability

Abbreviation	Description
ISCA	Infrastructure Sustainability Council of Australia
IWC	Integrated water cycle
IWCM	Integrated water cycle management
kg/d	Kilograms per day
km	Kilometre
LBG	Lake Burley Griffin
L/EP/d	Litres per equivalent population per day
LGA	Local Government Area
LMWQCC	Lower Molonglo Water Quality Control Centre
L/s	Litres per second
m	Metre
mm	Millimetre
m^3/s	Cubic metres per second
MBBR	Moving bed bioreactor
MBR	Membrane bioreactor
mg/L	Milligrams per litre
ML/d	Megalitres per day
MLRMC	Mugga Lane Resource Management Centre
NCA	National Capital Authority
nm	Nanometre
NOW	Formally - New South Wales Office of Water Presently - the Department of Primary Industries Water Department (DPI Water)
NSW	New South Wales
NZS	New Zealand Standard
OPEX	Operational expenditure
P&D Act	*Planning and Development Act 2007*
PDWF	Peak dry weather flow

Abbreviation	Description
PMF	Project management framework
PRA	Preliminary risk assessment
PWWF	Peak wet weather flow
QPRC	Queanbeyan Palerang Regional Council
Q_f	Pipe capacity
Q100	100 year average recurrence interval flood
RAS	Return activated sludge
SBR	Sequencing batch reactor
STP	Sewage treatment plant
t/y	Tonne per year
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
VENM	Virgin excavated native material
V_{SC}	Self-cleaning velocity in sewer
WHS	Work health and safety
WQOA	Water quality objective assessment
WRP	Water recycling plant
µm	Micrometre

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1 Introduction

1.1 Overview

The Queanbeyan Sewage Treatment Plant (STP) was constructed in the mid-1930s and treats Queanbeyan's sewage prior to discharge of effluent into the Molonglo River. While maintenance and works are regularly undertaken on the STP, the plant is no longer fit-for-purpose. A significant works program is required to address issues including structural failure, equipment obsolescence and maintenance issues, as well as refining the process train.

In early 2011, Queanbeyan Palerang Regional Council (QPRC) was faced with growing concern about the capacity and reliability of the Queanbeyan Sewage Treatment Plant (STP), and engaged Hunter Water Australia P/L (HWA) to prepare an options study to upgrade the STP. This study recommended a major upgrade to the plant including construction of new inlet works and a new membrane bioreactor (MBR) process with combined biological/chemical phosphorus removal, single sludge stream and aerobic sludge digestion. Since that time the condition of assets on site has continued to deteriorate and the population has increased resulting in the design capacity of the existing plant being exceeded. The existing STP is estimated to have a design equivalent population (EP) of 34,500 (MWH, 2008) and is currently serving about 37,000 EP.

While the STP is meeting current effluent licence conditions, the maturation lagoons are a key asset in achieving this effluent quality and there is a risk that these lagoons may fail again as occurred in 2010 due to flooding.

Some of the existing equipment is obsolete and there are issues with maintenance of the existing plant. There is the potential that the current process is unable to meet more stringent discharge criteria if imposed in the future.

It is estimated that the existing Queanbeyan STP has about 3 to 5 years' effective service life remaining before its condition or ability to meet load requirements presents a major risk to QPRC and the community. This assessment is based on the previous studies undertaken at the plant (e.g. MWH (2008) and HWA (2011) and the recent Condition Assessment undertaken as part of this Masterplan work (GHD, TM003, July 2105).

On these grounds, QPRC has proposed to undertake the upgrade of the Queanbeyan STP. The aim of the upgrade project will be to have a STP that provides a level of service that conforms to industry practice for the protection of public health and the environment.

The project consists of the planning, design and construction of sewage collection, treatment and disposal facilities to serve Queanbeyan within the Queanbeyan Palerang local government area (LGA). QPRC intends to deliver the project in six distinct phases to provide hold points that will facilitate proper buy-in by regulators and other stakeholders for the Queanbeyan Sewage Treatment Plant Upgrade. QPRC has completed Phase 1 Project Inception and Phase 2 Project Delivery Plan of the project. This document is the output from Phase 3 - Masterplan and Feasibility.

1.2 Project drivers

The following drivers have instigated this upgrade project by QPRC:

- Capacity required for current and future population growth
- Asset life of existing infrastructure, as there is little remaining useful life for some of the existing assets
- Operability and reliability of STP
- Desire for a new STP to provide a level of service that conforms to industry best practice for the protection of public health and the environment
- STP design that meets regulator/stakeholder concerns/requirements
- Optimisation of STP design to achieve Infrastructure Sustainability Council of Australia (ISCA) rating of 'Excellent' or 'Leading'.

1.3 Scope of masterplan

This Masterplan establishes the framework and constraints for the upgrade project. Issues examined include existing infrastructure in Queanbeyan and the surrounding region, future growth, environmental constraints, water quality objectives and technology selection.

This Masterplan identifies the infrastructure that best meets expected growth and development of Queanbeyan. Some of the key matters addressed by the Masterplan include:

- Stakeholder consultation regarding objectives / expectations, cross border arrangements, cross border regulation, key design criteria, and service strategies and options
- Review of existing sewage collection and treatment arrangements for Queanbeyan including demands, inflows, influent quality, service level, and service costs
- Review of future growth projections for Queanbeyan LGA
- A water quality objectives analysis (WQOA) to identify treatment criteria in terms of public health and environment protection; particularly for the Molonglo River and Lake Burley Griffin
- Options for providing services to meet future needs including potential for recycled water reuse, decentralised services, energy and carbon footprint reduction
- Review of treatment technologies (including emerging trends) and their advantages and disadvantages that could be adopted for Queanbeyan to meet agreed treatment criteria
- Masterplanning options workshop to compare and rank the various treatment options, and initiate approvals processes
- Review of environmental and operational risks that could adversely affect project outcomes
- Review of approved requirements
- Review of the project and that the project is still economically sound.

The timeframe for this Masterplan is a 50-year planning horizon. This means that the constraints and issues identified and considered now will also be considered into the future.

2 STP upgrade regional context

2.1 Geography

2.1.1 Queanbeyan Palerang Local Government Area (LGA)

Queanbeyan is a regional centre in the Southern Tablelands in south-eastern New South Wales (NSW) adjacent to the Australian Capital Territory (ACT). The city's mixed economy is based on light construction, high technology, manufacturing, service, retail and agriculture. At the 2011 census, Queanbeyan had a population of 37,991. The LGA is characterised by a medium density urban centre at Queanbeyan City in the north and rural residential blocks in the south. Growth areas have been identified through the central corridor of the LGA as identified in Figure 2-1.

2.2 Climate

According to the Bureau of Meteorology, Queanbeyan's climate, and the surrounding region, is characterised by hot summers (mean maximum 29 °C) and cold winters (mean minimum -0.2 °C). Mean annual precipitation is 594.8 mm. These conditions will need to be considered in the design phase of the STP Upgrade Project.

2.3 Land development

According to the QPRC website:

"Queanbeyan is one of NSW's fastest growing cities with our population set to grow from 42,000 to around 70,000 in the next 20 years."

2.3.1 South Jerrabomberra

A significant development area of relevance for the Queanbeyan STP upgrade project is the South Jerrabomberra Development Area. The South Jerrabomberra site is located in NSW south of Queanbeyan, near the existing suburb of Jerrabomberra, and adjacent to the Hume industrial area in the ACT. Land in the region has previously been occupied by homesteads and grazing land, and is bordered on the northwest by the Queanbeyan-Cooma Railway Line. The 417 ha South Jerrabomberra area is anticipated to eventually have approximately 4,700 homes.

A number of developments are anticipated in the area, which will be a mix of residential, commercial and industrial developments. The anticipated neighbourhood developments are (listed in order from north to south):

- Poplars – primarily industrial/commercial development
- Environa and North Tralee – primarily industrial development
- South Tralee – primarily residential development
- Forrest, Morrison and Walsh (land to the south of South Tralee) – residential areas.

A range of community and recreational facilities have been proposed including an aquatic centre, a regional sporting complex (Poplars), open space and sporting fields, a private secondary college and a primary school. Two local centres have been identified for retail and commercial purposes within Poplars and South Tralee. A 250 m wide open area is planned as a buffer between South Jerrabomberra and the adjacent Hume light industrial area.

These developments are likely to progress in a series of stages over a period of 25 years. Initial construction will begin with South Tralee, including works on access, sewer, water, electricity and gas. About 1,300 homes are eventually expected to be contained in this first neighbourhood of approximately 180 ha area.

2.3.2 Googong Township

Googong Township is located near Googong Dam off Old Cooma Road, 5 km south of the Queanbeyan Central Business District. The region is characterised by gently undulating slopes and plains and used originally for grazing land. The 780 ha Googong development is planned to have around 5,550 homes for approximately 16,000 people, as well as schools, parks, shops and businesses.

Infrastructure development for the Googong Township includes:

- Upgrade of access roads between Queanbeyan and Googong
- Installation of a sewage treatment plant (water recycling plant) (WRP) to deliver recycled water to homes for non-potable use including toilet flushing, fire-fighting and irrigation for gardens and public parks and spaces
- The WRP includes potable and recycled water reticulation networks, pump stations, reservoirs and sewage collection network
- Construction of a multi-purpose community centre and library, indoor sports and aquatics centre, two neighbourhood community centres and a community clubhouse
- A variety of parks, playgrounds and sporting field facilities, as well as a network of walking and bike paths
- New waterways and ponds
- Provision of gas services and telecommunication coverage.

The Township is comprised of five neighbourhoods, with North Googong being the first to be developed. Each neighbourhood has a central hub ranging in size from several shops to a small retail centre. In addition, the Googong town centre will be a focal point for the region and include a variety of shops, cafés, restaurants, community facilities and commercial places, as well as housing apartments and townhouses.

Googong Township will progress in a series of neighbourhood stages over a period of around 20 to 25 years. The civil works at Googong began mid-2012 and the first housing construction developments commenced in early 2013.

The nearby Googong Foreshore area around Googong Dam will be managed as a separate water catchment, wildlife refuge and public recreation area.

2.3.3 Australian Capital Territory

The Queanbeyan STP is located in the ACT and therefore has a broader regional context. While there is no pressure at present to develop the Queanbeyan STP as a regional facility, land development in the vicinity of the STP in the ACT could affect future decision making in respect of future planning for sewage treatment and disposal. Some of the more immediate developments that could affect future STP upgrades, include:

- Light industrial areas at Fyshwick and Hume
- Canberra airport
- Future development sites as identified in Figure 2-2
- The ageing Fyshwick STP facility
- Canberra development in the north including the Capital Metro plans
- Consideration of flows and runoff from Oaks Estate and Beard Estate.

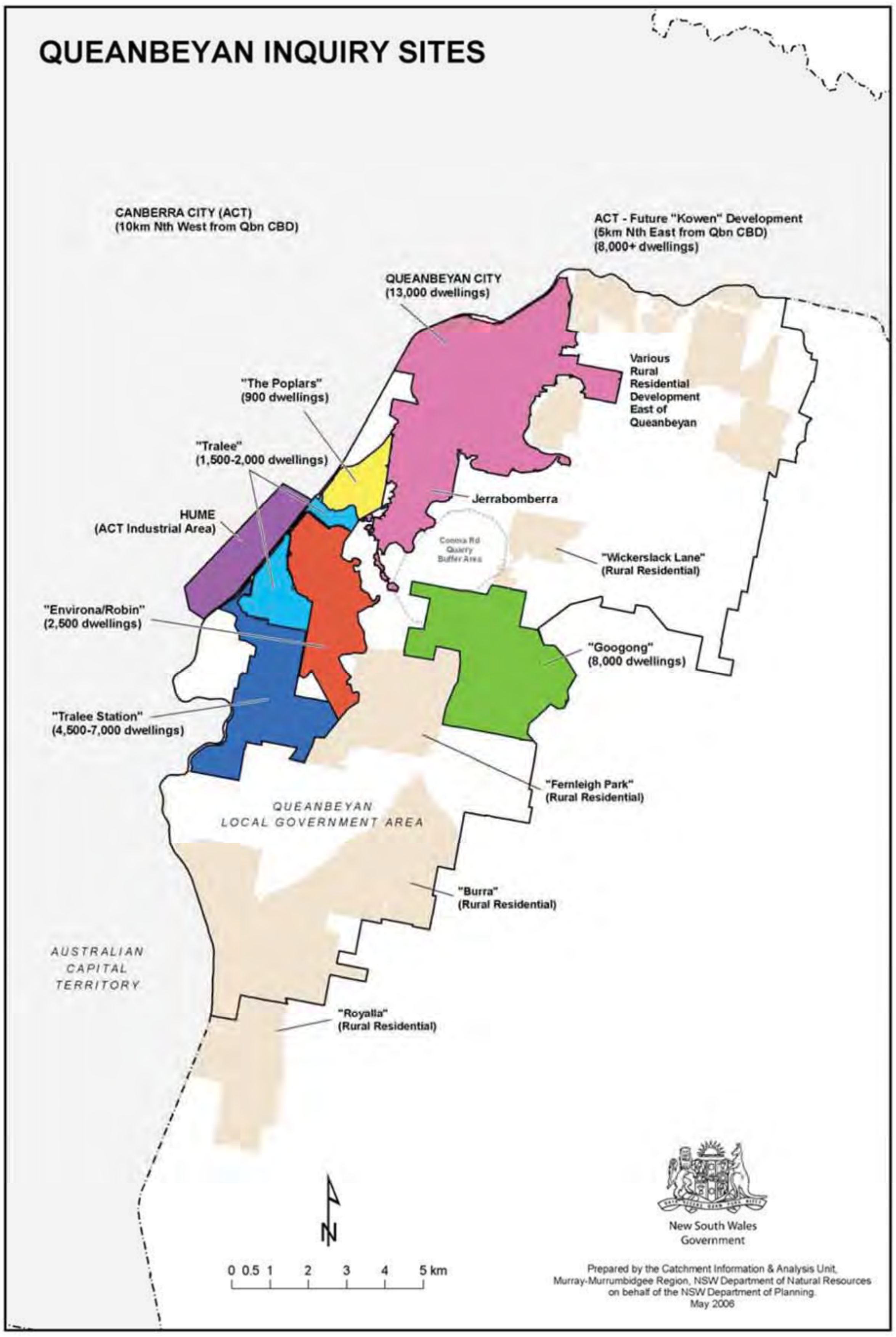

Figure 2-1 Future development areas in Queanbeyan LGA

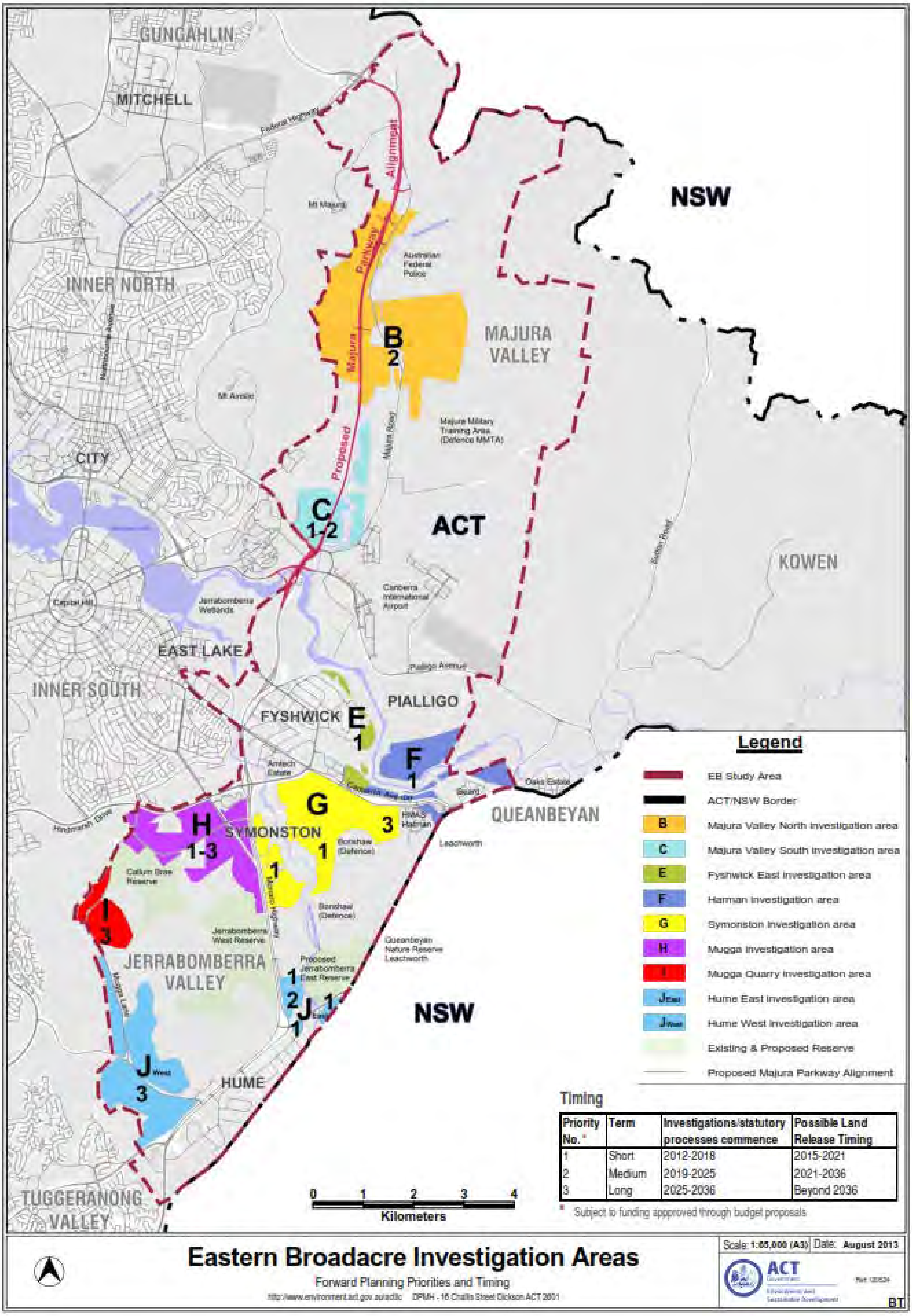

Figure 2-2 ACT Eastern broadacre development investigation areas

2.4 Regional sewerage infrastructure

2.4.1 Fyshwick STP

The Fyshwick Sewage Treatment Plant is located on approximately 32 hectares in the vicinity of the commercial and industrial areas at Fyshwick and the Jerrabomberra Wetlands. The plant treats sewage from the Majura, Fyshwick, Hume, Jerrabomberra and Narrabundah catchments, discharging the treated effluent to either:

- The Lower Molonglo Water Quality Control Centre (LMWQCC) for subsequent discharge to the Molonglo River downstream of Canberra, or
- The North Canberra Water Reclamation Plant for further treatment and subsequent use as recycled water for irrigation.

Icon Water prepared the “Canberra Sewerage Strategy (CSS) 2010-2060” report in response to the ACT population growth, changes in environmental conditions, foreseeable changes in government policies and community needs, and advances in treatment technology. The report aimed to identify and evaluate future treatment and discharge options for the Fyshwick STP site in the next 10 – 20 years.

The “CSS 2010-2060” report identified the following issues with Fyshwick STP:

- The Fyshwick plant was not able to handle peak wet weather flows during an event in December 2010 and capacity should be upgraded to 6 ML/d to handle such flow events
- There is leakage from lagoons to groundwater, as the lagoons are not completely sealed with an impervious base
- All sludge and a high proportion of the effluent is returned to the sewer for subsequent treatment at LMWQCC, which involves duplication of treatment effort and cost
- There is possible contamination of soils in some areas of the site, based on experience at similar treatment sites.

These issues are key drivers for service upgrade and Icon Water needs to decide the future of the Fyshwick STP - renew, replace or close. This decision remains with Icon Water but QPRC needs to consider it, given its proximity to the Queanbeyan STP. Fyshwick STP should be considered for a broader future regional solution to wastewater management.

A workshop in August 2015 aimed to formulate a best for region approach for sewerage management which considers the capacity and remaining asset life of the Fyshwick STP. An outcome of this workshop was an agreed governance structure for decision making in a regional context. An additional outcome of this workshop was a roadmap for collaboration and timely decision making that includes information gaps studies to support options analysis. This work is ongoing at the time of this Masterplan.

2.4.2 The Lower Molonglo Water Quality Control Centre (LMWQCC)

The LMWQCC, located in the north west of the ACT, near West Belconnen is the main wastewater treatment plant for the ACT. The LMWQCC currently treats 80 ML/d of sewage from Canberra. Future upgrades to this plant have forecast an increase in capacity to 300 ML/d to accommodate future growth and wet weather flows.

The best for region workshop (August 2015) identified that flows from the ACT would continue to be treated at the LMWQCC and that, whilst the flow distribution may change, the altered flow regime would not fundamentally change the Queanbeyan STP upgrade.

2.5 ‘Best for region’ sewage treatment solution

Queanbeyan’s location on the border of NSW and the ACT puts it in a unique position. The STP is located in the ACT on leased land and ACT Environment and Planning Directorate (EPD) (which includes the Environment

Protection and Water Regulation Division), ACT Health and the National Capital Authority (NCA) regulate various aspects of the STP operations1. The collection system network is located in NSW and QPRC is the service provider and is therefore regulated by the NSW Department of Primary Industries, Water Department (DPI Water).

During Phase 3 Masterplan and Feasibility of the QPRC STP Upgrade project, potential regional opportunities for wastewater management were discussed with the ACT Government and Icon Water. In May 2014 correspondence between QPRC and Icon Water identified a willingness to consider a regional solution for sewage treatment. During February 2015 a workshop was held with a range of stakeholders to outline the Draft Masterplan. In August 2015 a best for region solution was workshopped, with a framework for progress agreed between Icon Water, QPRC and the ACT Government (Particularly EPD and EDD).

In 2015 the interim ACT and Region Catchment Management Coordination Group was formed by the ACT Environment Minister. This group consists of multiple regulators and stakeholders including QPRC. The function of this committee is to implement an integrated catchment management approach in the ACT and Region, including improving water quality in Canberra's lakes (REF ACT Government Environment and Planning, 2014. ACT Water Strategy 2014-44 Striking the Balance. ACT Government Canberra, ACT).

[1] *ACT EPA regulates discharges to the Molonglo River and NCA and ACT Health regulate discharges to Lake Burley Griffin from a water quality and human health perspective respectively, but only the ACT EPA issues a licence to operate the Queanbeyan STP*

3 Future growth

To determine what quantum of flows need to be accommodated, projection of population growth was undertaken.

Population was determined from population statistics such as from census data as well as historical QPRC water usage data. The population values were then converted to equivalent population (EP) values to better account for the sewage inflows to be treated by the upgraded STP.

An EP calculator was developed to determine the EP (hence sewage flows) to be serviced by the upgraded plant over time. 28 existing and future urban areas were considered. Anticipated growth for the QPRC Local Government Area (LGA) was discussed with QPRC staff taking account of expected development nature, size and timing. This information was incorporated into the EP calculator and a series of maps was generated to show the likely growth areas and concentration of EP across the Queanbeyan LGA for Current, 10, 25 and 50 year horizons.

Further information about the EP calculator can be found in Appendix A.

3.1 Population projection

Figure 3-1 shows the results of population projection generated by the EP Calculator and Table 3-1 shows the impact with and without the Googong Township which is served by its own STP. Five projections were generated:

- Lower bound limiting population
- Upper bound limiting population
- Lower bound expected population
- Upper bound expected population
- Population from EP considerations.

Population growth will result mostly from the nature of the expected release and construction of development areas, particularly in Googong and South Jerrabomberra. Planning is already well advanced for these developments and therefore growth is likely to occur in the early to middle period of the planning horizon.

This projects the total population for the Queanbeyan LGA prior to its amalgamation with Palerang. The population to be serviced by the STP Upgrade will depend on the staging and arrangement selected, i.e. all at existing site or decentralised.

Maps illustrating the growth concentration are shown in Appendix B.

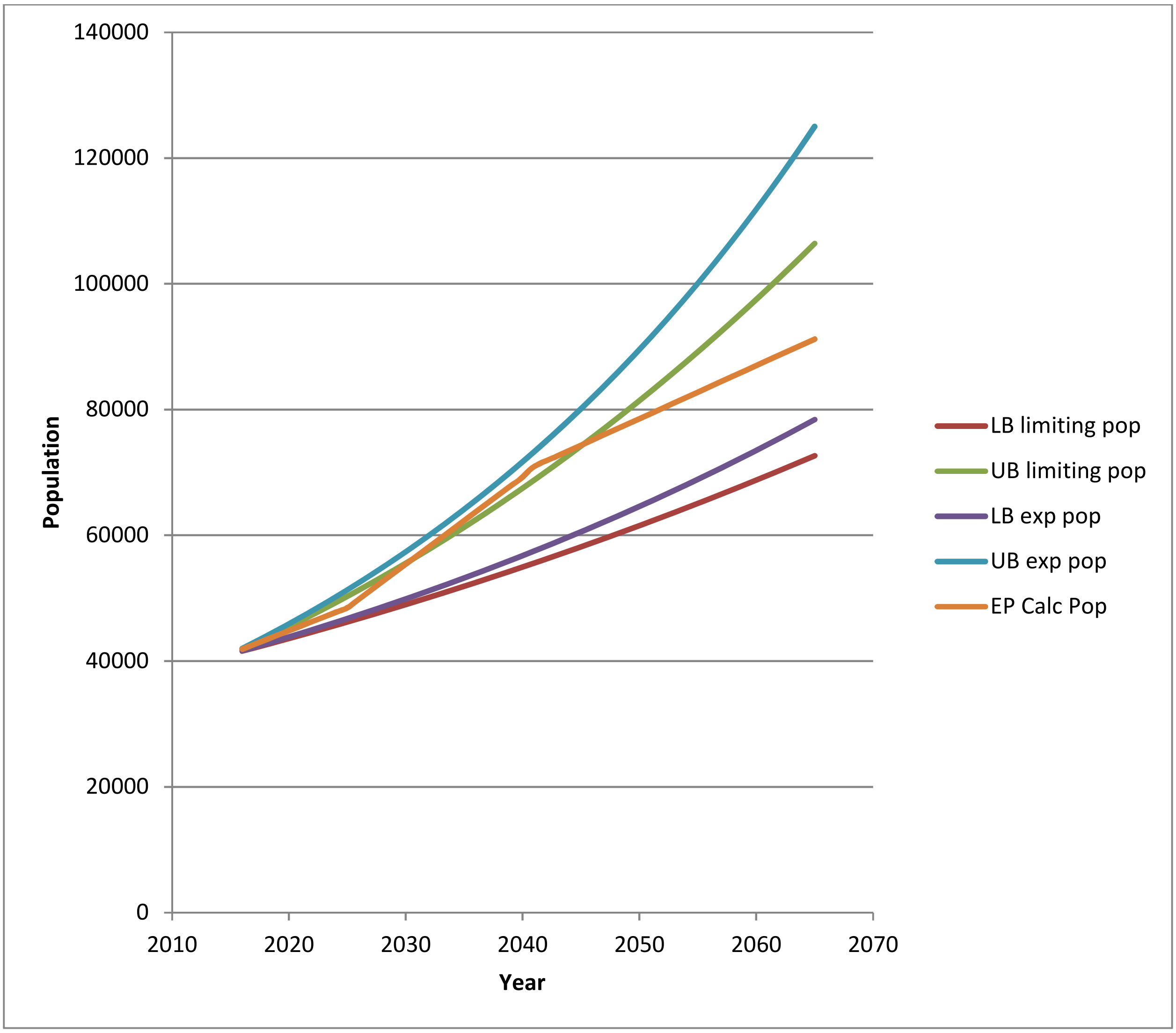

Figure 3-1 Population projections for the Queanbeyan LGA

Table 3-1 EP projection Inclusive / Exclusive of Googong as per EP Calculator projections

Timeframe	Year	EP Excluding Googong	EP Including Googong
Current	2015	45,737	45,917
10 Years	2025	53,885	59,949
25 Years	2040	76,972	92,535
50 Years	2065	101,362	116,925

3.2 Concluding observations

The greater portion of growth is expected to occur in the middle part of the LGA within the 10 to 25-year horizon and in the southern part of the LGA within the 25 to 50-year horizon. Some low to moderate growth may occur in the middle part of the LGA (e.g. initial stage of South Tralee development) and as a result of urban infill over the next 10 to 15 years.

The first stage of the STP upgrade needs to provide sufficient time to address broader planning concerns as well as regional issues. Considering the population projection and other factors a planning horizon of about 10 to 15 years for the first stage seems appropriate. The first stage of the Queanbeyan STP Upgrade should allow for 60,000 EP to provide for 10 to 15 years' growth and in so doing:

- Address immediate needs in respect of existing STP condition and performance reliability, hence risk of not meeting discharge requirements
- Provide sufficient time to properly investigate longer term needs in respect of potential development in the LGA service provision
- Allow sufficient time to properly address regional cross border and other LGA planning issues.

It should be noted that these projections do not make allowance for ACT contribution to sewage flows, though depending on timing of possible ACT contributions some may be able to be accommodated.

4 Existing sewerage infrastructure

4.1 Queanbeyan sewage collection network

The Queanbeyan STP services a catchment made up of urban and some rural residential properties, including the neighbourhoods of Crestwood, Jerrabomberra, Karabar, Queanbeyan, Queanbeyan East, Queanbeyan West and Rural East. Several pump stations within the catchment deliver flow to the STP via two independent trunk mains.

The STP treats sewage from the QPRC area and discharges treated effluent into the Molonglo River. It services all urban properties and some rural residential properties within the former Queanbeyan City Council area, the extent of which is displayed in Figure 4-1 and Figure 4-2. The Queanbeyan sewerage system consists of a gravity reticulation system with 19 pump stations and 280 km of pipeline. The capacity of the Queanbeyan STP existing treatment processes has been estimated to be around 34,500 EP (MWH, Dec 2008). The location of the STP is unique in that it also services a small urban area (Oaks Estate) in the ACT.

The existing STP receives flow from in and around the Queanbeyan area however, with the STP located in the ACT and relatively near the Fyshwick STP, future consideration could be given to possibly integrating the Queanbeyan and Fyshwick STPs in some way.

The Queanbeyan catchment area is anticipated to grow over the next 20 years with the development of the Googong and Tralee – Environa – Robin areas. Googong will be serviced by its own STP and a decision has yet to be made as to whether to service other areas by additional STPs. It is possible that the connected population to the Queanbeyan STP could grow considerably and therefore it is necessary to upgrade the STP to ensure effective treatment of current loads and to allow for the expected future population. This masterplan identifies this issue but does not seek to specifically address it.

4.1.1 Collection system age and condition

Table 4-1 summarises the length (percentage) of sewers by age as well as the length of sewers that have been renewed to date. Sewerage infrastructure in Queanbeyan is ageing (with declining condition), with about 50% of the collection system older than 30 years. In addition, the collection system is also coming under increasing pressure from urban infill, which is expected to increase sewage flows in a system, which is already at or near capacity.

The effective service life of sewers is about 70 years. Consequently, there will be an increasing need to renew or replace the system over the next 10 to 20 years. A five year works program (2015 to 2020) identifies a further 21.25 km (about 6.5%) of gravity sewers to be renewed in order to maintain current service levels. The present rate of sewer renewals appears to be keeping pace with the rate of decline in condition and capacity. Flow gauging studies are being undertaken by QPRC to better understand flows in the system and to develop better strategies to reduce wet weather infiltration.

It is expected that sewer renewals and reduced wet weather infiltration will, in time, assist to provide additional system capacity for growth due to infill (in particular) and possibly to a lesser extent large urban development south of Queanbeyan.

Table 4-1 Length of Queanbeyan sewers renewed by age

Age of Sewer	Gravity Sewers			Pressure Mains		
	All (m)	Renewed (m)	% Renewed	All (m)	Renewed (m)	% Renewed
≤ 10 years	19,526	64	0.33%	398	0	0.00%
10 – 20 years	62,256	136	0.22%	1,979	0	0.00%
20 – 30 years	85,485	3,133	3.66%	784	0	0.00%
30 – 40 years	38,062	3,203	8.42%	1,049	0	0.00%
40 – 50 years	66,806	10,563	15.81%	0	0	0.00%
50 – 60 years	22,767	5,790	25.43%	135	0	0.00%
≥ 60 years	37,632	10,573	28.10%	0	0	0.00%
Total All Sewers	332,534	33,462	10.06%	4,345	0	0.00%

Notes:

a) Data obtained from the Conquest Asset Register at January 2015

b) Shows the distribution of sewers by age

c) Shows the distribution of sewers by renewal.

4.1.2 Collection system capacity

There is limited data about future infill development in Queanbeyan. This means that estimated growth rates for Queanbeyan are both general and qualitative. Current data suggests that growth due to infill is not likely to exceed 7,500 EP over the planning period of 50 years. Hence, any major extra load on the collection system is likely to be caused by new development south of Queanbeyan (e.g. South Jerrabomberra). Modelling of sewage flows in the existing urban area did not reveal any major issues. The only sewer likely to be affected is the DN 600 Jerrabomberra Trunk Sewer, which may be used to service land development south of Queanbeyan.

The Morisset St Pump station and Jerrabomberra trunk sewer are key pieces of infrastructure within the sewage collection system. Jerrabomberra trunk sewer would need augmentation to accommodate flow from additional land development. Morisset Street Pump Station has been inspected and some minor issues found. These should be addressed as part of the upgrade project.

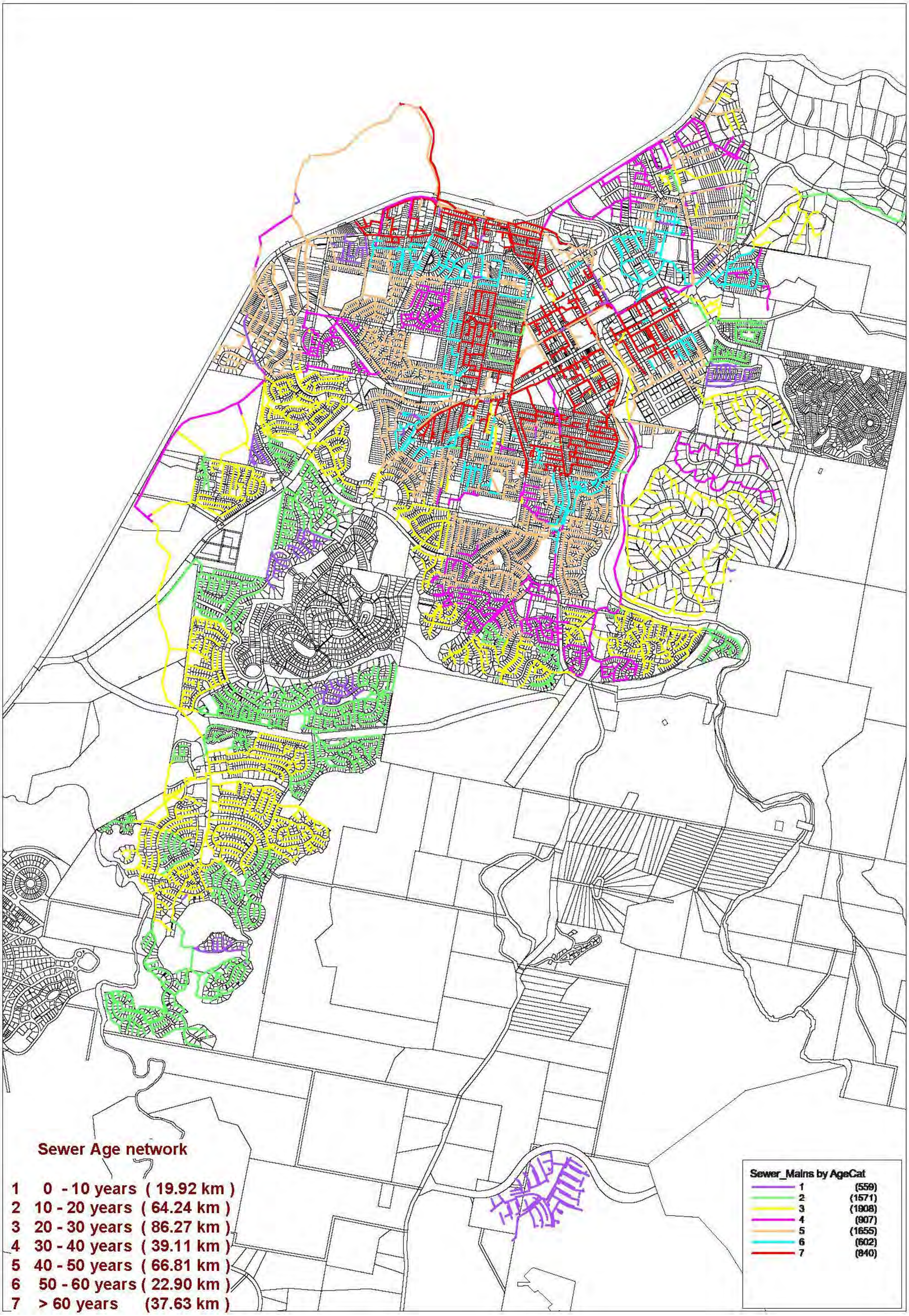

Figure 4-1 Age of the QPRC LGA sewer network

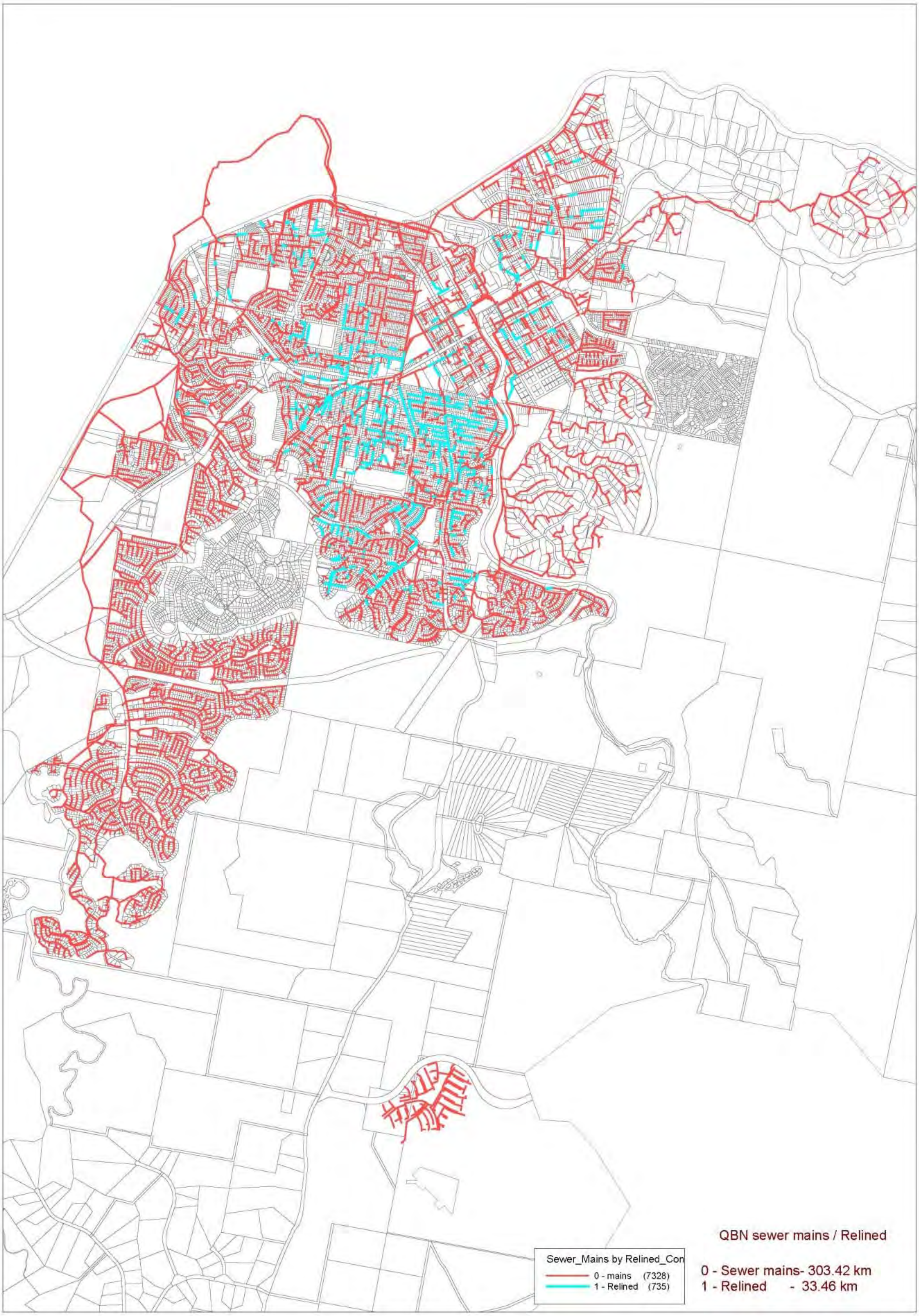

Figure 4-2 Distribution of relined sewer mains in the QPRC LGA

4.2 Sewage quality

A sampling program carried out by HWA and QCC (2011) found that the Queanbeyan inlet raw sewage at the STP inlet works resembled typical Australian domestic sewage. Notably, however, the Total Suspended Solids (TSS) 50th percentile for Queanbeyan STP is relatively high at 82 g/EP/d compared with typical domestic sewage TSS of 63 g/EP/d. This can be attributed to the high amount of limestone existing in the Queanbeyan area contributing a relatively high concentration of calcium. The per capita sewage load in Queanbeyan is estimated to be 226 L/EP/d and the peak wet weather flow factor is estimated to be 5.5 x ADWF. These values are considered typical of Australian domestic sewerage systems.

The maturation lagoons have been in operation for over 40 years and are at the end of their operational life (investigation into structural integrity by HWA (2011)). Further, these lagoons lie below the level of the 1 in 100-year flood level and were damaged by the 1 in 20 year floods of 2010, leading to failure of Pond 2 embankment and release of around 30 ML of treated effluent plus additional pond sediment. This situation is a significant concern for ongoing operations as the ponds provide final polishing and disinfection of the treated effluent, and provide an effective buffer in times of high flow especially during wet weather events. Repair works have since remediated the flood damage. A Maturation Pond Management Plan has been developed and implemented to facilitate early detection and management of potential failures.

4.3 Queanbeyan Sewage Treatment Plant (STP)

The STP has been upgraded a number of times in its eighty-five year lifespan, with its most recent upgrade occurring in the mid-1980s. The Queanbeyan STP was constructed in the mid-1930s, and is reaching the end of its service life. It has had a number of issues, which include:

- Structural failure
- Equipment obsolescence
- Maintenance issues
- Work health and safety (WHS) issues.

This STP was first commissioned in 1937 and since then has had three treatment trains added in upgrades. An outline of the current process train is provided in Figure 4-3. This process train is a mix of technologies patched together over time in reaction to capacity issues rather than a coherent integrated approach to meeting water quality objectives. Consequently, the process train needs to be refined. The following sections discuss the STP condition assessment. A full record of the condition assessment is presented in Appendix I. This assessment details the minimum suggested improvements for immediate attention, operation over the next 2 to 5 years and the possible refurbishment of parts of the STP for a 15 to 20-year lifespan, as part of a 60,000 EP plant upgrade.

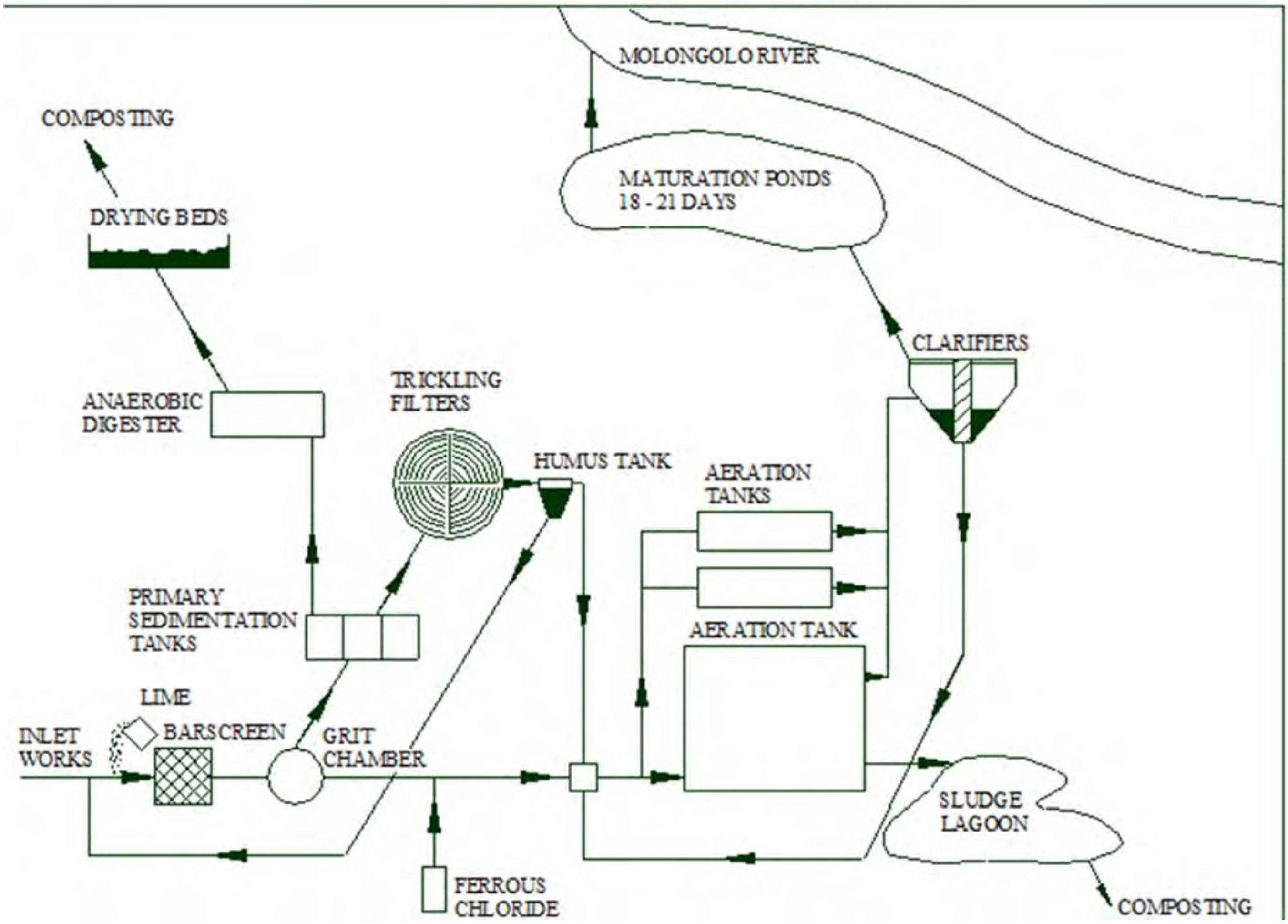

Figure 4-3 Queanbeyan STP process flow and discharge to Molonglo River

4.3.1 Inlet works

Two 12 mm screens are operated in duty and standby or bypass mode. The screens work on a flow based method and therefore not all inflows are screened. Due to the coarse nature of the screens a limited volume of screen material is actually removed from the process stream. A refurbishment was undertaken in 2014 in order to improve reliability. This entailed refurbishing the existing parts, adjusting the gearing ratio to 20%, checking the motor and reducing the bar aperture from 20 mm to 12 mm. Further influent screening improvements are needed to eliminate rags and coarse material from the treatment process. Rags enter the process train through the wide spacing of the bar screens on the inlet works. The rags contribute to high maintenance requirements for the biological filters, sludge tanks and lagoons.

The existing Vortex Grit Chamber appears to be in a satisfactory physical condition; however, the existing William Bobby cannot be used due to the hydraulic limitation of the inlet works. As a result, the primary grit chamber is not used and no grit removal occurs. Timber stopboards are currently used for flow splitting. The stopboards and penstocks are manually operated.

There is no influent overflow or bypass to a wet weather storage dam. Unauthorised flows to the environment are currently difficult to control during wet weather conditions. Given the likely trigger for new licence conditions or for a pollution reduction program to be applied by the NSW EPA should substantial upgrade of the plant be proposed; such a bypass would be expected as part of a future upgrade. The inlet works wet weather distribution arrangement requires operators to attend site since it is not an automated process. This may potentially lead to surcharge if the response time of operators is slow.

Based on the existing asset condition the minimum suggested improvements are:

- Screen all inflows
- Install smaller aperture screens (3-6 mm). Replace the raked bar screen with either a step screen or spiral sieve screen to capture a significantly higher volume of screenings
- Investigate and fix hydraulics to prevent overflows and hydraulic backup
- Replace the Vortex Grit Chamber as component of new inlet works as part of STP augmentation
- Consider the replacement of timber stopboards with more appropriate material and automated lifting to improve duty performance and WHS
- Install an influent overflow and storage bypass facility of sufficient volume to enable later treatment of bypass flows during high inflow events.

Given these, and considering the 60,000 EP plant upgrade, the recommended option for the inlet works is to construct a new inlet works with mechanical screens, grit removal, screenings and grit handling equipment and hydraulic flow distribution infrastructure

4.3.2 Trickling filters

The four rock-media tricking filters are fed by rotating distribution arms, which are hydraulically propelled by the pressure of the incoming influent. There is no forced aeration; hence the units use very little energy. The trickling filters appear to be under-utilised both hydraulically and biologically, with no visible slime build up on the media surface.

Two of the trickle filters were installed in 1935 and show clear signs of structural deterioration with large cracks throughout the concrete structure. The concrete is in poor condition. The trickling filter walls were found to have moved off their foundations and managing to be held in place with the measures deployed such as steel pre-stressing cables.

Trickling filter effluent is pumped to the head of the secondary biological treatment zone (Trains 3 and 4), post the flow splitting zone. The water quality at this point is not known and therefore the process performance benefit of sending the trickling filter effluent through the secondary biological treatment is not clear. The use of trickling filters prior to secondary treatment may be impacting the Carbon : Nitrogen : Phosphorus ratio as well as causing hydraulic loading pressure on the secondary biological process (40% of the hydraulic load).

Based on the existing asset condition the minimum suggested improvements are:

- Consider decommissioning the TF1 and TF2 process train since all the effluent from this is routed through the Activated Sludge process train. Decommission to avoid catastrophic failure.
- Consider action to repair TF 3 and 4 if they are to be retained beyond five years.
- Conduct monitoring of the trickling filter effluent to assess if this can be re-routed direct to the maturation ponds. A portion of nutrient load and hydraulic load could at least be re-directed from the secondary process.

4.3.3 Aeration tanks

There is no heating of air or water influent in the aeration tanks, limiting the efficacy of biological treatment in the cool climate conditions. Aerator speeds are controlled against the measured DO concentration set points by Variable Speed Drives (VSDs) fitted to the second and third aerators. Examination of historical dissolved oxygen and motor speed trends indicates that currently, the aerators are not controlling the dissolved oxygen levels as effectively as they could be. Aerator speeds appear to be almost constantly adjusting, and as a consequence the measured DO concentration in the aerated tanks is constantly changing (oscillating or overcorrecting).

Aerators are unable to maintain the required DO levels in the water. Aerator number 2 T1CH1 in particular appears to be in a deteriorated condition and underperforming.

Based on the existing asset condition the minimum suggested improvements are:

- Apply measures to aerate less either via SCADA / control / VSD adjustment / putting some aerators to 'off'
- Aeration zone should aim to be around 1.5 mg/L DO, although operator experience will dictate
- Possibly re-locate DO probes from being too close to the side wall and away from the aerator to get a better sensor placement
- Consider a retrofit 'cover' that could push the turbulence and DO transfer downward into the mixed liquor.

4.3.4 Anaerobic digestion

The anoxic zones appear to have some turbulence (leading to air entrapment) due to poorly performing mixers. This air entrapment reduces the effectiveness of the anoxic nature of the zone, resulting in poorer nitrogen removal. Anecdotally the zones are not perceived to be anoxic and are too small to support their denitrification purpose, with TN high at around 14 mg/L.

Based on the existing asset condition the minimum suggested improvement is:

- Maintenance / refurbishment of the mixers as may be required to ensure air is not entrained and they operate efficiently.

4.3.5 Clarifiers

The structural condition of the existing clarifiers is sound, with the concrete in all three clarifiers in good condition.

Uneven flow distribution is observed from the flow splitter chamber after the aeration tanks causing high solids loading to one of the settlement tanks. Currently the highly loaded Clarifier No.1 is cross-connected to the RAS Pump Station 2 to increase the re-circulation rate of return sludge and rectify the distribution issue. The RAS pumps, which consist of three ITT Flygt submersible pumps, also have uneven flow distribution causing high solid loading to RAS Pump Station 2.

Furthermore, as a result of the high levels of sludge that are carried in the aeration tanks (MLSS of 6,500 mg/L), there is noticeable carry over from the clarifiers to the Maturation Ponds which affect the effluent water quality.

Based on the existing asset condition the minimum suggested improvements are:

- Modify and extend the existing launder sprays to spray and break up the scum at the peripheral weir, and that the fixed brushes installed on the travelling bridge for weir cleaning are reinstated and maintained. This should help prevent scum clumping and accumulation at the weir. This should be fitted to each clarifier.
- Remove scum baffles and bridge scraper, allowing scum to enter Tertiary Lagoon inlet where it settles out instead of wasting at the clarifier, thereby re-entering the activated sludge system.
- Install new weir plates and accurate levelling of the plates.

4.3.6 Maturation ponds

During the heavy rainfall in early December 2010, the No. 2 maturation pond embankment failed on the northern side of the pond. In view of the design standards for maturation ponds and the service life of the structures it was considered that the embankment had reached the effective end of its design life. It is possible there may be further failures in the ponds due to the inherent condition of the pond and the possibility of further extreme rain events. In regard to the future management strategy it is considered that some minor remedial works be undertaken in areas of high risk and that a formal surveillance program of the embankments be implemented.

There is a level of algae actively within the maturation ponds which affects the effluent water quality. This is largely attributed to the 40 years of silt accumulation in the pond. The algal activity within the ponds results in changing bicarbonate concentrations and a rise in TDS, associated with seasonal algal blooms. This is also linked with the change in pH, which has exceeded the limits for the STP.

These dynamic processes within the maturation pond result in poor water quality and insufficiently disinfected effluent. The ponds have been fitted with aerators however these have not been used for years. The performance and condition of the aerators in the maturation ponds has not been described.

Based on the existing asset condition the minimum suggested improvement is:

- Undertake a risk assessment for the inlet tertiary lagoon facility. It is anticipated that as a minimum, the risk assessment recommendations would include a requirement for fencing around the perimeter of the inlet lagoon, together with warning signs alerting personnel to the hazards upon entering the fenced area.

Given the improvements identified for the existing secondary treatments, and considering the 60,000 EP plant upgrade, the recommended option for the secondary treatment process involves a MBR or conventional activated sludge process using best biological design principles with combined biological / chemical phosphorus removal, single sludge stream and aerobic sludge digestion.

4.3.7 Sludge handling system

Sludge from the activated sludge process is wasted to one of two lagoons, where it is stored and stabilised prior to drying on the site's sludge drying beds. Only one of the sludge lagoons is fed over a period of typically 6 to12 months, whilst the other is retained on standby. After this time period, which allows for settling and partial dewatering, partially dewatered sludge is placed onto drying beds. The sludge lagoons are at capacity, with both lagoons full to near overtopping. In a storm event, an environmental incident could result due to lagoon volume and lack of alternate options for storage.

In addition, the sludge drying beds are at capacity causing a backlog of waste in the lagoons. The stockpile area is also at capacity and an alternative is required in the short-term.

Based on the existing asset condition the minimum suggested improvements are:

- Review operations and hydraulics to ascertain root cause of both lagoons being substantially full. Based on this review – determine options to mitigate.
- Undertake mechanical dewatering of sludge drawn from the lagoons (possibly utilising mobile dewatering equipment) to enable the sludge drying beds to be bypassed, or the loading on the sludge drying beds to be significantly increased.
- Consider disposing of dewatered cake (14 to 17% solids) to a future waste sludge cake receival facility, or direct to the sludge drying beds for further drying.
- Establish additional drying beds.
- Consider sludge dewatering equipment including a screw press, belt filter press or centrifuge.

Considering the 60,000 EP plant upgrade, the two options considered for upgrading the sludge dewatering facility are either:

- Expansion of the existing manually operated drying beds
- Construction of a new mechanical dewatering facility incorporating either: centrifuge or belt filter press equipment, polymer dosing system and sludge out-loading infrastructure.

4.3.8 Electricals and motors

The majority of the STP components need to be replaced or rehabilitated. The majority of the electrical controls and electrical equipment is described as obsolete.

The motors throughout the Queanbeyan STP are described as aged, inefficient and have a reduced lifespan. This was indicated by the electrical investigation by KMH Electrical in 2012. The motors are identified as relatively small for their operations. The continuous high load on the motors throughout the plant had caused them to age and the motors are expected to be nearing the end of their operational lifespan.

Other instruments such as flowmeters are non-operational, and if functioning not calibrated.

The adjustment of penstocks is not automated.

4.3.9 Civil structures

A large proportion of the original treatment plant is still integral to the current treatment process. Civil structures associated with the original plant show a lot of wear and tear, which is understandable with exposure to harsh conditions over a long period. This is demonstrated by the extensive cracking around the trickling filters that are now post tensioned (braced) with steel cabling. Other concrete structures show similar signs of deterioration and the structural integrity of pipework around the cold digester arrangement is in a state of disrepair. It is unlikely any of the structures meet current standards (water retaining structures, earthquake loading, WH&S etc.) and as such represents a considerable legal / liability risk for Council. The remaining life of the ageing infrastructure is questionable, given its current age and there will be a substantial cost in refurbishing and maintaining the aged assets, albeit for a reduced lifespan (15 - 20 years) when compared with new infrastructure.

Cost estimates for the repair and refurbishment of treatment components that are required to support operation immediately and in the short term (2 - 5 years) are presented in Appendix I.

4.3.10 Existing authorisation

The Queanbeyan STP is currently certified under the Environment Protection Act 1997 (Environmental Authorisation 0417). The general requirements of this authorisation include:

- General water protection conditions
- Monitoring
- Reporting
- General conditions for diversion to the lagoons
- Management of sludge.

The ACT Environmental Protection Authority (EPA) has previously supported the proposed STP upgrade under the conditions of "no pollutant increase" (letter, Lucy Vincent (EPA) to Greg Fogarty (QPRC), 13 November 2008).

The operations of the whole sewerage system (STP and collection system) comes under the jurisdiction of DPI Water, which carries out periodic inspections of the STP. This means that the regulatory context for the STP operations is complex.

A new licence would be required as a result of this upgrade project.

4.4 Concluding observations

With an ageing plant, operability and reliability present a number of challenges, largely relating to operator involvement. The key issues are as follows:

- Work Health and Safety (WHS) risks exist as a result of aged infrastructure and manual operation of stopboards and penstocks
- Hydraulic capacity issues and treatment inefficiency for the inlet works and primary screening
- Environmental discharges of untreated stormflows in the absence of stormflow storage
- The treatment train has been developed in a somewhat adhoc approach, with adjustments being made to the original STP components. The current treatment train could be improved to enhance treatment and operability
- The sludge handling facilities are undersized and sludge treatment could be enhanced

- Most equipment throughout the STP is manually controlled with limited feedback into the plant SCADA system; hence not all equipment failures are detected for response
- Most of the STP mechanical and electrical plant / equipment is at the end of its effective life and needs replacement.

The existing Queanbeyan STP condition currently presents a risk to QPRC with numerous suggestions for both immediate and short-term improvement. Beyond operability and WHS issues, there will be a stronger focus on water quality and environmental discharges. Tighter discharge criteria are likely to be imposed in the future when licence conditions are re-negotiated. Following a workshop for this project, Heath Chester (ACT EPA) commented *"*Queanbeyan *STP effectively sets the baseline of the nutrient status for Lake Burley Griffin, thus any reduction in nutrient input from the STP will assist the River and Lake in being more resilient to other stressors".* Whilst diffuse nutrient pollution of the River and Lake present a highly important contribution of nutrients to these waterways, the Queanbeyan STP presents the highest known point source discharge of nutrients within the catchment and thus improvements in treatment will be a target for the Catchment Management Co-ordination Group and will ultimately be of value to the receiving waterways.

Given the advances in treatment technology, the age and condition of the existing STP, and the likely more stringent future effluent discharge requirements, the appropriate course of action for QPRC is to upgrade the existing STP, potentially replacing it completely. Table 4-2 presents the short and long-term options for the treatment. Many treatments need immediate intervention and short-term refurbishment to sustain the existing plant operation. Most are unfit or unable to be adapted to be functional within the scheme of the new 60,000 EP STP. Comments are provided to this effect.

Given the treatment limitations the most obvious option for consideration is full replacement. The other options include some re-use of existing assets where they can be retained and refurbished to a 25-year lifespan. The benefits of full refurbishment are as follows

- Better assurance that completed works will meet required discharge requirements
- Better assurance that completed works will have an adequate service life over and above additional service life that might be achieved through renewing or retrofitting the existing plant
- Easier and less risk during commissioning and transfer of operations to the new plant (the existing STP can be kept in operation while commissioning and proving the new STP)
- The ability to accommodate future increased loads due to growth, particularly in the south of the LGA.

Table 4-2 Short and long term options for treatments

Area	Outcome (2-5 years)	Comment	Outcome (15-25 years)	Comment
Inlet screens	Refurbish	For interim service only	Redundant	• Outdated and undersized process unit and would serve no purpose in a new or updated plant
Inlet flow splitting and flumes	Refurbish	For interim service only	Redundant	• Outdated and undersized process unit and would serve no purpose in a new or updated plant
Aerated grit chamber	Retain – performing no role	For interim service only	Redundant	• Undersized and underperforming process unit and would serve no purpose in a new or updated plant
Vortex grit chamber	Refurbish	For interim service only	Redundant	• Undersized and underperforming process unit and would serve no purpose in a new or updated plant
Primary clarifier and Imhoff tanks	Retain	• Imhoff tanks outdated process unit • Structures/concrete in very poor to fair condition • Primary solids removal not consistent with an improved environmental discharge of < 5 mg/L TN as want to retain carbon • Limited to no residual design life • Not compliant with WHS standards.	Redundant	• Limited possibilities in refurbished or new plant options: – Inlet flow balancing volume (for MBR using existing bioreactors) – Solids removal for part load – Standby emergency storage unit.

Area	Outcome (2-5 years)	Comment	Outcome (15-25 years)	Comment
Trickling Filters 1 and 2	Retain (monitor closely for catastrophic failure). Bypass if other secondary treatment is sufficient.	• Structures/concrete in fair to poor condition • Poor location – Low elevation • Not consistent with an improved environmental discharge of < 5 mg/L TN.	Redundant	• Trickling filter outdated process unit and would serve no purpose in a new or updated plant.
Trickling Filters 3 and 4	Retain	• As above.	Redundant	• As above
Secondary reactors	Retain (some possible refurbishment / improvements to process aspects)	• Structures / Concrete generally good condition • Residual design life not clear • Difficult construction and operation staging – likely to increase timeline by 18 to 24 months as cannot be taken fully offline • Trapezoidal base difficult to retrofit diffused aeration • Down-rate would require retrofit to meet TN < 5 mg/L.	Refurbish / Redundant (dependant on concept design and hydraulic cycle) (concrete may not have sufficient residual design life).	• Possibilities for use in refurbished or new plant as: – Aerobic digester (2 – 2.5 ML required) and existing aeration maybe OK - to achieve Grade B Biosolids – Balance volume for MBR plant - either new plant or combined with refurbishment (6 – 8 ML required) – Bioreactor in MBR process (6 - 7 ML required) – challenge to refurbish/ reconfigure and maintain treatment

Area	Outcome (2-5 years)	Comment	Outcome (15-25 years)	Comment
Humus clarifier and tank	Retain	• Structures/concrete in fair condition • Poor location – low elevation = pumping costs to downstream process step • Limited to no residual design life • Not compliant with WHS.	Redundant	• Treatment would serve no purpose in a new or refurbished plant • Too small to be much significant use in future plant as a tank for an alternate use.
Clarifiers	Retain	• Structure/concrete in good condition • Poor flow split between tanks • Chain scrapers: very old technology • Weirs and scum baffles/skimmers require replacement • Poor position – Low elevation and close to flood level (unless effluent lagoons reused) – need to pump to tertiary process step to achieve a potential future TP target of < 0.1 mg/L. • Suspect foundation encroachment from flood inundation.	Refurbish, including flow splitter (dependant on concept design and hydraulic profile)	• Possibility to reuse as tertiary clarifiers to settle chemical P solids • Would require significant mechanical retrofit to achieve performance required – difficult in the shape of clarifier
Anaerobic digester	Redundant	-	Redundant	

Area	Outcome (2-5 years)	Comment	Outcome (15-25 years)	Comment
Maturation Ponds	Retain (possible vegetation removal)	• Structures in poor to fair condition and require substantial retrofit and refurbishment to achieve performance • Concern about long-term stability of creek-side embankments • Below flood level – retention may require a flood levee bank be constructed • Outlet for environmental discharge is impacted hydraulically by the Molonglo River water level.	Refurbish / Redundant (dependant on concept design and hydraulic profile)	• Possibilities for use in refurbished or new plant options: • Effluent polishing and solids removal with use of secondary clarifiers in tertiary clarifier duty
Sludge lagoons	Refurbish plus additional lagoon	• Struggle to meet current performance due to size as sludge is not pre thickened • Not compliant with WHS standards.	Refurbish / Redundant (Dependant on concept design and hydraulic profile).	• With WAS pre-thickened to 4.5% DS - Provides 80 days in each lagoon. • Possible to therefore use in refurbished or new plant to achieve Grade B biosolids.
Sludge drying beds	Refurbish plus additional bed	-	Refurbish / Redundant (dependant on concept design and hydraulic profile).	• Possible to use in refurbished or new plant.

Area	Outcome (2-5 years)	Comment	Outcome (15-25 years)	Comment
Bypass storage lagoon	New facility proposed	-	Retain.	• Possible to therefore use in refurbished or new plant.
Buildings - all	Refurbish (limited)	-	Refurbish / Redundant (dependant on concept design).	• Possible to therefore use in refurbished or new plant.

5 Future sewerage infrastructure

5.1 South Jerrabomberra

Significant development is planned for the South Jerrabomberra valley, located to the South East of Queanbeyan Central Business District, as shown in Figure 5-1. In the first stage of development, this area will be served by a sewage pump station (SPS) to transport sewage to the Jerrabomberra Trunk Sewer (hence Queanbeyan STP). In the future, an upgraded SPS and Jerrabomberra Trunk Sewer or an independent STP could serve the area. It is possible that unplanned discharge to the Jerrabomberra Creek system could occur from sewerage infrastructure constructed to service this area in the short term. Depending on future planning decisions about servicing the South Jerrabomberra area there may be a need to allow for planned licensed discharges of treated effluent.

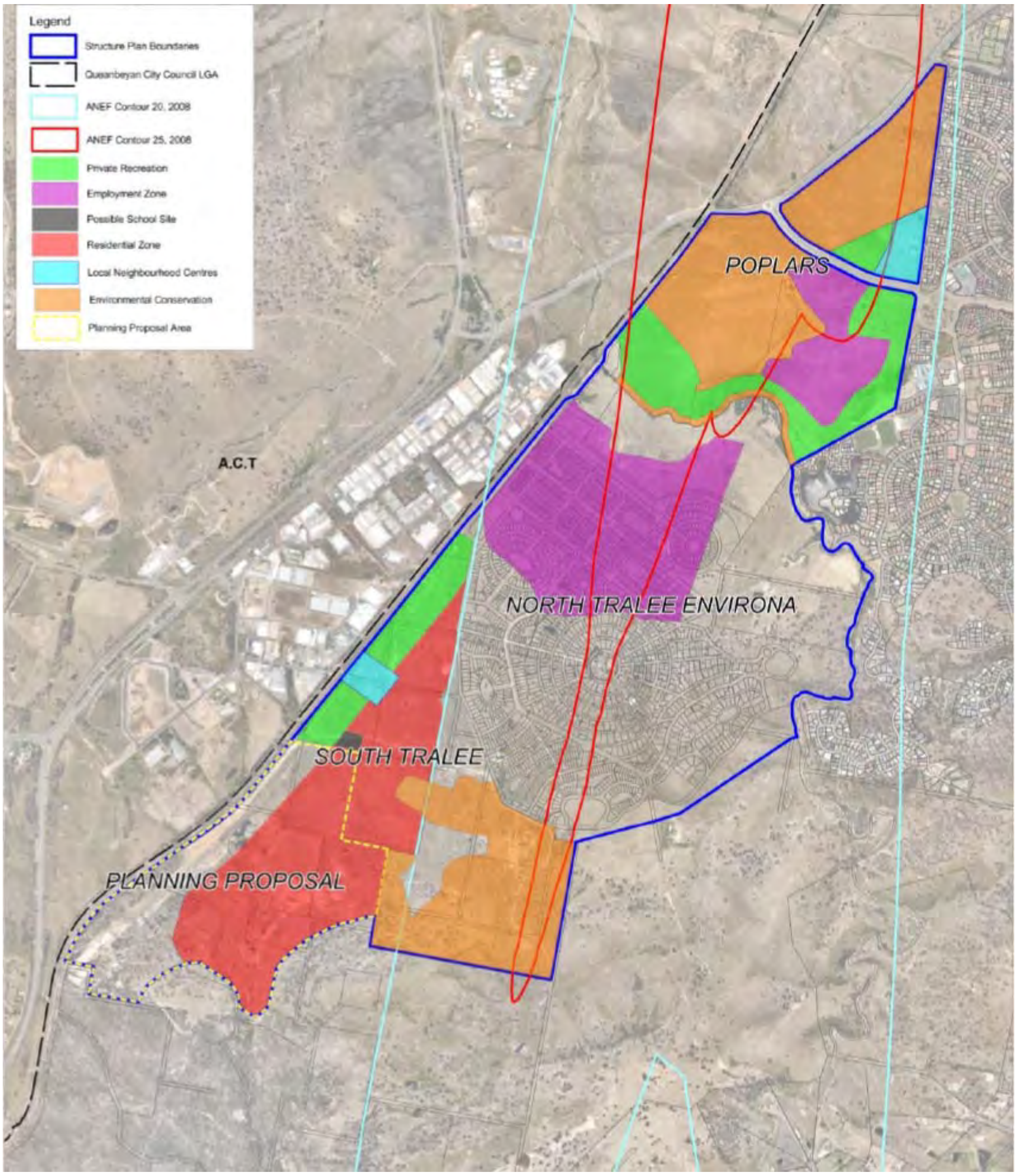

Figure 5-1 Proposed future land uses of South Jerrabomberra

Sewage from the development will need to be treated either by the Queanbeyan STP (via the Jerrabomberra Trunk Sewer) or a future local decentralised STP.

A pump station at the northern end of South Tralee has been proposed to service the initial stage of this development. An additional independent pump station may be needed to service the northern developments of Environa, North Tralee and Poplars.

The existing telemetry system is unable to communicate reliably with these proposed pump stations and will therefore need to be upgraded. Upgrading of the telemetry systems should be considered as part of the first stage of upgrading the existing STP.

The 600 mm diameter Jerrabomberra Trunk Sewer could potentially be used to drain major developments to the south of the Queanbeyan urban area. The impact from new developments (viz. Tralee) and urban infill on the trunk sewer was analysed using XPSWMM software. This software tracks sewage flows as they progress downstream taking into account storage effects within the pipe network.

The model for the STP Masterplan was developed in conjunction with planning for the South Jerrabomberra / Tralee developments. These investigations indicated that the optimum point of connection for future loads is manhole W76 on the Jerrabomberra Trunk Sewer. The computer modelling assumed that future developments south of Tralee would also be connected at manhole W76.

Although the model provides a reasonable snapshot of likely flow conditions, a more detailed analysis will be needed during concept design to confirm results and provide sufficient basis for design of future augmentations. The criteria used to identify problem areas in the Jerrabomberra Trunk Sewer are listed in Table 5-1 and loads on the trunk sewer used to calculate flow conditions are listed in Table 5-2. It should be noted that the average dry weather flow (ADWF) used in this capacity assessment is more conservative than the value derived for the growth projections (refer Section 3). This was done to account for uncertainties about future conditions.

Table 5-1 Sewer Capacity Criteria

Item	Description	Value
ADWF (for existing urban areas)	Daily dry weather discharge from an equivalent person. This includes a minor allowance for dry weather ground water infiltration. The given value is based on experience in the existing sewerage network and makes allowance for declining sewer condition over time and also takes into account increased base flows due to deterioration of private sewers.	240 L/EP/day
ADWF (for future urban areas)	Daily dry weather discharge from an equivalent person. This includes a minor allowance for dry weather ground water infiltration. The given value is based on data related to new developments being planned for Googong and Tralee. A lower per capita discharge was assumed in these areas because the designs will be based on newer technology, low infiltration design and construction methods, and water efficient approaches.	210 L/EP/day
Peak dry weather flow (PDWF / ADWF) ratio	The software uses flow hydrographs (diurnal flow variation) as an input instead of a multiplier. The ratio of the peak value to ADWF in the model is indicated. The diurnal pattern (attached) was based on data from similar catchments as Queanbeyan does not have any gauged data.	2.20

Item	Description	Value
Peak wet weather flow (PWWF / ADWF) ratio	Wet weather events were not modelled as there was limited hydrologic data. However, flows into the STP indicate that the ratio of wet weather flow to average dry weather flow is in the order of 5.50. This ratio was used together with the dry weather modelling results to assess the risk of overflows from the system.	5.50
PDWF / Qf ratio	Wet weather flows up to a design event are usually contained within the pipe barrel i.e. the pipe capacity (Qf) must be equal to the PWWF. This means that the PDWF must be limited in order to provide sufficient capacity for wet weather ingress. The value given is based on current data for Queanbeyan.	0.40
d/D ratio at PDWF	This ratio value is a direct result of circular pipe hydraulics and the PDWF/Qf ratio of 0.40.	0.44
Vsc	The generally accepted self-cleaning velocity (minimum) at PDWF for sewers is 0.70 m/s. This provides flow conditions in the sewer, which will transport solids along the sewer rather than allow solids to settle and build up in the sewer.	0.70

Table 5-2 Sewage Loads on the Jerrabomberra trunk sewer

Planning Horizon	Queanbeyan		Future Urban Areas		Total Development	
	EP	ADWF (ML/d)	EP	ADWF (ML/d)	EP	ADWF (ML/d)
Current	42,924	10.30	2,100	0.50	45,024	10.81
Yr 10 - Ca. 2025	44,362	10.64	7,488	1.73	51,850	12.44
Yr 25 - Ca. 2040	46,609	11.20	26,678	6.39	73,287	17.59
Yr 50 - Ca. 2065	50,611	12.15	43,837	10.52	94,448	22.67

Notes:

1) The estimate of EP (effective population) and sewage flows was based on EP projections prepared for this Masterplan (refer Section 3).
2) Growth in existing urban areas was assumed to be about 0.33% per annum.

Table 5-3 shows the outcomes of the analysis of the expected growth in sewage flows.

Table 5-3 Outcomes of analysis

Year	Comment / Observation	Length (m)
Current	There appears to be sufficient capacity in the trunk sewer for current loads and the sewer appears to operate within appropriate hydraulic standards. However, some surcharging of manholes in the lower reaches is likely to occur during wet weather events.	(W78-IC) 6,953
Yr 10 - Ca. 2025	The trunk sewer between manholes W78 and W34 appears to have sufficient capacity for expected loads and operate within appropriate hydraulic standards.	(W78-W34) 4,383
	Between manholes W34 and W1 the sewer exhibited surcharging of manholes and there appeared to be a high risk of overflow between manholes W8 and the STP inlet channel.	W1 – W34 2,575 m W8 – STP 635 m
	The extent of surcharging between manholes W34 and W8 was not considered significant. Accepting a lower operating standard for this section could be used to delay major investments in upgrading the capacity of the sewer.	
Yr 25 - Ca. 2040	The trunk sewer does not have sufficient capacity for the expected Year 25 loads and there appeared to be a significant risk of overflow at a number of points along its length.	6,652 m
Yr 50 - Ca. 2065	The trunk sewer does not have sufficient capacity for the expected Year 25 loads and there appeared to be a significant risk of overflow at a number of points along its length.	6,652 m

Notes:

1) Analysis assumes the whole of any additional loads from future development will be transferred to the Jerrabomberra Trunk Sewer at Manhole W76
2) Figure 5-2 (following) shows the affected sections of the Trunk Sewer due to expected Year 10 loads.

Figure 5-2 Expected condition of the Jerrabomberra trunk sewer after 10 years (Image from South Jerrabomberra Structure Plan 2013)

5.2 Googong Township

Googong Township is designed around an integrated water cycle (IWC), which aims to cut potable water consumption by up to 60%. The IWC includes all elements associated with the supply of potable water, the collection and treatment of sewage flows and transfer of treated flows into the recycled water system for reuse in the community. The system includes potable water, recycled water and sewerage collection networks (collectively known as the Network) and a Water Recycling Plant (WRP).

The Googong Township IWC infrastructure comprises of the following:

- The WRP
- Reservoirs for recycled and potable water
- Pump stations for sewage, recycled water and potable water
- Mains pipework for sewage, recycled water and potable water to connect to the neighbourhoods
- Structure for the discharge to the stormwater management system
- An Interim Sewer Service was implemented to provide a sewer service for the initial occupancies in the development.

As a result of the IWC arrangements, sewage flows from the area will not drain to the Queanbeyan system, hence have been disregarded in assessing future flows for the proposed Queanbeyan STP upgrade. In contrast, the Googong STP makes no provision for solids treatment and disposal. Hence, solids from the Googong WRP will need to be considered in developing a solids management strategy for the Queanbeyan Palerang LGA.

5.3 Concluding observations

A summary of the risks associated with not upgrading the existing trunk main and the existing hydraulic capacity of treatment at Queanbeyan are presented in Table 5-4. This includes the risk of development in the South Jerrabomberra area being delayed, or alternatively being accommodated without capacity, resulting in environmental and public health consequences.

Table 5-4 Summary of risks

Development Risk	Environmental Risk	Public Health Risk	Economic risk	Reputational Risk
• Risk expansion cannot occur due to capacity constraint • Risk expansion will occur regardless of capacity due to political and developer pressure.	• Risk of discharge from the trunk main • Risk of bypass overflow and inadequate treatment, resulting in poor water quality downstream • Sludge handling risk of being unable to manage increased sludge loads, resulting in an environmental incident or trucking off-site.	• Risk of direct contact with discharge from the trunk main • Resulting public health risk to downstream Queanbeyan River users.	• Loss of potential revenue if Council constrains development • Financial cost of environmental breeches • Cost of sludge handling and disposal outside of the LGA.	• Risk to the reputation of Council through constrained development.

It is recommended that:

- The South Jerrabomberra sewer trunk will need to be upgraded to meet future capacity:
  - Consider augmentation of the Jerrabomberra Trunk Sewer between manholes W8 and the inlet channel of the STP
  - Any further augmentation should be delayed until a final service strategy is decided for future development to the south of Queanbeyan
  - A survey and sewer gauging program should be implemented for the whole length of the trunk sewer (manhole W78 to the STP inlet channel) to enable a more detailed analysis of the sewer
- Continue discussions with Icon Water around cross-border arrangements and a regional approach to sewage management.
- A septic tank receival station should be included in the new plant.

6 Environmental constraints

There are environmental constraints in the QPRC LGA that could potentially affect future construction and expansion in the region. This must be addressed when considering the location of sewage infrastructure. The more important criteria are discussed further below.

6.1 Heritage reserve

Land that is listed as heritage protected will have particular restrictions regarding construction in the area such as the type of structure that can be erected, restriction on removal of vegetation to accommodate for space for a new STP etc. Particular care must be taken to meet these requirements, and so this will affect population growth in the regions displayed in Figure 6-1.

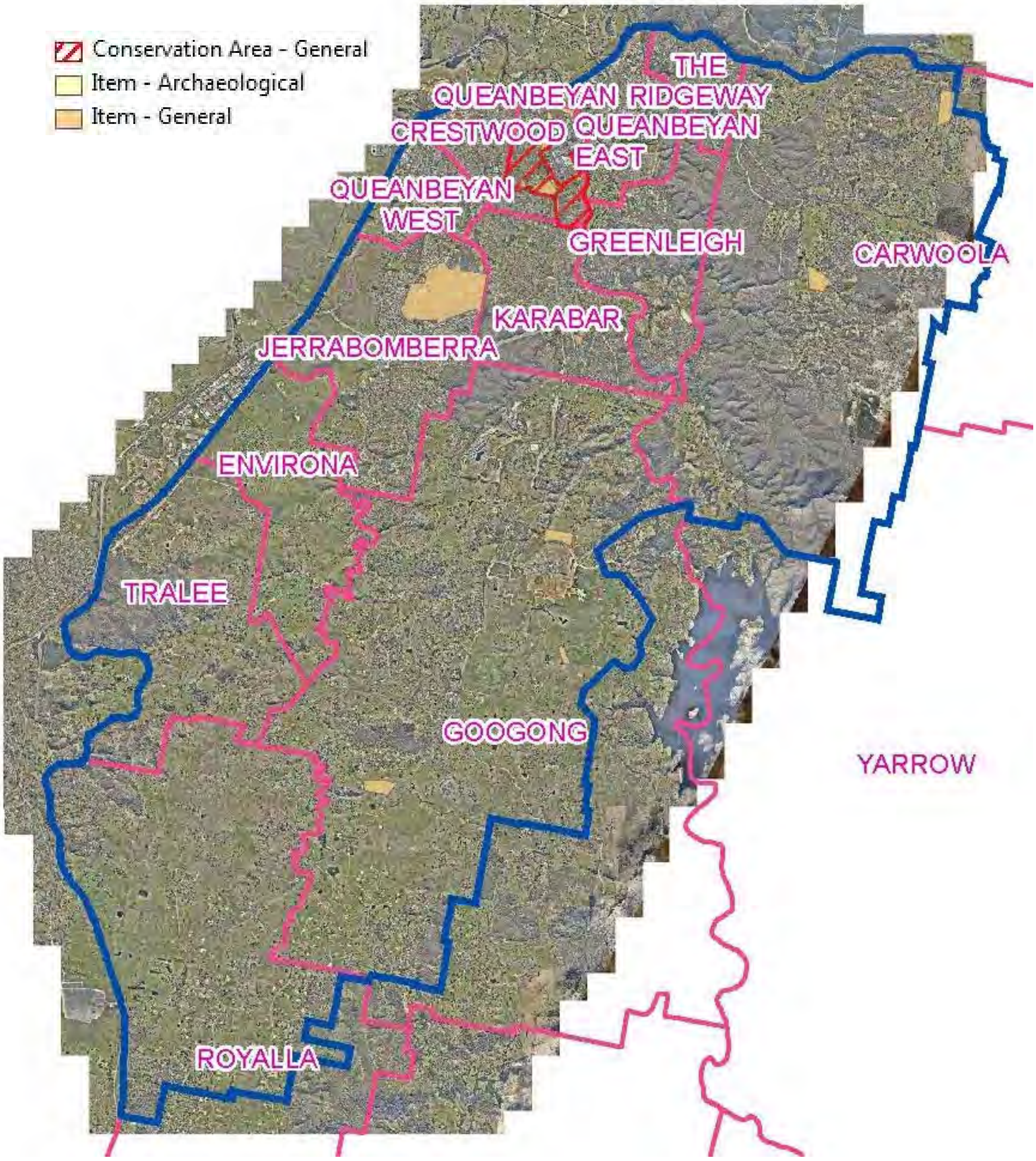

Figure 6-1 Heritage reserve areas in the QPRC LGA

6.2 Scenic protection

Canberra government enforces restrictions in order to protect the aesthetic integrity of regions considered scenic. This will affect projects that would require significant landscaping or that would obstruct scenic views. Areas under scenic protection are displayed in Figure 6-2.

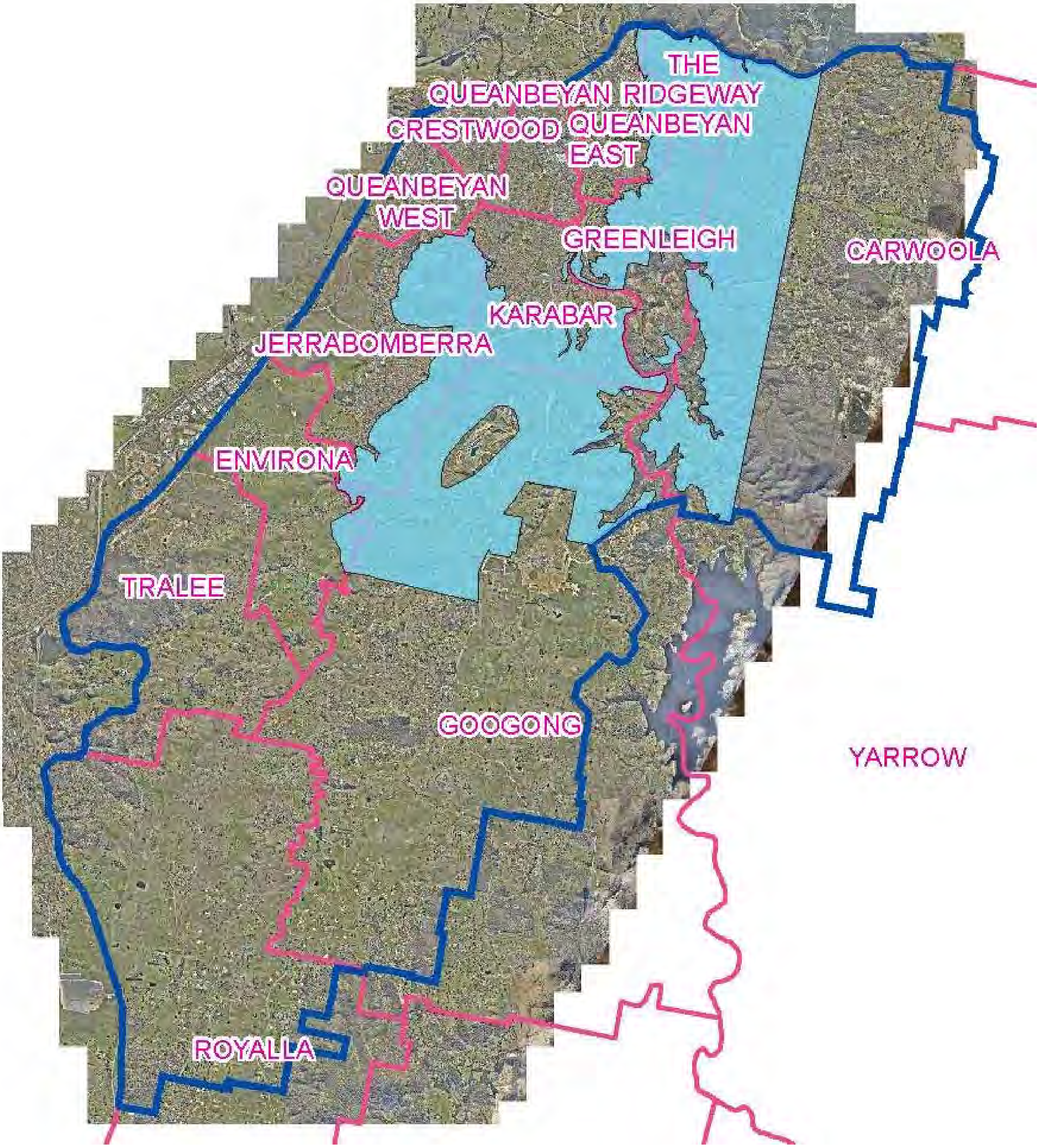

Figure 6-2 Scenic protection areas in the QPRC LGA

6.3 Quarry buffer

The Holcim quarry is located west of Googong, as shown in Figure 6-3. This buffer area is required to be maintained and cannot be encroached on by development.

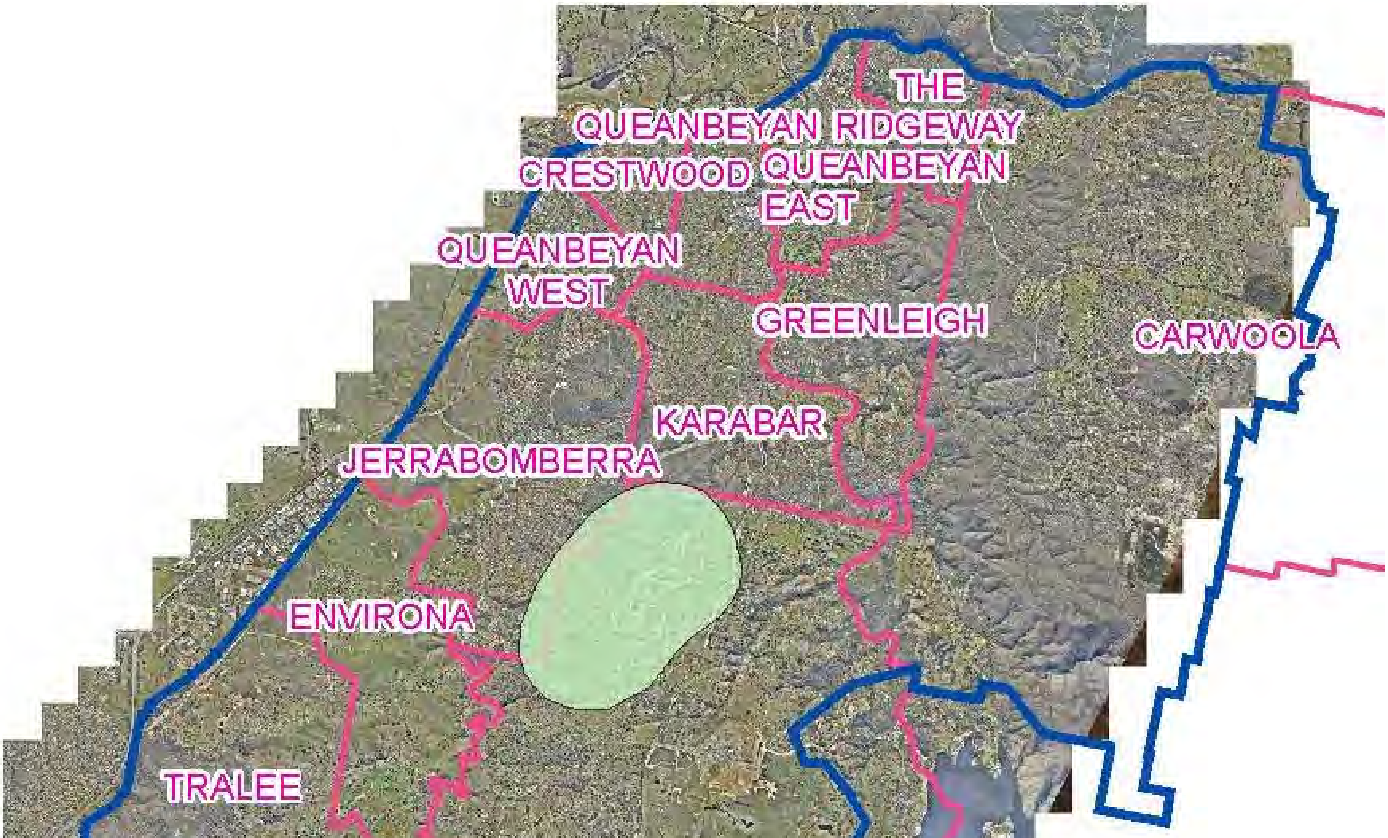

Figure 6-3 Quarry buffer area in the QPRC LGA

6.4 Australian Noise Exposure Forecast (ANEF)

Canberra Airport is situated north west of Queanbeyan giving rise to flight paths directly over the western portion of the LGA. Figure 6-4 displays the noise effects caused by the nearby airport on the Queanbeyan LGA.

ANEF modelling produces a noise exposure (ANEF) map showing contours for 20, 25, 30, 35 and 40 ANEF units. Higher contour numbers represent greater cumulative amounts of aircraft noise over an average one-year period. ANEF units are not decibel measurements - they are measures of adverse community reaction to aircraft noise. Above 20 ANEF homes, schools, hospitals and nursing homes should have noise insulation and above 25 ANEF, aircraft noise is too great for these buildings even with insulation. Even at 15 ANEF, 35% of people are seriously or moderately affected by aircraft noise. ANEF of less than 20 is acceptable for the building of new residential dwellings.

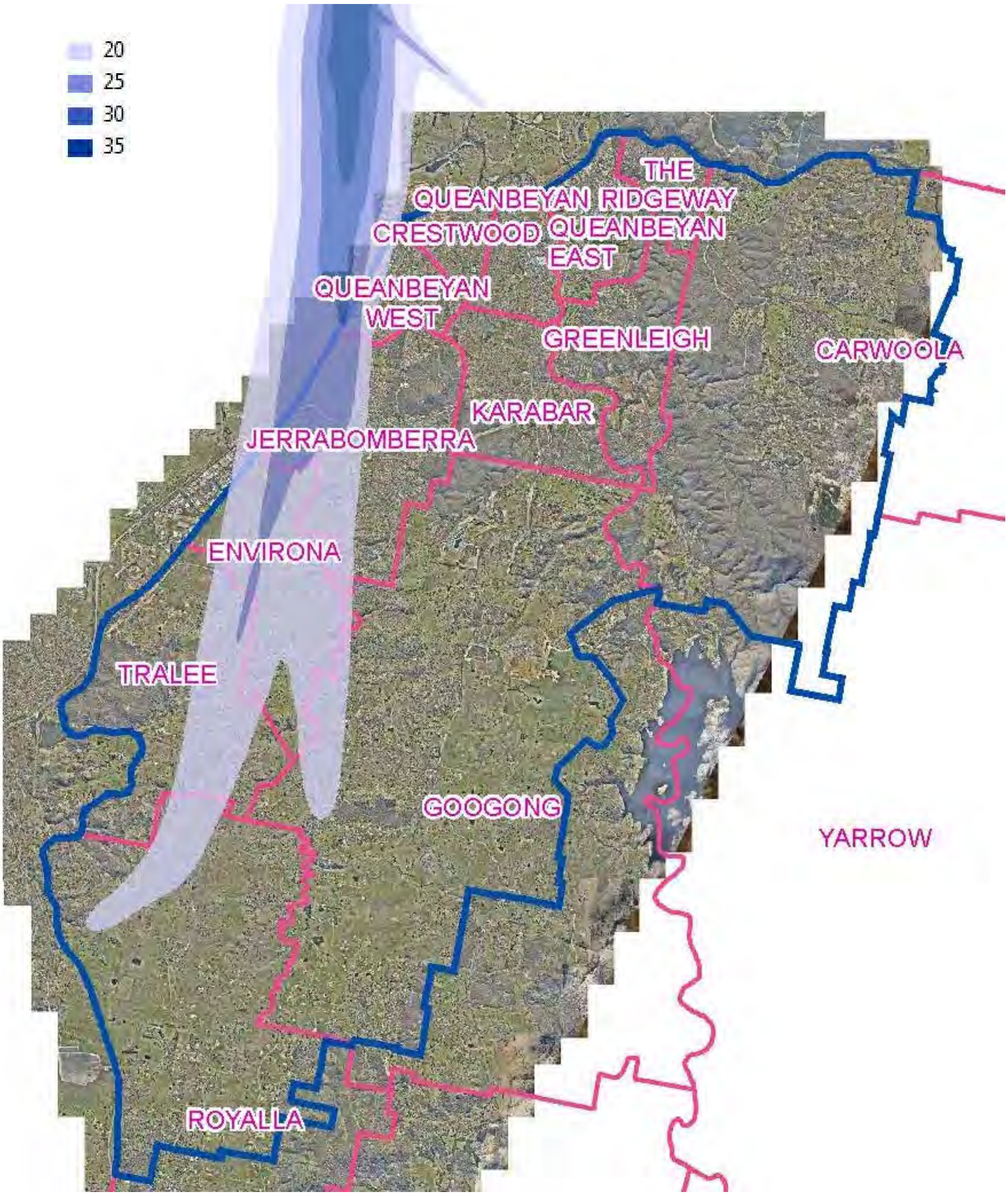

Figure 6-4 ANEF for airport noise levels in the QPRC LGA

6.5 Floodplains

Rainfall in the area flows from the surrounding mountain ranges towards Queanbeyan River, which runs from the Googong reservoir, down through Karabar / Greenleigh, towards Queanbeyan where it merges with the Molonglo River. The area at the bottom of the Queanbeyan River, where it merges with Molonglo, is at risk of flooding, as illustrated in Figure 6-5.

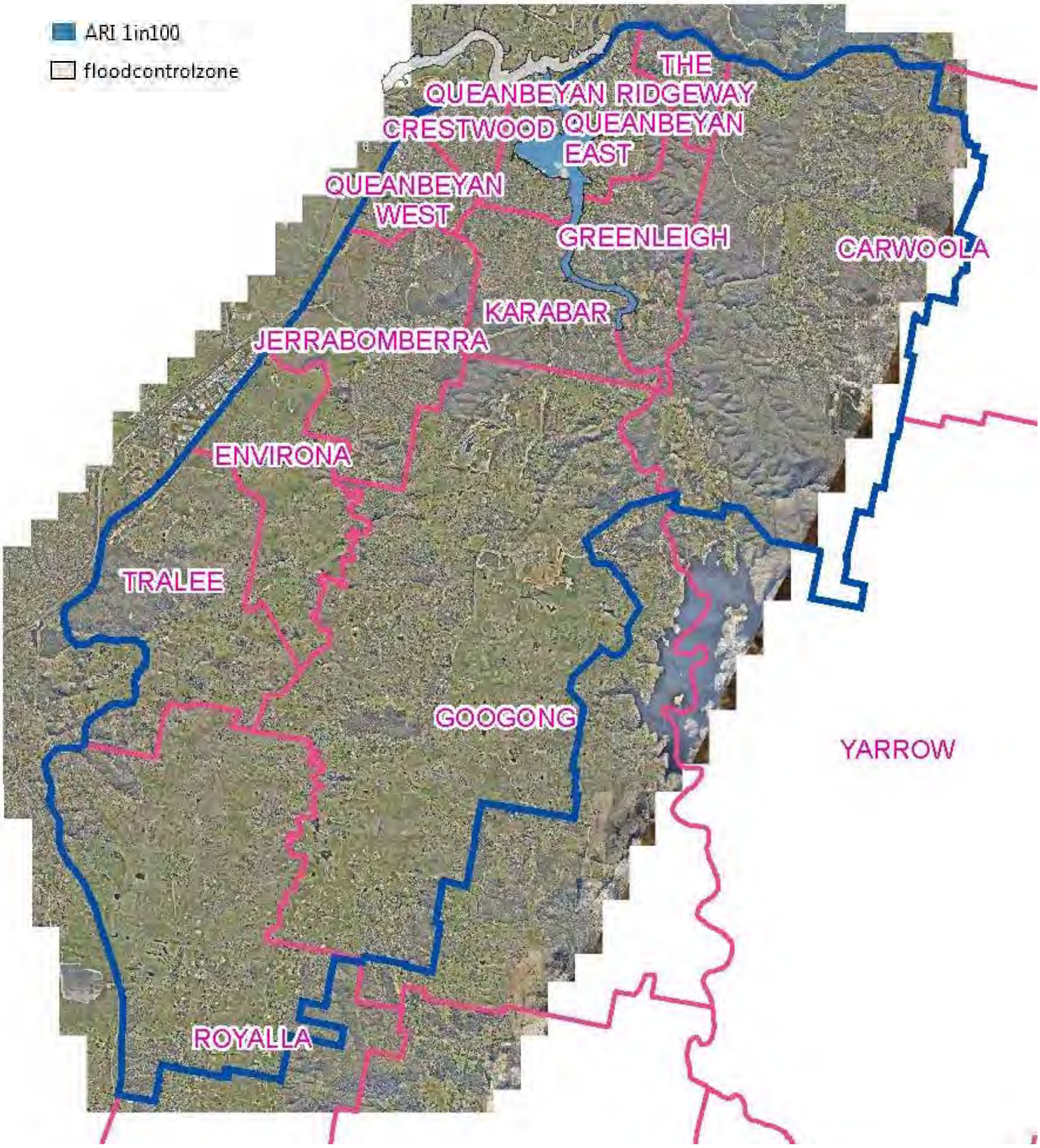

Figure 6-5 Floodplain areas in the QPRC LGA

Flooding is an issue at the existing site. Figure 6-6 shows (in yellow) the Q100 flood line for the existing STP site. The river is shown schematically in blue, and the main STP process assets are outlined in green. Any future work will need to ensure that the infrastructure is protected from the Q100 flood, and that any existing infrastructure that lies within the Q100 is decommissioned appropriately.

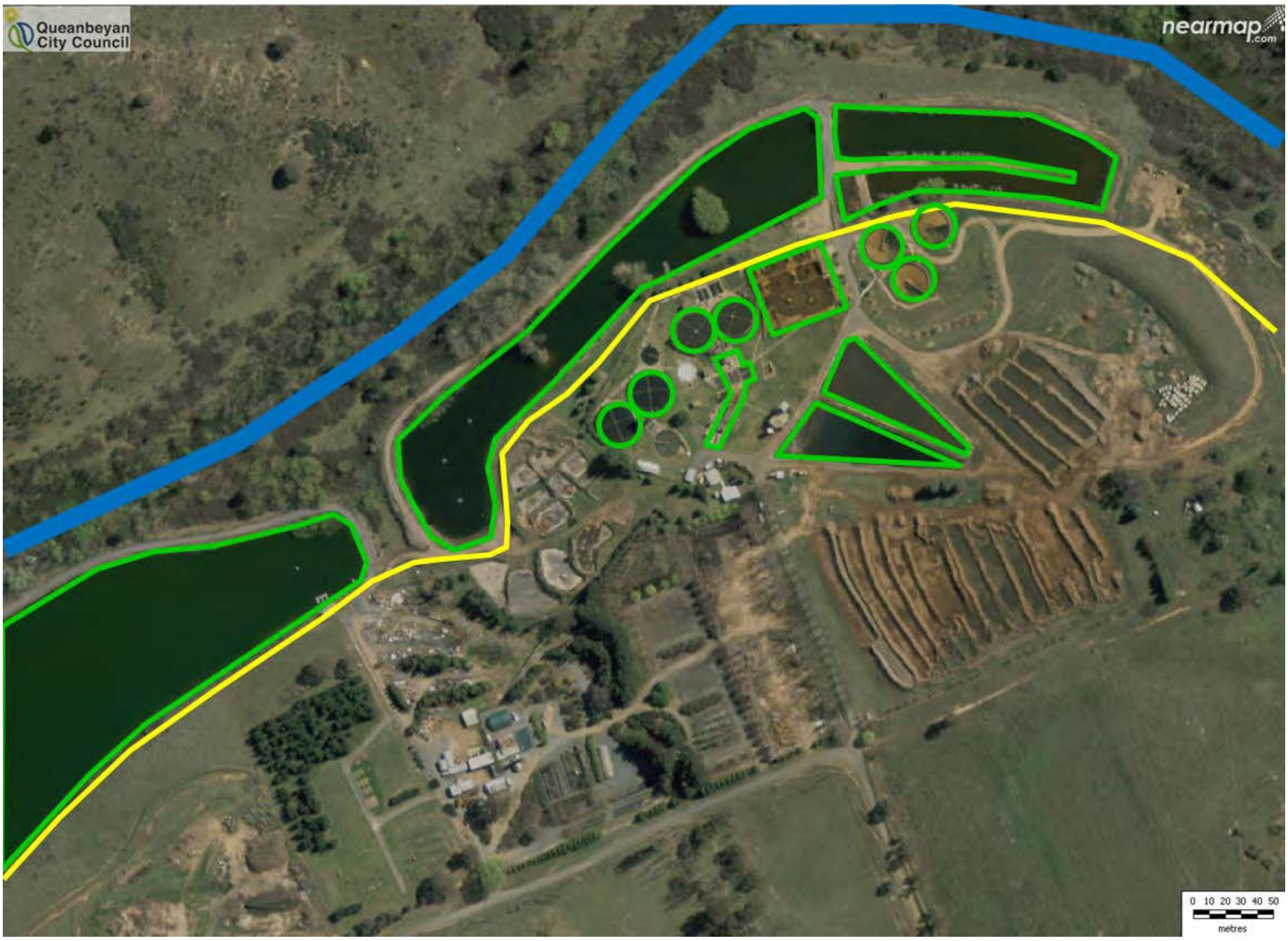

Figure 6-6 Contour of Q100 flood line in relation to Queanbeyan STP infrastructure

6.6 Bushfire prone areas

Although the Queanbeyan suburbs are densely populated, the majority of the LGA is significantly vegetated. These areas are quite bushfire prone, especially in the north-eastern mountain ranges. Figure 6-7 indicates the possible bush-fire risk level throughout the LGA; as linked to the vegetation category being proportional to the bushfire risk level.

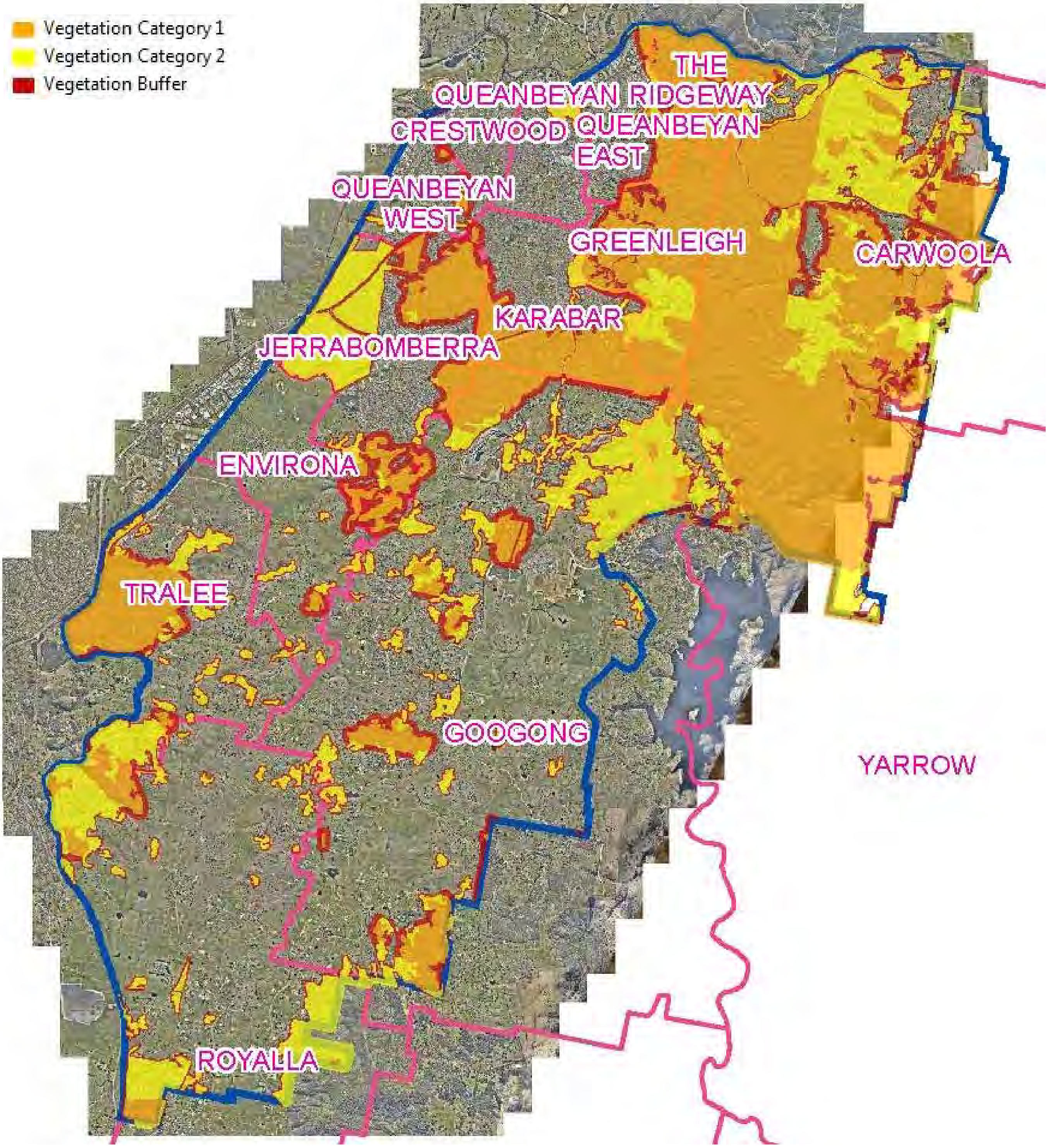

Figure 6-7 Areas in the QPRC LGA with significant bushfire risk

6.7 Review of current site

A preliminary review of the environmental aspects considering constraints and issues for the current site has been undertaken. Consideration has also been given to how some of these issues can be managed. The results of this review are given in Table 6-1.

Table 6-1 Current site environmental aspects and potential mitigation

Environmental Aspect	Potential Mitigation
Odour	***Issue*** The nearest sensitive receptor is at the south-eastern boundary of the site in Oaks Estate and Beard Estate. All possible measures would need to be considered to reduce the emission of odours that could potentially affect sensitive receptors. Wind and other meteorological aspects need to be determined to assess their effect on potential odour emission. No conditions exist in the Licence. ***Mitigation*** Liaison with stakeholders should occur to determine if odour emissions are occurring. Considerations should be taken for any activity during construction which could increase the levels of odour emissions.
Noise and Vibration	***Issue*** All reasonable steps would need to be taken to reduce construction equipment noise and minimise impact on neighbouring properties. The nearest sensitive receptor is at the south-eastern boundary of the site. ***Mitigation*** Construction activities would be restricted to certain times of the day, e.g. Monday to Friday 7 am – 6 pm, Saturday 8 am to 1 pm. No work would be undertaken on Sundays or public holidays. Equipment selection and design should consider noise impact implications. Blowers and other potentially noisy equipment could be housed in suitably designed buildings to provide noise attenuation.
Transport and Traffic	***Issue*** There would likely be an increase in traffic to the site during construction works; including construction vehicles, deliveries and construction personnel travelling to and from site. This could lead to a large amount of congestion, resulting in a disruption to other transport routes. Further, the extra traffic may increase the possibility of erosion along road-sides. ***Mitigation*** Speed limits should be adjusted to manage traffic appropriately. There should also be an increase in road signage. Machinery should be maintained and checked to be in working order. Further, road load limits and sight distances should be taken into consideration when formulating a traffic management plan. The approach roads to the plant will need to be upgraded.
Chemical Handling	***Issue*** There is potential during construction and operation for the occurrence of spills and leaks. This could potentially contaminate soil and waterways. Further, the health of fauna, flora, and humans could be adversely affected. ***Mitigation*** Designated areas should be determined to accommodate potentially damaging materials. The storage and handling of chemicals should be in accordance with the safety data sheet and other guidelines. There should be appropriate procedures and emergency plans in place, and these plans should be included in staff inductions and training.

Environmental Aspect	Potential Mitigation
Sludge Handling	***Issue*** Large amounts of contaminated material (in the form of sludge) would be produced during operational activities. If managed inappropriately, this could contaminate local waterways and soil. Section 3 of the Licence indicates that sewage sludge and screenings should be managed on site such that there is no discharge to surface water or groundwater. It is anticipated that in the new plant, this practice would not be allowed to continue but instead treatment and disposal should occur. Reuse of sewage sludge in the ACT should be in accordance with the National Water Quality Management Strategy Draft Guidelines for Sewage Systems Sludge (Biosolids). ***Mitigation*** Proper disposal methods and safety plans should be designed and incorporated into staff inductions and training. The design of systems that produce sludge should allow for safe removal.
Land Use	***Issue*** The site is an existing STP and this use would continue under this project. There are adjacent land users who may be affected by construction or operational impacts. ***Mitigation*** Appropriate liaison with the different stakeholders to maintain open and clear communication channels should be incorporated. An allowance for stakeholder feedback would also assist mitigation.
Soil Contamination	***Issue*** There is known contamination on the site due to burial of solids and screenings. ***Mitigation*** Consider location of new works to avoid contaminated areas. Provide for remediation in the scope of works for construction.
Flora and Fauna	***Issue*** The STP site is not likely to be a habitat for any threatened species (though this needs to be checked during the EIS) and therefore it is unlikely that the proposed construction works at the site will have an impact on any threatened species. Threatened ecological communities listed in the EPBC Act should be considered. Those communities which are likely to occur are: • Natural Temperate Grasslands of the Southern Tablelands of NSW and the ACT (Endangered) • White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Critically Endangered). Consideration should also be given to ecological communities that may be present in the maturation lagoons. ***Mitigation*** Tree removal would be minimised in design. Environmental management plans would be required for construction and operation stages.

Environmental Aspect	Potential Mitigation
Air Quality	***Issue*** Local air quality could be affected by emissions from construction traffic and equipment. Earthworks required as part of the construction works may give rise to dust impacts. It is not anticipated that there will be long-term impacts on air quality from the operation of the STP. ***Mitigation*** Construction vehicles and equipment would be required to have been serviced within the six-month period prior to the commencement of construction activities; Limit the area of bare ground to be exposed at any one time (where possible); Water down bare ground during construction, particularly during windy conditions.
Water Quality	***Issue*** Operationally the proposed upgrades to the plant will improve treated effluent quality and therefore reduce the potential impacts of effluent leaving the site. Impacts to water quality could arise during construction due to sediment run-off. The Licence indicates various load limits for pollutants. ***Mitigation*** A project specific construction environmental management plan would be prepared prior to construction commencement. In maintaining current environmental flow levels, a monitoring system will need to be put in place. Further, effluent quality will still need to be monitored to minimise the risk of contamination in the effluent. Design phase should consider river bank restoration and protection to guard against flood damage and spills from ponds.

6.8 Concluding observations

The following measures should be considered when deciding the location of the future STP:

- Avoid heritage listed sites, scenic protection areas, and quarry buffer zone
- Construction within the ANEF affected areas could be considered appropriate as aircraft noise is unlikely to be an adverse impact on STP operations
- Avoid infrastructure within the Q100 flood level without adequate flood protection measures in place
- Avoid bushfire prone areas or provide adequate protections, appropriate to STP operations
- Consider and incorporate mitigation of environmental issues (such as water quality, odour, noise, contaminated land etc.) on existing site as part of concept design.

7 Water quality objectives assessment

7.1 Scope

A water quality objective assessment (WQOA) was undertaken to investigate, model and examine the effects of current and future STP operations on receiving water quality for a range of possible treatment, effluent quality and release scenarios. The outcomes from this study were used to inform the development of future effluent quality objectives which in turn will influence decisions on treatment options, technologies and operations of the new STP. Water quality and flow data analyses have been undertaken to understand the present and historical conditions in the Molonglo River and in Jerrabomberra Creek, and how these may have been influenced by the STP.

The data analysis was used to inform and develop detailed models of the Molonglo River quality in the reach from the present STP discharge location to Lake Burley Griffin (LBG). The model was then used to understand the 'baseline' water quality of the river in the hypothetical absence of any STP discharging into the river. This baseline was superimposed with several test scenarios for various future STP loading, effluent quality and flow rate permutations to understand the impacts that future plant operations may have on receiving water quality. It is anticipated that the model outcomes will inform a discussion on future effluent quality and Molonglo River management objectives. The effluent discharge and water quality scenarios reviewed are summarised in Table 7-1, at the Locations as shown in Figure 7-1.

For the full report, refer to Appendix D.

Table 7-1 Scenarios used for WQOA

Scenario	Equivalent Population (EP)	Discharge (m^3/s)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Faecal Coliforms (CFU/100 mL)
1	0 (i.e. no STP)	0	N/A	N/A	N/A
2	45,000 (current)	0.133	5	0.1	Time series generated from fitting lognormal probability distribution to historical effluent data and random sampling (log mean = 3.38, standard deviation = 1.27)
3	45,000 (current)	0.133	10	0.2	
4	45,000 (current)	0.133	15	0.3	
5	77,000*	0.223	5	0.1	
6	77,000*	0.223	10	0.2	
7	77,000*	0.223	15	0.3	
8	100,000**	0.291	5	0.1	
9	100,000**	0.291	10	0.2	
10	100,000**	0.291	15	0.3	

*Estimate for ca. 2040. ** Estimate for ca. beyond 2060.

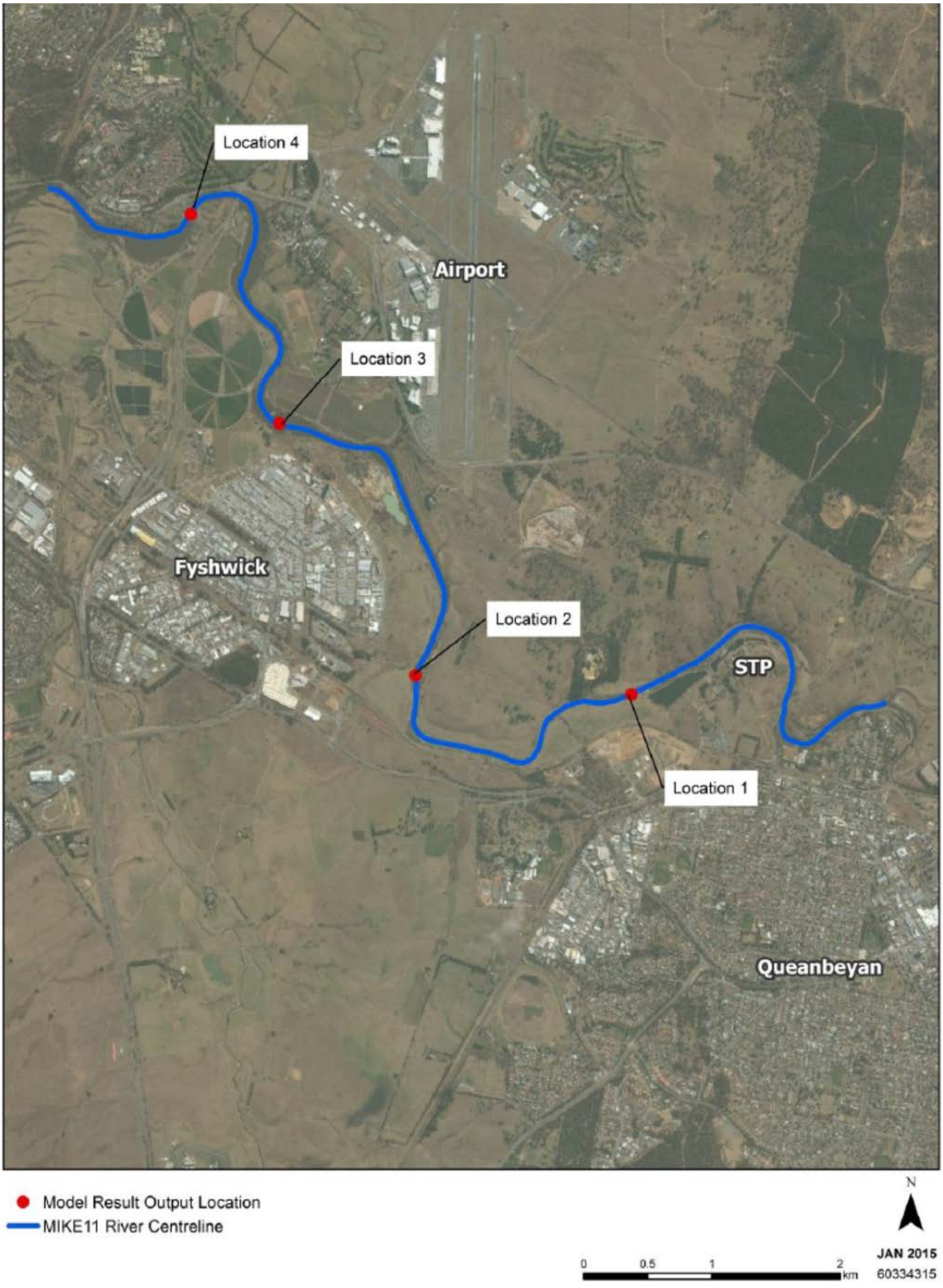

Figure 7-1 WQOA locations

7.2 Water quality data review outcomes

Prior assessments conducted that looked at the impacts of the existing STP on Molonglo River and LBG water quality concluded that the release of fully treated sewage effluent to the river can have both positive and negative impacts on the receiving environments. The impacts are summarised as follows:

7.2.1 Positive impacts

- Effluent discharge from the STP contributes to baseflow and is considered a positive impact on the Molonglo River and downstream, including providing flows to LBG. Since the construction of the Googong Dam, the STP is one the few sources of inflow into the lake in very low flow conditions
- The STP discharge contains nitrogen in the form of nitrate. When nitrate from other sources are lacking, nitrate entering the lake offsets potential adverse conditions occurring in waters at the bottom of the lake.

7.2.2 Negative impacts

- The loading of phosphorus and BOD in the effluent discharge can contribute to blue-green algae growth.
- STP operations can be affected by heavy rains or flood events. For these events, a series of by-passes are designed to protect the sewage process systems. The by-pass directs partially treated sewage to a series of maturation lagoons where it is mixed with fully treated effluent prior to discharge. Under extreme flood conditions, faecal bacteria can be washed out from the maturation lagoon system. It is also worth mentioning that while spills of untreated sewage contribute to faecal contamination that can potentially lead to lake closures, such events are infrequent. The long-term contaminant loads from the STP under by-pass conditions is likely to be quite minor compared to the large loads of faecal bacteria entering the catchment system from other sources (e.g. overland runoff from urban/industrial areas, domestic animals and grazing areas, etc.).

Water quality data was collated from the ACT Government, Icon Water and QPRC with an aim to further test the outcomes from water quality modelling and ascertain the STP impact. However, the nature of available river water quality data collected upstream and downstream of the Queanbeyan STP did not enable clear conclusions to be drawn about the impact of the STP on the Molonglo River, especially during STP diversion events. Upstream of the STP the urban and agricultural land-use influence river water quality, especially total nitrogen and faecal coliform concentrations. Downstream of the STP there is a greater percentage of total nitrogen and chlorophyll-a concentrations that are above relevant guideline concentrations, which may be influenced by STP inputs, but also by other land-uses in the vicinity of the downstream water quality site on the Molonglo River. During STP diversion events the small amount of matching river water quality data does indicate that there are increased faecal coliform concentrations due to the effluent. However, there is a lack of before, during and after diversion river water quality data to draw conclusions of the effects of STP diversions on river water quality. Historically, diversion events from the STP have been associated with elevated faecal coliform concentrations in the Molonglo River, but there is a lack of data to empirically understand broader water quality responses during and immediately following these events.

7.3 Water quality modelling approach

The data analysis highlighted that suspended solids, dissolved oxygen and pH levels in the Molonglo River downstream of the STP are generally within recommended guideline levels under the STP's current operation. The suspended solids levels of the effluent have generally been more favourable than the background water quality in the Molonglo River, suggesting that the existing licencing conditions (and indeed STP performance) is providing adequately for managing solids content.

A prior review has identified that the biological oxygen demand (BOD) may be having negative impacts in terms of algae growth potential in the lake; however no BOD data was available for the effluent and the dissolved oxygen levels in the river downstream of the STP tend to be within guideline values. Guideline exceedances were mainly associated with nutrient and coliform levels in the Molonglo River. Understanding the nutrient and faecal coliform impacts of the effluent on the receiving waters, and the complex impacts of future increases in the serviced population and discharge rates, required further investigation.

Detailed models of the Molonglo River quality in the reach from the present STP to LBG were developed. The model was then used to understand the 'baseline' water quality of the river in the hypothetical absence of any STP discharging into the river. This baseline was superimposed with several test scenarios for various future STP loading, effluent quality and flow rate permutations to understand the impacts that future plant operations may have on receiving water quality.

7.4 Water quality model findings

The models suggest that in the vicinity of where the Molonglo River enters the LBG (even under future possible plant arrangements and EPs):

- Total nitrogen (TN) levels in the river can perhaps be managed to levels similar to the present and historical case even allowing for an increase in served population by adopting an effluent target in the range 5 – 10 mg/L. Presently the STP achieves effluent TN with a mean of 16 mg/L and 90th percentile of 26 mg/L.
- If total phosphorous (TP) effluent targets of 0.1 – 0.2 mg/L were adopted there would be insignificant to minor increases on TP content of the Molonglo River due to the influence of background levels of TP just upstream of the STP and other inputs downstream such as the turf farm, and the river and water quality processes. Note also that the present plant already achieves effluent average TP levels of 0.09 mg/L and 90th percentile of 0.15 mg/L
- The STP effluent is likely having little impact on the presence of coliforms at this site, owing to the relatively lengthy travel and residence times and the processes of microbiological decay. The scenario 1 (no STP) model results are very similar to those outputs for all other scenarios, indicating coliform sources closer to the location (i.e. other than the STP) are likely to be much more influential. Achieving similar or greater levels of log-reduction of coliforms at the STP in future may not translate into observable improvements in coliform presence at this site. Again, note that the historical median faecal coliform measurement in the STP effluent is 28 cfu/100mL, while the median measured in the river just upstream of the STP has been 170 cfu/100mL, suggesting that outside of acute impacts of wet weather bypass event periods, the STP discharge is beneficial to the balance of faecal coliforms in the river.

By extension adopting the targets for effluent quality in the ranges listed above would suggest that there would not be significant increases in nutrient or coliform concentrations in the river water entering LBG, even allowing for future load increase. However, if concentrations are maintained then the greater flows from the future plant could increase the overall loads of nutrients entering the lake, which is important particularly from the perspective of algal bloom potential. This is illustrated by Figure 7-2 and Figure 7-3.

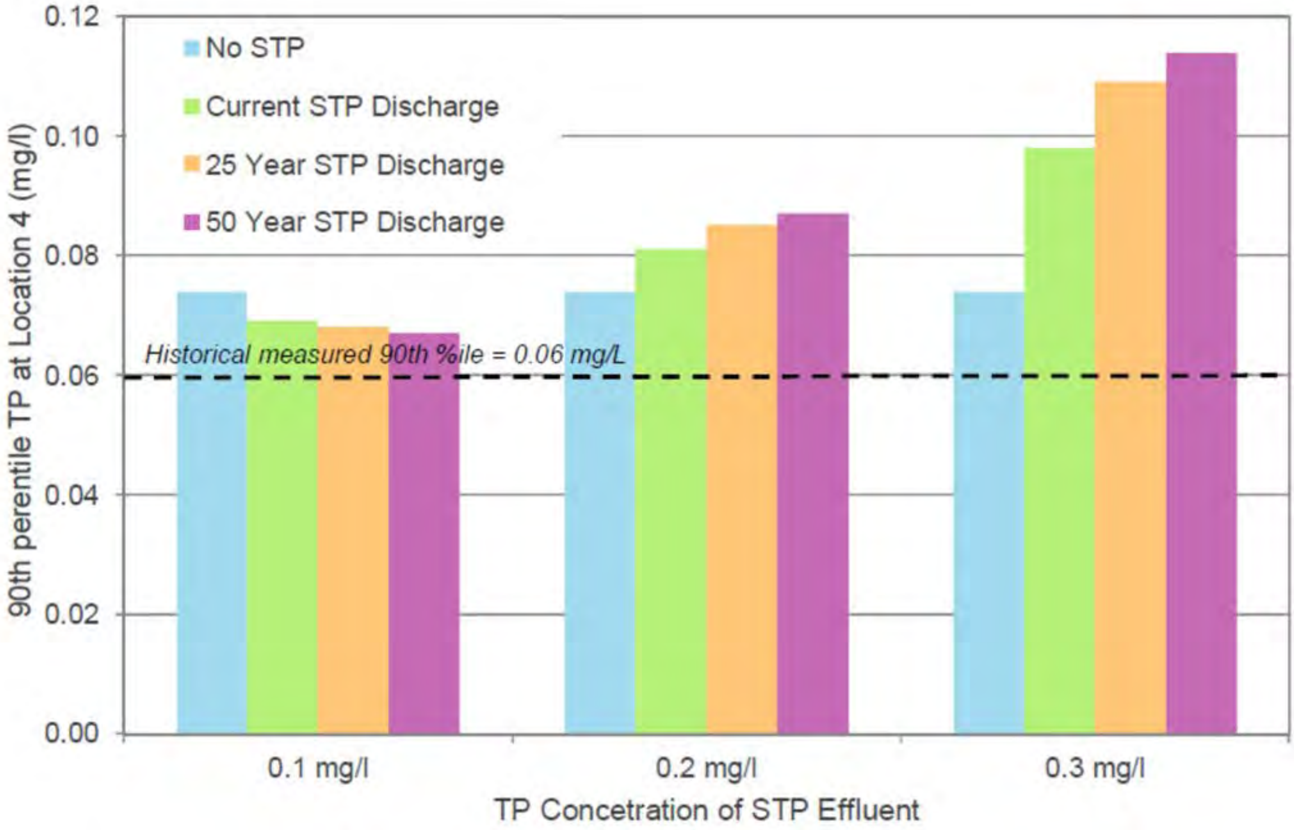

Figure 7-2 Total phosphorus concentration of STP effluent at location 4 (downstream of the STP)

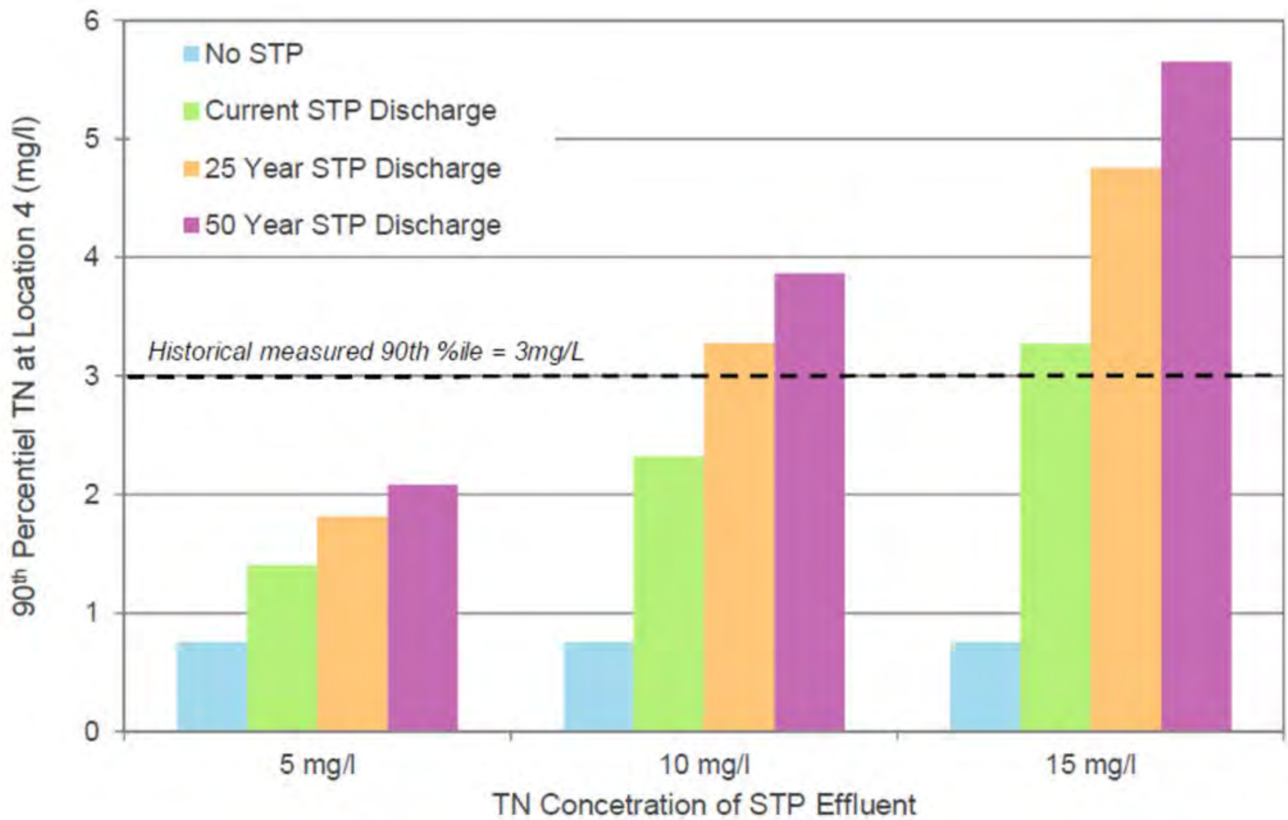

Figure 7-3 Total nitrogen concentration of STP effluent at location 4 (downstream of the STP)

7.5 Setting effluent quality objectives

The modelling outcomes indicate that, with regard to the nutrient river quality at the confluence with Lake Burley Griffin, a 'negligible or beneficial impact' outcome on water quality concentrations may be achieved by adopting effluent quality targets of 5-10 mg/L for TN and 0.1-0.2 mg/L for TP. These could be suitable as target median and 90th percentile effluent concentrations respectively. The present licenced faecal coliform effluent objectives and performance has served adequately to provide a beneficial impact on measurable coliform concentrations in the Molonglo River. As such, the historical performance of the effluent could be adopted as formal future targets for coliform presence in the effluent which would correspond to median of ca. 30 cfu/100 mL and 90th percentile of ca. 200 cfu/100 mL. These values correspond to some of the more stringent licence conditions at other STPs in New South Wales. Such values would improve the presence of pathogenic organisms in the effluent and hence the receiving environments. Future rationale for alternate coliform (or other microbial) level indicator may be dictated by a desire to treat water to levels appropriate for beneficial reuses by achieving log-reduction targets outlined in the Australian Guidelines for Water Recycling (2006).

The present BOD and suspended/dissolved solids licencing conditions can be considered as starting points for discussions about future licencing conditions, noting that the receiving water quality impacts are within current guideline limits.

7.6 ACT EPA licence requirements

As indicated in section 4.3.10, a new licence would be required for an upgraded STP. This licence would be set to meet the requirements of the *Environmental Protection Regulations (2005),* Schedule 4, Part 4.7. These requirements have therefore been taken into consideration in the basis of design outcomes.

7.7 STP bypass event modelling

Operation of the Queanbeyan STP can be affected by heavy rains or flood events. For these events, a series of by-passes are designed to protect the sewage treatment process systems. The by-pass directs partially treated sewage to a series of maturation ponds where it is mixed with fully treated effluent prior to discharge. Extreme flood conditions can result in this water being washed out of the maturation pond system and into the Molonglo River, potentially resulting in rapid declines in water quality.

The potential impact of the STP bypass events on the water quality within the Molonglo River was assessed using the MIKE11 ecological processes model previously developed as part of the Queanbeyan Sewage Treatment Plant Objectives Review and Assessment prepared by AECOM (2015) for QPRC. This model extends from the confluence of the Molonglo and Queanbeyan River upstream of the STP down to Lake Burley Griffin, and simulates variations in Total Nitrogen (TN), Total phosphorus (TP) and Faecal Coliforms. For details on the model development and calibration refer to the above mentioned report.

The available data on STP operation during normal conditions and during bypassing events were used to develop a number of model simulations to cover a range of possible bypassing scenarios. A total of 18 events were derived based on 3 actual bypass events occurring during the second half of 2010. These events were selected as they provide a good representation of the range of bypass flow volumes and durations that can occur.

As expected, the shorter duration bypass events with higher nutrient and faecal coliform concentrations resulted in a plume with significantly higher concentrations than the longer duration bypass events with lower concentrations of nutrients and faecal coliforms.

The long term modelling undertaken for the Queanbeyan STP Objectives Review and Assessment found that the plume from the STP generally took in the order of a month to reach the Dairy Flat Road water quality monitoring site. The increased flow in the Molonglo River during bypass events acts to dilute the plume from the STP. The amount of dilution is dependent of the magnitude of the Molonglo River flows relative to the STP bypassing flows.

For STP bypassing occurring during more regional scale flood events where there are large concurrent flows within the Molonglo River the impact of STP bypassing is small, even for longer durations of STP bypassing with high nutrient and faecal coliform concentration. The December 2010 bypass event is representative of such a case, where there is minimal change in the water quality in the Molonglo River.

7.8 Concluding observations

The following effluent discharge criteria shown in Table 7-2 are considered appropriate and unlikely to result in a net increase of impacts on downstream water quality. The design outcome should also be based on 100% river discharge.

Table 7-2 WQOA outcomes for performance of STP and proposed licence limits

Parameter	Units	Performance	Statistic	Proposed Licence Limit (100%ile)
Total Nitrogen	mg/L	10 5	90%ile 50%ile	10
Total Phosphorus	mg/L	0.15 0.1	90%ile 50%ile	0.2
Faecal coliforms	cfu/100mL	30 200	Median 90%ile	60
BOD	mg/L	10 5	90%ile 50%ile	10
Suspended Solids	mg/L	10 5	90%ile 50%ile	10

8 Sustainability

8.1 General

There are various legislative (State and Federal) and policy requirements that must be fulfilled in order to set up the project and ensure compliance. A key deliverable among these requirements is incorporating Sustainability into the Project Management Framework (PMF) and minimising the environmental and social impact of the resulting STP. A policy framework document has been developed that lists these legislations / policies, which specify sustainable outcomes and their relevance to the STP project.

QCC's "Sustainable Building Design Policy" was adopted in March 2013 to help Council fulfil its legislative obligations, as outlined in the framework document. The Sustainable Building Design Policy required Council Infrastructure projects (with a total expenditure greater than $3,000,000) obtain External Certification to ensure compliance with Council's Sustainability obligations and facilitate Triple Bottom Line reporting. The STP project falls within this requirement.

Benefits to Council in adopting this level of evaluation include:

- Rigorous assessment of risk management and proficiency of design, construction and operation
- Recognition as a leading public infrastructure project with certified sustainability rating
- Capacity building through knowledge and training of staff in water sensitive urban design, sewerage management and plant design
- A final facility with zero or negligible impact on the environment
- Rewards for excellence in best practice technology with demonstrated level of zero net impact on the environment
- Improved experience and credibility of the project team in sustainability principles
- Prestige and proven ability to create a long-term legacy of a sustainably engineered facility.

Under the policy, Council is obliged to obtain external certification of sustainability outcomes for the STP Project. The PMF incorporates this requirement and the policy was used to select a suitable external certifier. Council has engaged the Infrastructure Sustainability Council of Australia (ISCA) to be the external certifier for the project.

8.2 ISCA and the IS rating tool

The IS (Infrastructure Sustainability) rating scheme for infrastructure is developed and administered by ISCA.

ISCA's measurement tool, the IS Rating Scheme, has been designed to measure a range of sustainability criteria across design, construction and operation, with some of the major themes comprising:

- Management and governance
- Using resources
- Emissions, pollution and waste
- Ecology
- People and place
- Innovation.

Importantly, the tool is designed to achieve sustainable outcomes without an increase in capital cost, through strategies such as improved decision-making, more effective stakeholder / community consultation, evidence and data collection.

8.2.1 IS Rating for the STP

Getting an IS rating for the STP would help QPRC demonstrate compliance with Federal, State and QPRC internal policies. In the instance that Council is able to achieve an IS rating of “Excellent”, compliance with the Sustainable Building Policy would be achieved as described below.

The major target for Council’s “Sustainable Building Design Policy” is a “Zero net impact on greenhouse gas and water use compared to previous years” for the “As Built” product leading to:

- No Net increase in Green House Gas Emissions
- No Net increase in Council Water Use
- Increase waste recovery rates to 80%.

There are three ratings that can be awarded to infrastructure projects that go beyond business as usual:

- Commended (Measurement and Implementing Initiatives)
- Excellent (No Net Impact)
- Leading (Restoration and Enhancement).

The ratings can be achieved for the following stages:

- Design
- As Built
- Operation.

However, baseline data informing the current performance of Council’s STP against the above mentioned factors is required to provide a benchmark against which the performance of the new STP will be measured. In order to achieve this, an “Operational” Rating for the existing STP will be sought. For the new STP, QPRC will seek a “Design” leading to an “As Built” rating.

Council’s Sustainability Officer is responsible for managing the external certification process for the Project with support by a suitably qualified and experienced consultant.

8.2.2 Future Projects

In compliance with the Sustainable Building Policy, QPRC will need to get external certification for any projects with a total expenditure in excess of $2,000,000. Future projects like the CBD Upgrade and the Ellerton Drive connection would fall under this category. The experiences gained from using ISCA for the STP would be transferrable to other projects leading to a more streamlined approach to sustainability certification for future projects. This capacity building for QPRC staff will facilitate better sustainability outcomes for future projects without (completely) relying on support from external consultants.

8.3 Reuse of Effluent

Currently, QPRC does not reuse treated effluent from the Queanbeyan STP as no suitable reuse options have been identified. There is the potential that reuse options may be identified in the future. As such, it is recommended that a recycled water study be undertaken that can identify reuse options for future development stages of Queanbeyan STP. This may assist QPRC in managing any new environmental licence conditions imposed on the future STP, as well as meeting the expectations of stakeholders in committing to nutrient reduction in the downstream river and lake.

8.4 Concluding Observations

The project delivery should consider sustainability in all project related activities (including project management, procurement, materials selection etc.) with the goal of obtaining Design and As-Built IS ratings of Excellent with an IS score in the range of 65 to 75% or better.

Undertake a recycled water study to determine the viability of reuse in the future which also considers potential impacts on the yield of the Molonglo River and downstream users.

9 Treatment technology approaches

Various technology options were considered for each step in the treatment process as a preliminary starting point, notwithstanding the Concept Design stage. These are included in this Masterplan Report for completeness. The selection of the treatment process train will be determined during the concept Design phase of the project. All options reviewed are detailed in Appendix G.

9.1 Preliminary

9.1.1 Screening

- Coarse – Simple bar racks spaced 1-10 cm apart to remove large debris. Wire or bar screens are spaced 6-10 mm apart for finer screening
- Fine – Smaller apertures, range of 1-6 mm. This is often used to protect downstream processes such as membranes
- Mechanical Belt Sieve – has the potential to reduce the suspended solids load on the treatment plant by 30%

9.1.2 Grit Removal

- Horizontal Flow – flow velocity is controlled in a long, narrow basin. Permits heavier grit to settle
- Aerated – Spiral flow pattern is induced in a grit chamber. Acceleration causes heavier grit to settle. Also strips odorous compounds
- Vortex – system uses gravity and centrifugal forces to separate grit and sweep it into a collection chamber.

9.2 Primary

9.2.1 Equalisation tanks

Wastewater flow rates and loading rates vary greatly depending on day, week or season. Equalisation tanks are sometimes used to buffer influent flow and load which benefits biological treatment.

9.2.2 Primary Settling

Velocity of wastewater is greatly reduced to remove organic solids that will readily settle. Primary settling can remove 50-60% of suspended solids and 25-35% of BOD_5.

9.3 Secondary

9.3.1 Suspended growth processes

The activated sludge process utilises an aeration tank where aerobic bacterial culture is maintained in suspension:

- Activated Sludge with Biological Nitrogen Removal (BNR):
  - The first and simplest BNR plant was the Ludzak-Ettinger process, which incorporates an anoxic zone and relies on the nitrate formed in the aerobic zone being returned via RAS to the anoxic zone to undergo denitrification
  - The modified Ludzak-Ettinger process involves the addition of an internal recycle to feed more nitrate to the anoxic zone. The Bardenpho process incorporates a second anoxic zone post aerobic zone, allowing further denitrification to occur

- Activated Sludge with Biological Nitrogen and Phosphorous Removal:
  - *3-Stage Phoredox:* A modification of the MLE process incorporating an anaerobic zone for phosphorus removal. The 5-Stage Phoredox process incorporates an anaerobic zone for phosphorus removal prior to the first anoxic zone, and secondary anoxic and re-aeration zones for improved nitrogen reduction
  - *UCT configuration*: Designed to largely eliminate the effect of nitrate in the upfront anaerobic zone, as when nitrate is present, bacteria will use this nitrate and consume organics, leaving less organics available for phosphate-accumulating organisms.
- *Pasveer Oxidation Ditch:* A continuous flow, activated sludge system where wastewater is mechanically circulated through a ditch with rotors that agitate and aerate the influent. The aerated wastewater is allowed to settle and the activated sludge is removed. A portion of the sludge is returned to the ditch in order to promote microbial activity.
- *Sequencing Batch Reactors:* An activated sludge process designed to operate in batch or non-steady state conditions. The SBR tank carries out the functions of equalisation, aeration and sedimentation in a time sequence rather than in the conventional space sequence of continuous-flow systems.
- *Aerobic Granular Sludge*: Consists of aggregates of microbes that coagulate and settle significantly faster than typical activated sludge flocs. The high sludge settling rates achieved with granular sludge, result in smaller reactor volumes and a short-duration settling phase.
- *Membrane Bioreactors:* Combines activated sludge treatment with a membrane liquid-solid separation process. The membrane component uses low pressure microfiltration or ultrafiltration membranes and eliminates the need for clarification and tertiary filtration.
- *Facultative Lagoons:* Do not provide biological nutrient removal, however they can provide a satisfactory level of treatment where wastewater is disposed to land, depending on discharge requirements. Lagoon systems provide primary sedimentation as well as a significant equalisation effect, and can also provide biological treatment.

9.3.2 Attached growth processes

Attached growth processes remove soluble and colloidal organic materials by the means of a biological film on a fixed media. This film typically comprises a large and diverse population of organisms:

- *Trickling Filters:* Consists of a shallow bed filled with crushed stones or synthetic materials. Wastewater is introduced over the bed and a biofilm is created that becomes thick and falls off (sloughing). The popularity of trickling filters has declined with increasing requirements for biological nutrient removal.
- *Moving Bed Biofilm Reactor:* Utilises specialised plastic carriers to create a surface on which a biofilm can attach. The waste water enters the first Moving Bed Biofilm Reactor at low level and over flows via screened ports at high level until it passes with unattached biomass into the clarifier.
- *Integrated Fixed Film Activated Sludge:* Incorporates an attached growth media within a suspended growth reactor. As such, the Integrated Fixed Film Activated Sludge still requires a large activated sludge clarifier and sludge return system.

9.3.3 Anaerobic processes

Anaerobic processes are mostly used in the treatment of high strength industrial wastes. For domestic wastewater applications, the most widely used anaerobic processes are septic tanks, anaerobic lagoons, and the Upflow Anaerobic Sludge Blanket (UASB):

- *UASB:* Influent wastewater is distributed at the bottom of the reactor and migrates upwards through a sludge blanket. The organic components in the wastewater are converted into biogas which is collected in the gas solids separator at the top of the UASB reactor.
- *Anaerobic Lagoons:* Deep earthen basins with sufficient volume to permit sedimentation of settleable solids, to digest retained sludge, and to anaerobically reduce some of the soluble organic contaminants. Raw wastewater enters near the bottom of the pond and mixes with the active microbial mass in the sludge blanket.

9.4 Tertiary

9.4.1 Filtration

- Depth Filtration – Uses a porous median (such as sand) to retain particles throughout the media
- Surface Filtration – Involves removal of particulate material by mechanical sieving. Filter pore sizes range from 5-30 µm
- Membrane Filtration – Involves use of membranes with very small pore sizes in the range of 0.01-1 µm. Processes used are:
  - Microfiltration – 0.07-2.0 µm
  - Ultrafiltration – 0.008-0.2 µm
  - Nanofiltration and Reverse Osmosis – <2 nm high pressure process. Also uses electro dialysis.

9.4.2 Adsorption

Adsorption is used to remove substances such as nitrogen, sulphides and heavy metals by accumulating the substances in a solid medium. The most common solid adsorbent is activated carbon.

9.5 Disinfection

Disinfection is the primary mechanism for inactivation/destruction of pathogenic organisms.

9.5.1 Chlorination

The most commonly used disinfectant technique. Several chlorine compounds include:

- *Chlorine*: Used as a gas or pressurised liquid. Highly toxic
- *Sodium Hypochlorite*: Aqueous solution with around 12-17% chlorine. Less hazardous than chlorine but more expensive
- *Calcium Hypochlorite*: Dry form, meaning easier transport and storage. Dissolution required before dosing – difficult in large installations
- *De-chlorination*: May be required before discharge of effluent to the environment, due to toxicity of residual chlorine.

9.5.2 Ultraviolet

UV radiation damages microorganisms and interferes with the processes of cell synthesis and cell division.

9.5.3 Ozone

Ozone is an extremely reactive oxidant that disinfects as a result of cell wall disintegration. Generally used at medium-large sized plants. Also helps with odour control.

9.6 Sludge handling

9.6.1 Thickening

Concentrates sludge solids and reduces its volume. Generally accomplished through physical processes such as:

- *Gravity Thickening*: Undertaken in circular tanks similar to primary and secondary settling tanks.
- *Dissolved Air Flotation*: Achieved by dissolving air in wastewater then releasing into a flotation tank at atmospheric pressure
- *Centrifuge*: Sludge is fed to a rotating bowl that contains an accelerating inlet rotor, creating centrifugal forces that push solids to the outer wall. Used at medium to large plants
- *Gravity Belt Thickener*: Consists of conditioning and polymer system and rotating cylindrical screens. Conditioned sludge is fed to the rotating screens which separate the flocculated solids.

9.6.2 Stabilisation

Undertaken to reduce pathogens, eliminate offensive odours and reduce or eliminate the potential for further degradation of organic matter. Stabilisation can be undertaken through biological, chemical or physical means. The main methods of stabilisation are:

- *Alkaline Stabilisation*: The addition of alkaline material maintains a high pH level and causes the destruction of pathogenic organisms
- *Anaerobic Digestion*: Involves the decomposition of organic matter with no oxygen present. Anaerobic microorganisms consume organic matter and produce methane and carbon dioxide
- *Aerobic Digestion*: Involves aeration of sludge, similar to activated sludge. Commonly used at smaller plants and those without primary settling and sludge, for stabilisation.

9.6.3 Conditioning

Sludge and biosolids are conditioned in order to improve their dewatering characteristics. The most common conditioning agents are polymers, used to achieve flocculation or aggregation of solids and therefore achieve efficient solid-liquid separation.

9.6.4 Dewatering

Dewatering is undertaken to remove water and produce a high solids content final product called biosolids cake. Dewatering techniques are mostly mechanical.

- *Centrifuge*: Commonly used for dewatering wastewater biosolids. Sludge is fed to a rotating bowl that contains an accelerating inlet rotor creating centrifugal forces that push solids to the outer wall of the bowl
- *Belt Filter Press*: Sludge is firstly conditioned with polymer and then distributed evenly over the width of the belt. The belt filter press applies mechanical pressure to force the separation of water from the sludge
- *Plate Filter Press*: The plate filter press is comprised of a series of filter chambers formed between filter plate presses supported on a metal frame. The plates are clamped together with hydraulic rams, and the high pressure gradually dewaters the sludge
- *Rotary Fan Press* – conditioned sludge is fed into the enclosed slow moving (<1 rpm) dewatering channel between two parallel stainless steel, filter screen plates

- *Screw Press*: Flocculated sludge is pumped into a cylindrical screen basket wherein an auger slowly rotates. The diameter of the auger's shaft increases towards the end of the basket and the gap between its flights decreases. This change in volume causes a change in pressure that dewaters the sludge
- *Solar Dryers*: Sludge is loaded into a drying hall and is slowly turned from one end to the other. Water evaporates, leaving 65-80% DS.

9.7 Ancillary processes

9.7.1 Chemical Dosing

Chemical dosing is undertaken in a variety of circumstances at STPs and can be employed in a solid, liquid or gaseous form. Chemical dosing systems are generally designed to be either batch or constant feed.

9.7.2 Odour Control

Odours at treatment plants can be minimised by proper attention to design details, such as the use of submerged inlets and weirs, minimising turbulent areas, proper process loading rates, covering or containment of odour sources, and off-gas treatment.

- *Activated Carbon*: Adsorption through beds of activated carbon is a commonly used odour treatment method.
- *Bio-tricking Filters*: A biofilm layer of microorganisms supported by packed bed filters absorb and oxidise odorous gases.
- *Chemical Scrubbers*: Allow oxidation of odorous compounds through contact with air, water and chemicals.

10 Solids management

10.1 Introduction

QPRC will need to consider management of the biosolids that are produced as by-products of the wastewater treatment process from the STP. Solids management strategies implemented by other local councils and utilities were reviewed and compared to identify options suitable for implementation at Queanbeyan STP.

This section summarises the findings of investigations into solids management options, notwithstanding the Concept Design stage. For further detail, refer to Appendix F.

10.2 Local regional solution

Several councils and utilities around the local region were contacted to gain an understanding of their solids management procedures, capabilities and future plans. The informal discussions were focused around answering the following high-level questions:

- What are the current procedures being adopted for your solids management?
- Would your council/group have capacity for accepting the solids that are produced from Queanbeyan STP?
- Would your council/group consider giving their solids to QPRC as part of a larger regional solution?

The responses from various councils and groups are summarised below:

- *LMWQCC (ACT):* Currently all streams of solids arriving at LMWQCC enter by sewer. The sewage is treated and the solids are removed before being incinerated in a furnace. It may be feasible for LMWQCC to receive more waste; however the EPA licence restricts the furnace from receiving solids from other sources. Incineration of the solids produces a soil-enhancing product called Agri-Ash, which is sold for agricultural use. By giving solids to another facility LMWQCC would generate less income from Agri-Ash.
- *Mugga Lane Resource Management Centre (MLRMC):* ACT NOWaste's MLRMC is the only putrescible waste landfill in the ACT. MLRMC currently disposes of approximately 290,000 t/y and is undertaking capital works to increase the capacity. Currently there are no solids from sewage treatment being received by MLRMC, but NOWaste have advised that there would be no issues with doing so. They would also likely consider giving organic solids to another facility as a collaborative solution for resource recovery.
- *Murrumbateman Landfill (NSW):* This is the only licensed landfill operated by Yass Valley Council. The landfill is licensed under EPA for application of waste to land, including non-putrescible biosolids and dewatered putrescible grit or screenings from sewage treatment systems. This landfill is being converted into transfer stations, and waste will ultimately be disposed of at the regional landfill facility at Bald Hills near Jugiong.
- *Yass STP (NSW):* The Yass STP is capable of treating sewage for 6,800 EP and has allowed for future expansion to 10,800 EP. Currently grit and screenings are bagged and disposed of on site. There is storage space for several more years, but when full the waste will be trucked to the regional landfill facility in Bald Hills. Council is considering the options for someone to take sludge waste, potentially to be used as a land fertiliser. Under EPA licence Yass STP may receive and process products from other STPs.
- *New Murrumbateman STP (NSW):* Yass Valley Council has recently completed a new STP at Murrumbateman. It is expected that sludge generation from this treatment plant will be small initially and not require disposal for several years. Council would prefer a solution which is close by for giving away their sludge. However, if there were no nearby solutions found, the Council would likely consider giving sludge to a regional facility with QPRC. The cost of transportation of the sludge waste to the Queanbeyan region would likely be a major factor for Council.

- *Palerang Landfill Sites (NSW):* The former Palerang Council (now amalgamated to QPRC) has several landfill sites in the region. These landfills are progressively being closed and all waste will ultimately be transferred to the Woodlawn Waste and Resource Management site located within the Goulburn Mulwaree Council area.
- *Braidwood STP (NSW):* There are currently three STPs within the former Palerang Council area; at Captains Flat, Bungendore and Braidwood. The grit and screenings from the three STPs are all disposed of at landfill sites. Palerang Council advised they would be open to discussion about the option of giving sludge from STPs to a regional solution with QCC.
- *Landtasia Organic Farms (NSW):* Currently the Landtasia Organic Farms site in the former Palerang Council receives food and garden waste from the local region for composting and producing a solution for agricultural soils. Acceptance of biosolids is not part of the current Environmental Protection Licence (EPL) at Landtasia. It is unlikely that the licence for the existing site would be able to be upgraded to receive biosolids, due to its locality within the Sydney Catchment Authority region. While Landtasia is not able to accept biosolids, the operators at Landtasia are well experienced to assist the QPRC in developing (or operating) their own composting facility which accepts biosolids.
- *Glen Wastewater Treatment Facility (NSW):* Around 200-250 kg/d of grit and screenings is produced and taken by garbage truck to Cooma Landfill Resource and Waste Facility. A further 400 – 500 t/y of sludge is produced at the STP which is discharged into one of two sludge lagoons for drying. The sludge lagoons each have a capacity of around one year's volume of sludge. Every two years, after both sludge lagoons have been filled, the sludge is dewatered through a centrifuge (by an outside contractor) and carted to the Cooma landfill site. Cooma Monaro Shire Council would likely be interested in the option of giving sludge to a regional solution with QPRC, particularly since the disposal of sludge to Cooma landfill comes at a cost.
- *Goulburn Mulwaree Council (NSW):* There are currently two STPs in the Goulburn Mulwaree Council area; Goulburn STP and Marulan STP. Currently the STP solids are disposed of at a local farm in accordance with a licence under the NSW EPA. A new Goulburn STP is due for completion mid-2017. With the new STP upgrade, Council will be looking for additional solids disposal options. They are open to giving their solid waste to QPRC and would appreciate having discussions regarding any collaborative solutions.
- *Woodlawn Waste and Resource Management Site (NSW):* The Woodlawn Bioreactor currently receives 20% of Sydney's putrescible waste which is used to generate green electricity. Currently the site contains around 4 million tonnes of waste. The bioreactor would likely have capacity for receiving the solids from QPRC STP, however the solids would need to be in a suitably dry form to comply with the current licence.
- *Holcim Quarry (NSW):* Holcim have expressed interest in a proposal that involves remediation of the land on their site using a mix of biosolids and VENM (Virgin Excavated Native Material). QPRC currently has stockpiles of biosolids and green waste that could be mixed with VENM from Googong to create a commercially viable product.

10.3 Agricultural land application

10.3.1 Fertiliser / Soil conditioner for human crops production

Enhancing crop production by using sewage waste on land is a longstanding practice. In the past, farmers depended solely on various organic products and wastes until chemical fertilisers were invented to enhance crop production. This option is already being used extensively in Canberra with the quality product being received from Sydney. Environmentally this is a sound option and there is plenty of human crop productions close enough to the Queanbeyan STP to make the option worthwhile. Profitability of the option due to the cheap market rates is an issue. Increased funding or grants from the NSW Regional Regulated Area (RRA) or the Environment Protection Authority (EPA) even though it won't provide renewable energy to the plant seems a feasible option. There is also benefit of partnerships with Canberra Investment Corporation Limited and Googong Township Pty Ltd.

10.3.2 Fertiliser for animal crops production

Biosolids contain a range of valuable nutrients such as nitrogen, phosphorus, iron, calcium, magnesium and various other macro and micro nutrients which are essential for plant growth. Many of these nutrients are also essential components in the healthy diet of animals in order to maintain growth and for food production. There have been successful grazing experiments in Goulburn NSW, showing that application of dewatered biosolids significantly increased pasture production and livestock performance.

The use of biosolids as fertiliser for animal crops production has fewer problems with odour than other alternatives and the crops are in rural areas making limited opportunity for community complaints. As this can be seen as a way to help the farmers and agricultural industry, grants or increases in funding are likely as there is an industry in Queanbeyan for agriculture.

10.4 Non-agricultural land application

10.4.1 Forestry

Land application of biosolids within forests is a relatively new practice. This use had been difficult to achieve due to technology limitations in spreading biosolids evenly through heavily forested areas. However, various residuals, including pulp and paper mill sludge, ash, industrial residues, sewage sludge and wastewater, are utilised to enhance growth of forest ecosystems.

Environmentally this is a very good option and there is forestry close enough to the Queanbeyan STP to make the option economically viable.

The main concern would be the cost of transporting and spreading the biosolids. As there is a likelihood of receiving increased funding or grants this option appears feasible. A service provider would need to be identified.

10.4.2 Land reclamation

Biosolids have several characteristics that make them suitable for reclaiming and improving disturbed and marginal soils. The organic matter in biosolids improves the soil physical properties by improving granulation, reducing plasticity and cohesion, and increasing water-holding capacity. Biosolids increase soil cation exchange capacity, supply plant nutrients and buffer soil.

The opportunity of land remediation at the Holcim Quarry makes this option very feasible. This would provide a long term solution for biosolids management. The cost of transporting the biosolids is low and the likelihood of receiving increased funding or grants for this option is high, with the EPA ready to help businesses divert waste from landfill.

10.4.3 Mine site reclamation

The most widespread use of biosolids for land reclamation is repairing land damaged by mining. The restoration of mine soils with biosolids has been shown to increase soil organic matter, cation exchange capacity, soil nutrient levels, and to promote soil ecosystem recovery.

However, this is not an acceptable option as there are no mine reclamation sites in the proximity of the QPRC LGA; the nearest mine is at Thuddungra (200 km away).

10.4.4 Horticulture and landscaping

The use of biosolids for horticulture and landscaping is similar to land and agricultural application, but with a different intent. The biosolids product, often compost, is used for soil conditioning rather than as a replacement fertiliser. This is a viable option as there is a golf club, five nurseries and 14 football/cricket grounds located in Queanbeyan, all of which could make use of biosolids for landscaping purposes (soil conditioning).

The costs for transport will be low as the STP is in close proximity to the golf course and the football / cricket grounds. The likelihood of receiving increased funding or grants for this option is highly likely due to the existing use in Australia. As such, use for horticulture and landscaping in the QPRC region could be cost effective and feasible.

10.5 Energy recovery – Renewable energy resources

10.5.1 Thermal energy recovery – Heat generation

Utilisation of unused energy such as industrial waste heat is an important measure for reducing energy consumption to mitigate global warming and reduce heat waste. Recovered thermal energy may be utilised at the new treatment plant in a similar manner to LMWQCC to warm the raw sewage influent, or (with the aid of co-generation) used to provide power for the treatment plant. Although this option could enhance sustainability, it would do so at a higher initial capital cost compared to using natural gas.

10.5.2 Fuel production – Oil from sludge process

Conversion of sludge, which is heavily contaminated by heavy metals and/or toxic chemicals to oil is technically feasible, however capital and running costs of such processes are high. The Queanbeyan STP will not produce near enough sludge to make this solution economically viable.

10.5.3 Energy recovery – Gasification

Co-incineration with municipal solid waste has been effectively used elsewhere. However, this isn’t a feasible solution for the Queanbeyan STP as a gasification plant requires a power plant close by which is not the case for the STP.

10.6 Other uses

10.6.1 Recycling and use as a construction material

Recycling sludge for use as a construction material is becoming increasingly popular as it can be readily applied as well as the economic and environmental advantages. Given the close proximity of many construction suppliers this appears to be a good solution to the high demand for recycled sludge materials. Environmentally this solution is better than similar alternatives due to the use of construction material with lower embedded energy. Although the cost of recycling sludge to create construction materials is relatively high the option could become economically viable depending on the demand for such materials.

10.6.2 Commercial uses of biosolids

Efforts to “market” biosolids generally refer to the sale of large quantities to commercial consumers. Biosolids may also be sold in smaller quantities to homeowners and gardeners. In the first instance the new Queanbeyan STP is unlikely to be large enough to be commercially viable but may become so in the future.

10.7 Comparison

Comparing the potential solutions for biosolids disposal indicates that two solutions are not viable due to the location of the new STP in relation to potential users of the biosolids by-products. To be economically viable, Mine Site Reclamation possible users need to be within 100 kilometres of the new Queanbeyan STP. However, the nearest mine is 200 kilometres away.

The use of biosolids for land reclamation at the Holcim Quarry is seen as the optimal solution as this would provide a long-term, sustainable, and financially viable solution for biosolids management.

Use of biosolids by-product for animal crop production is politically and socially acceptable as the product’s safety has been proven in NSW and overseas, there are no odour problems to residents, and animal crop production is a large industry in Queanbeyan. Energy recovery is also an excellent solution due to the increased capacity to move towards energy neutrality for the new STP. This however would need a regional approach to be viable.

Table 10-1 Solids management solution comparison (criteria scores shown are out of 10)

Solution	GO NO GO	Sustainability	Local Regional Solution	Cost / Profitability	Politics	Feasibility	Total Score (/50)
Human Crop Production	GO	7	9	8	7	8	39
Animal Crop Production	GO	9	9	7	9	8	42
Forestry	GO	9	7	5	7	7	35
Land Reclamation	GO	9	10	8	8	9	44
Mine Site Reclamation	NO GO	-	-	-	-	-	0
Horticulture and Landscaping (Composting)	GO	9	8	7	7	8	39
Thermal Energy Recovery	GO	9	9	3	6	6	33
Fuel Production	NO GO	-	-	-	-	-	0
Cement Production	NO GO	-	-	-	-	-	0
Gasification	NO GO	-	-	-	-	-	0
Use as a Construction Material (Recycling)	GO	8	6	6	7	6	33
Commercial Use	NO GO	-	-	-	-	-	

10.8 Concluding observations

The solids management solution comparison showed that the most beneficial and viable options were:

- Reuse for land reclamation (e.g. Holcim Quarry Site)
- Production of fertiliser for animal crops
- Production of fertiliser for human crops
- Use for horticulture and landscaping.

These options should be given further consideration during concept design.

11 Options Road Map

A Masterplan options workshop was held on 27 November 2014 to discuss and eliminate, where possible, options for the Queanbeyan STP. Attendees at the workshop included the Project Management Team, senior managers from other QCC business units and STP operators. The purpose of the workshop was to determine constraints and identify issues for inclusion in the masterplan to be considered during concept and detailed design. The expected outcome of this workshop was to set the framework for future phases of this project, in particular potential treatment technologies.

The Workshop covered the topics of:

- Where to build?
- What to build?
- Eliminate options?
- What is to be taken forward?

11.1 STP location and staging

The existing site is already zoned for sewage treatment and has available space, likely to be adequate for construction of a new STP. Gradual forecasted growth in the Queanbeyan LGA is oriented towards the middle – south of the LGA (as discussed in Section 3). This growth was taken into account and the following points were raised in relation to STP location and staging options.

- Limited use for irrigation on sports fields
- Present infiltration occurring near the racecourse
- No alternate north site exists that may be suitable for a treatment plant
- Community engagement will have to occur from the start of the project
- Stormwater ingress to sewers will need to be fixed as soon as possible
- Remedial works are needed for the Morriset Street pump station
- Sewer mining is a possibility at Bayside and Morriset Street pump station.

Considering the above, staging options for the proposed STP to service the LGA were identified and assessed. The outcomes of the assessment were discussed and refined at a stakeholder masterplanning workshop. In particular, the overall deliberation showed that:

- The first stage of the upgrade should be located on the existing STP site and be sized to cater for at least 60,000 EP
- Consequent upgrade stages could either be located at the existing site or be located closer to future growth centres to create a decentralised service
- The timing and extent of the first stage of the upgrade gave considerable flexibility and opportunity to address regional and cross border issues beyond the first stage.

The Road Map for possible options, Figure 11-1, indicates the possible range of upgrade outcomes and the markers that trigger the need for ongoing planning decisions. The associated required infrastructure has been incorporated into the Road Map.

Recycled water is not currently produced at the existing STP and is not being considered for Stage 1 of the STP upgrade. At the Stakeholder Masterplanning Workshop held on 13 February 2015 stakeholders clearly indicated that recycled water would need to be considered in the future and QPRC agreed to undertake a recycled water study in conjunction with ongoing planning for the STP.

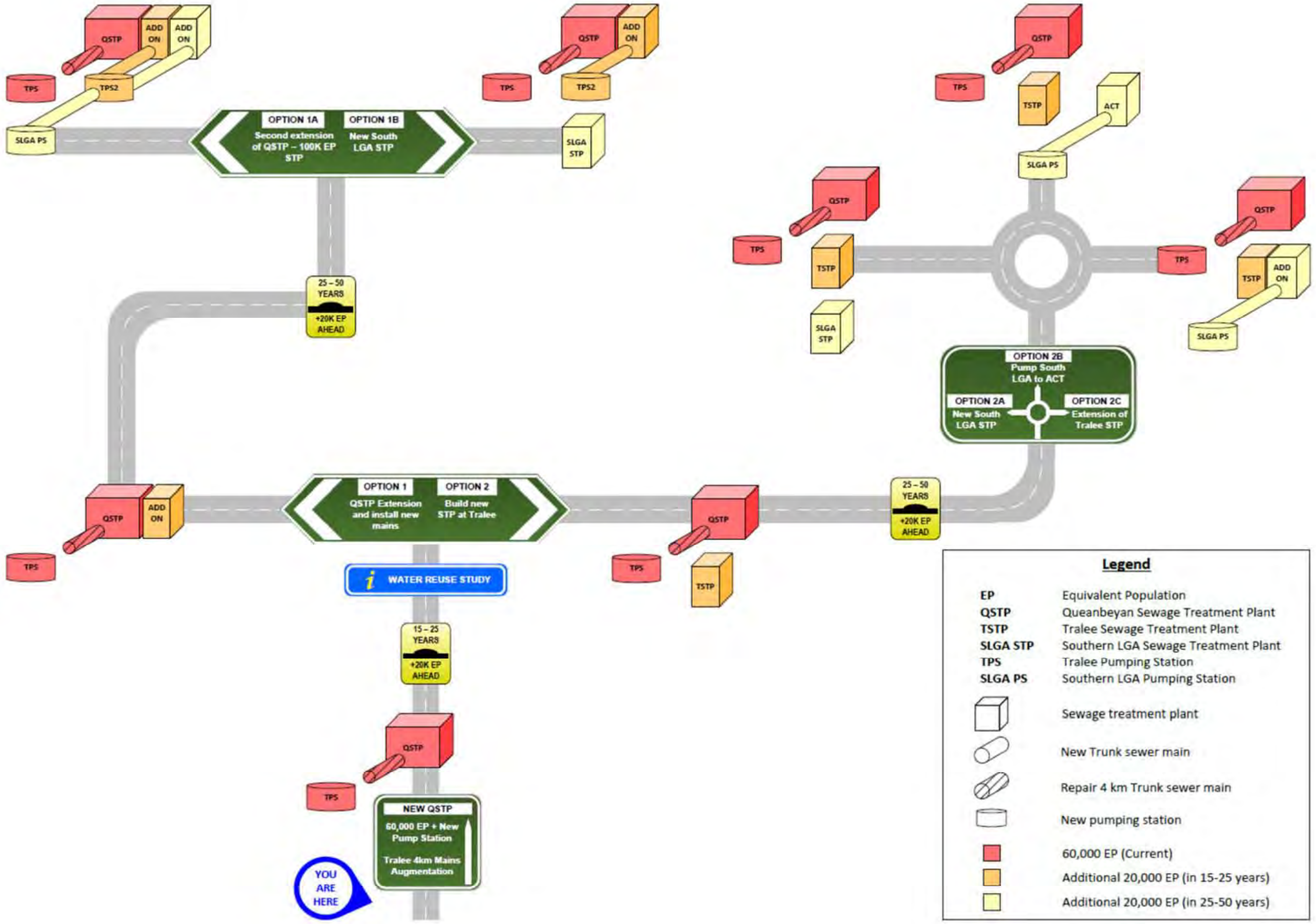

Figure 11-1 Road map for possible options

CURRENT

NEW QSTP

NEW PUMP STATION

4KM MAIN REPAIR

Figure 11-2 Proposed first development

OPTION 1
Y10-25
QSTP EXT
NEW MAINS
NEW PUMP STATION

Figure 11-3 Option 1 between 10 and 25 years

OPTION 2
Y10-25
BUILD
NEW STP
AT TRALEE

Figure 11-4 Option 2 between 10 and 25 years

OPTION 1A
Y25-50
1 x 100 K
EP QSTP

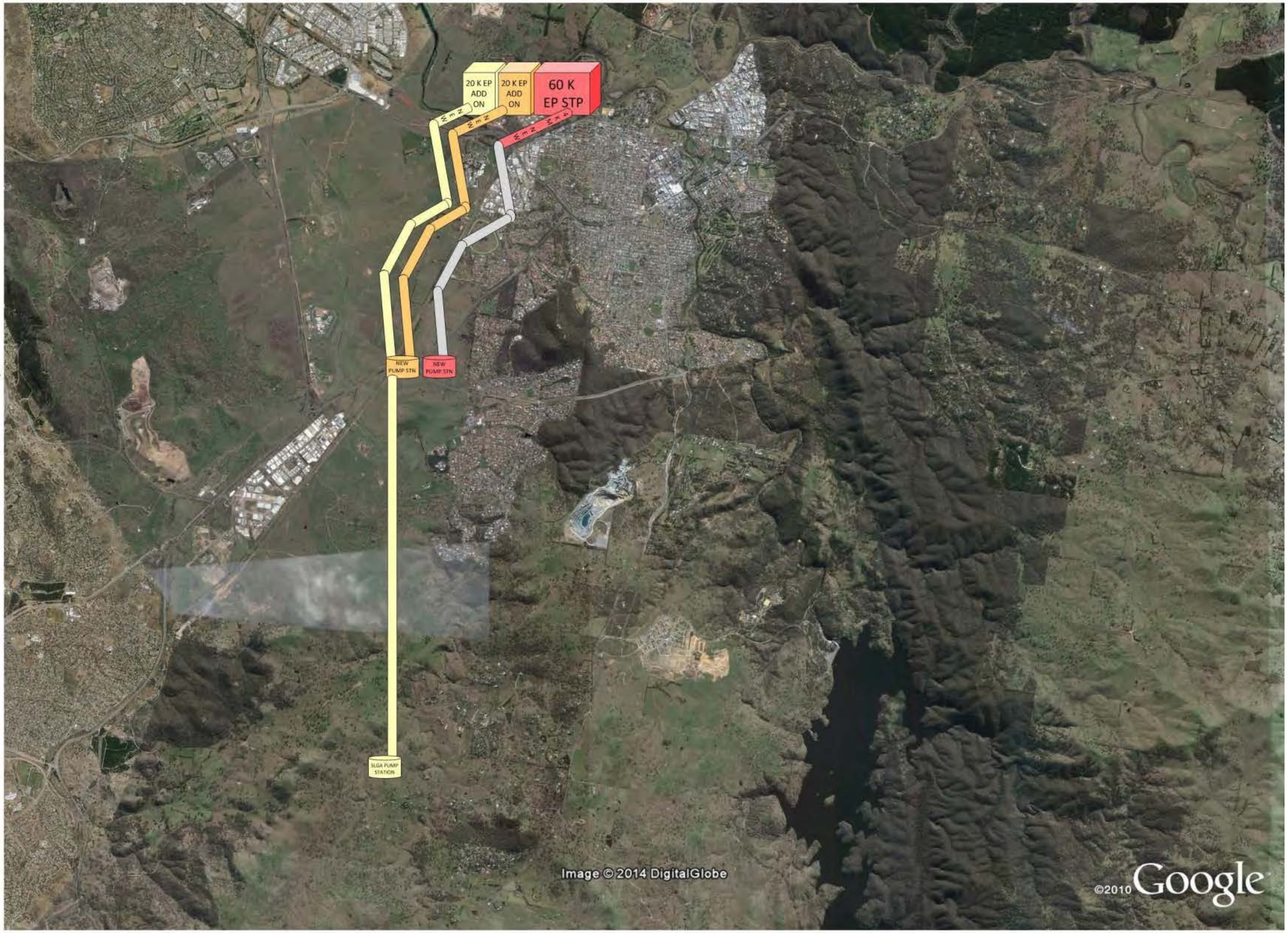

Figure 11-5 Option 1A between 25 and 50 years

Figure 11-6 Option 1B between 25 and 50 years

OPTION 2A
Y25-50
BUILD
NEW STP
AT SOUTH
LGA

Figure 11-7 Option 2A between 25 and 50 years

OPTION 2B
Y25-50
PUMP
FROM
SOUTH
LGA TO
THE ACT

Figure 11-8 Option 2B between 25 and 50 years

OPTION 2C
Y25-50
PUMP
FROM
SOUTH
LGA TO
TRALEE

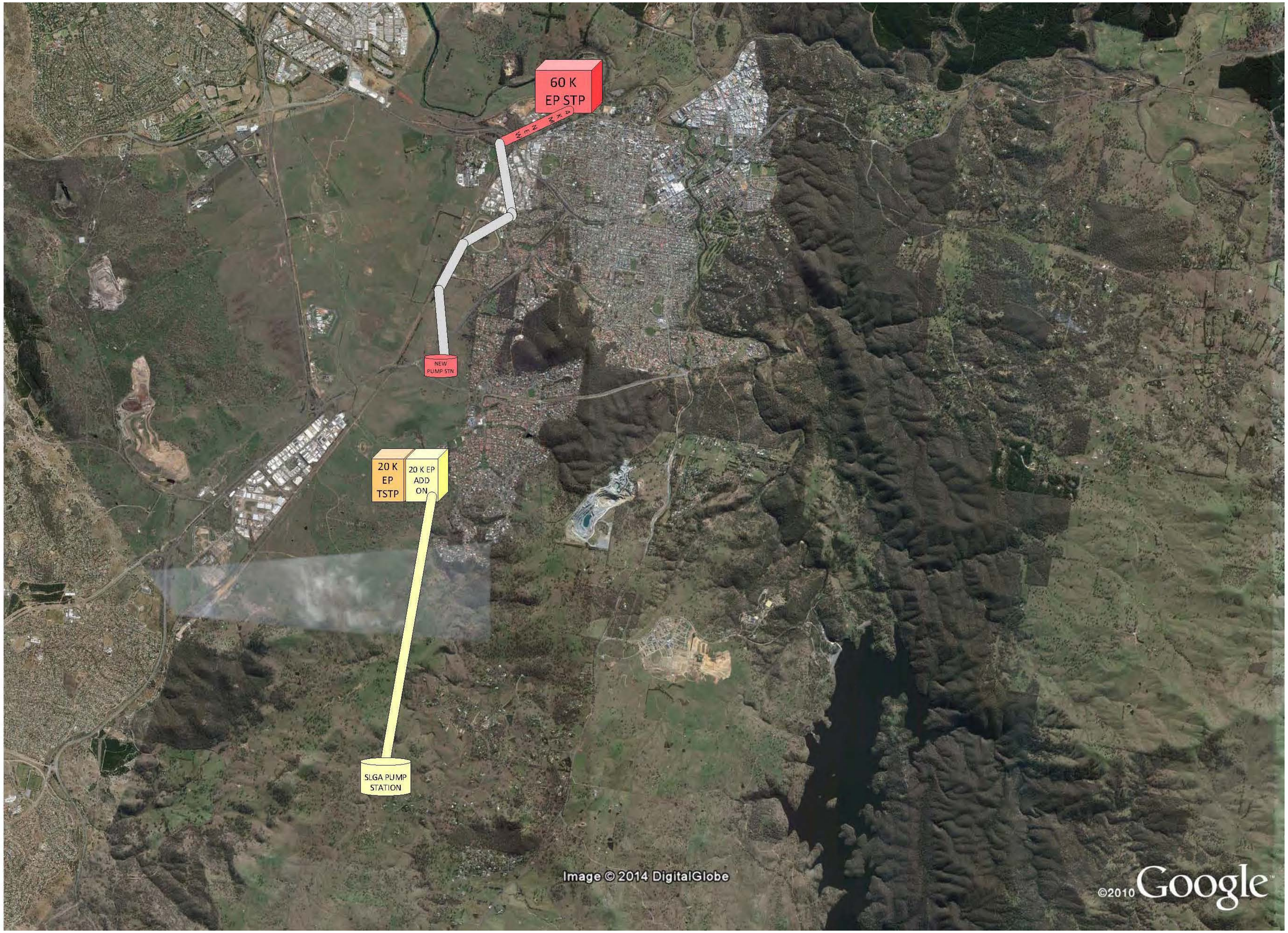

Figure 11-9 Option 2C between 25 and 50 years

12 Upgrade Options

12.1 Introduction and Background

In April 2015, the Office of Water2 (OW) stated some parts of QSTP were possibly reusable. OW requested QPRC to consider three upgrade approaches and propose an approach, which represents value for money3. The OW upgrade approaches included:

(a) Build a new STP

(b) Build a new STP, using restored parts of QSTP

(c) Restore QSTP and expand as needed to provide sufficient capacity.

Technical Memorandum TM004 was prepared for the purpose of assessing the three QSTP upgrade approaches. This is included in Appendix K.

12.2 Approach and Method

The QSTP upgrade requires a choice not only of build strategy but also of treatment technology. QPRC intends to deal with technology choices during concept design.

The analysis comprised the following steps:

(a) Review QSTP condition to identify what (if any) parts of the plant can be readily renewed and used for the new STP

(b) Identify one or two STP types that could be used to describe the build strategies (options)

(c) Prepare key criteria for sizing / quantifying the new STP options

(d) Describe the three build strategies (options) in terms of

    (i) Treatment process components

    (ii) Capital and operating costs

    (iii) Constructability

    (iv) Operability

    (v) Sustainability

    (vi) Future proofing.

(e) Consider other similar upgrade projects in NSW which might shed light on the decision to either Build New" or “Renew and Augment”.

(f) Undertake a multi-criterion analysis (MCA) to rank options and recommend a build strategy.

12.3 Existing STP Condition

A condition assessment was undertaken, which identified that only the aeration tanks, secondary clarifiers and sludge lagoons could be reused.

The following figure identifies the reuse potential of QSTP.

The inlet works, primary sedimentation tanks, trickling filters and effluent ponds were all discarded as having reuse potential due to their poor condition and in part being affected by the 100 year ARI flood level.

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2 The Office of Water in the NSW Department of Planning and Infrastructure

3 Value for Money: A balanced outcome in terms of cost, quality, risk, resource use, fitness for purpose, operability, water quality, environmental protection, and sustainability.

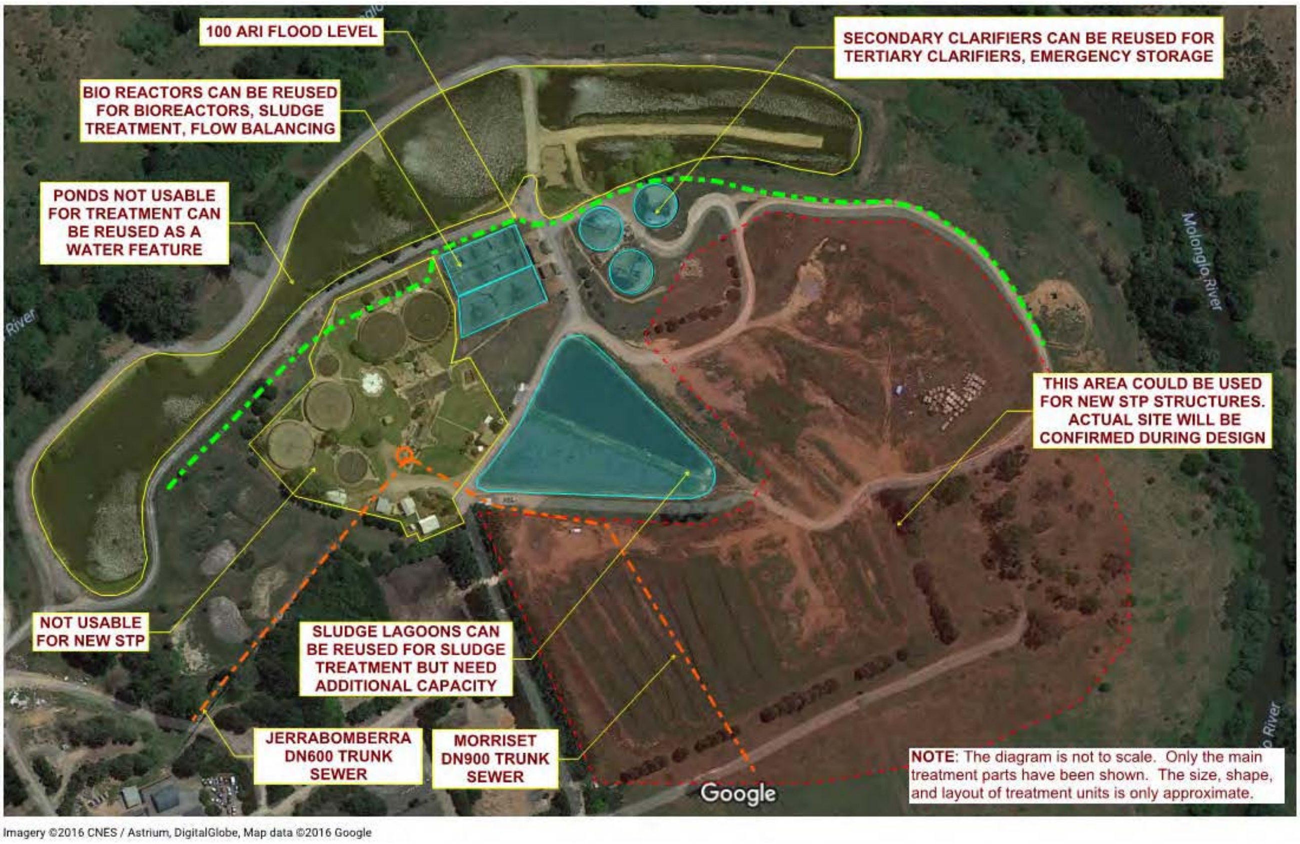

Figure 12-1 Reuse Potential of QSTP

12.4 Upgrade Options

Six build strategy options were compared. These included consideration of both Conventional Activated Sludge and Membrane Bio Reactor technology for each of the three build strategies. The options were as follows:

Table 12-1 QSTP Upgrade Options

Option	Build Strategy	Treatment Technology
1A	**Build New** all process units and equipment, completely abandon the existing plant	BNR - Biological Nutrient Removal CAS - Conventional process
1B	**Build New** all process units and equipment, completely abandon the existing plant	BNR - Biological Nutrient Removal MBR - Membrane process
2A	**Build New** main process units and **Reuse** some process units from STP	BNR - Biological Nutrient Removal CAS - Conventional process
2B	**Build New** main process units and **Reuse** some process units from STP	BNR - Biological Nutrient Removal MBR - Membrane process
3A	**Renew** main QSTP process units & **Augment** with new additional units	BNR - Biological Nutrient Removal CAS - Conventional process
3B	**Renew** main QSTP process units & **Augment** with new additional process units	BNR - Biological Nutrient Removal MBR - Membrane process

Preliminary site layouts were developed for each option and compared in terms of:

- Constructability
- Operability
- Sustainability
- Future Proofing, and
- Overall Delivery Risk

In addition, to assist consideration of the upgrade approaches, owners of four separate sewage treatment plants that have recently been, or are about to be upgraded were surveyed, and their responses used to inform the option assessment.

The drivers for the plant upgrade appear to have a strong link to the decision to proceed with a new plant, new plant with restored components or restore existing and augment:

- Capacity as a driver is open to retaining parts or restoring the plant for augmentation.
- Stricter licence conditions and in particular the ability to recycle water typically resulted in a decision for a new plant.
- Where capital cost is a primary driver, components may be retained where these perform satisfactorily and are in suitable condition. Items commonly reused are balance tanks, ponds, lagoons and sometimes secondary treatment units.
- Improved biosolids quality did not appear to determine the upgrade approach.
- Asset condition is obviously a key consideration in the decision as to reusing components.

The key drivers for the QSTP are capacity, stricter licence conditions and asset condition of most of the existing STP structures. Based on the lessons learned above, a preference for a new STP (Options 1A, 1B) would be expected.

12.5 Cost Estimates

CAPEX cost estimates were prepared for the six options and include construction of new works, rehabilitation of existing structures (where applicable), construction of other supporting capital works, additional preliminaries for extended construction (where applicable), Survey, Investigation and Design (SID) and contingency allowance of 25%. The CAPEX cost estimates fall within a range of plus or minus 5% which is within the level of estimating accuracy, which means that the options cannot be separated on a CAPEX basis. However, it is noted for each option, that the CAPEX cost of the BNR CAS option is slightly more expensive than BNR MBR.

The OPEX cost estimates include labour, power, chemicals, UV lamp and diffuser replacement, membrane replacement (7-year life adopted), Electrical and Instrumentation replacement each 17 years and disposal of biosolids. The OPEX estimate for the BNR MBR options is approximately 15% higher than the BNR CAS options.

The NPV was assessed using a Market Attractive Rate of Return (MARR) of 7%, and tested for sensitivity using rates of 4% and 10 %. The NPV costs fall within plus or minus 2% of each other making the difference between the options again insignificant on a cost basis. The slight advantage of the lower CAPEX of the BNR MBR options is countered by the higher OPEX costs resulting in the technology selection having no impact on the NPV assessment outcome.

12.6 Multi-Criteria Analysis

A Multi Criteria Analysis (MCA) was undertaken of the options considered. Six criteria were used being:

- Cost (NPV)

- Constructability, including quality, environmental and safety risks, timeframe for completion, likelihood of exceeding discharge licence conditions and extent of temporary works.
- Operability, including potential for increase in operating costs, ability to operate, WHS for operational staff, extent of autonomy and remote capability.
- Sustainability, including impact on environment, ability to reuse effluent and biosolids and ability to capture gas and resource recovery.
- Future Proofing, including achieving licence, increasing capacity and accommodating unexpected increases in flows or influent quality.
- Community Acceptance and Affordability, including impact on rates and QPRC financial position and QPRC reputation.

The criteria were weighted via a workshop together with QPRC's Director of Projects and Assets - Phil Hansen, Water and Sewerage Manager - Andre Pretorius, Principal Engineer (Water and Sewerage) - Peter Cox and Project Support Engineer - Simon Boulton. This resulted in the following weightings for the selected criteria provided in Table 12-2 below.

Table 12-2 MCA Criteria Weighting

Criteria	Weighting
Cost	14%
Constructability	4%
Operability	15%
Sustainability	13%
Future Proofing	17%
Community Acceptance and Affordability	37%

The criteria were then scored by the participants of the workshop with results and ranking as shown in Table 12-3 below:

Table 12-3 MCA Results and Rank

Criteria	Options					
	Option 1A	Option 1B	Option 2A	Option 2B	Option 3A	Option 3B
Cost	4.9	4.9	4.8	4.9	5.0	4.9
Constructability	4.3	4.3	2.7	2.7	2.3	2.3
Operability	4.3	4.0	3.3	3.0	3.3	3.0
Sustainability	4.3	4.3	4.0	4.0	4.0	4.0
Future Proofing	3.7	4.3	3.7	4.3	3.7	4.3
Community Acceptance and Affordability	3.7	3.7	2.7	2.7	2.2	2.2
Normalised Score	99	100	83	85	79	80
Rank	2	1	4	3	6	5

The MCA normalised scores indicate that Options 1A and 1B are difficult to separate and represent the preferred options. Options 2A and 2B similarly have close scores but are clearly separated in their ranking at 3rd and 4th and Options 3A and 3B also have close scores and are 5th and 6th in their ranking. The sub options of A and B based on the process selection can be seen to have no impact on the selection of the upgrade approach.

The sensitivity of the MCA outcome was then tested for the following criteria weighting scenarios:

- All criteria equally weighted
- Each criterion in turn considered the most important with 50% weighting and all other criteria with 10% weighting each.

Irrespective of the scenario selected above, the Options 1A and 1B always ranked the highest indicating that the selection is not particularly sensitive to the weightings adopted for the various criteria.

12.7 Concluding Remarks

The assessment presented in Technical Memorandum TM004 concluded that the "Build New" strategy is the preferred option. Financially, the options cannot be separated with the key considerations being Community Acceptance, Operability, Sustainability and Constructability.

13 Risk Based Cost Estimate

13.1 Approach

A risk based project total cost estimate has been prepared for the Stage 1 upgraded STP, i.e. a 60,000 EP sewage treatment plant at the existing STP site. This is in line with the proposed upgrade option presented in this Masterplan. Further options analysis is required prior to development of future stages and as such these have not been costed here.

The mean estimated project value for the first stage development is $108 million. The maximum estimated project budget cost is $140 million. This value includes:

- Consulting services for
  - Project management
  - Planning and design (including site survey and geotechnical surveys)
  - Environmental studies
  - Construction superintendence
  - Construction administration
- QPRC staff inputs
- Capital works cost
- Stakeholder and regulatory engagement
- Reimbursable items for QPRC staff and Consultants.

The cost estimate does not include decommissioning and site rehabilitation costs for the existing STP facility or costs for connecting the Tralee development to the Jerrabomberra Trunk Sewer. The cost estimate also does not include operating costs or ancillary costs such as land purchase (as existing site is proposed to be maintained).

The estimate has been prepared with consideration for the likely outcome of costs but, due to the early nature and scope of this work, it is possible that the final costs may vary from this estimate. This is illustrated in Figure 13-1, which shows a risk based spread of the likely overall project cost estimate. It should be noted that a rigorous scope analysis has not been undertaken and budget estimates have been prepared on the scope known at this time.

The cost estimate has been based on assuming the concept design is a relatively complete reference design (75% design) and the detailed design is assumed to be about 70 to 80% of the concept design effort.

The project planning horizon is 50 years and the project timeframe for the initial upgrade (60,000 EP) is assumed to be six years. Additional costs would be incurred for delivery of future stages of the STP (or decentralised alternative sites) for meeting future demands of the Queanbeyan LGA.

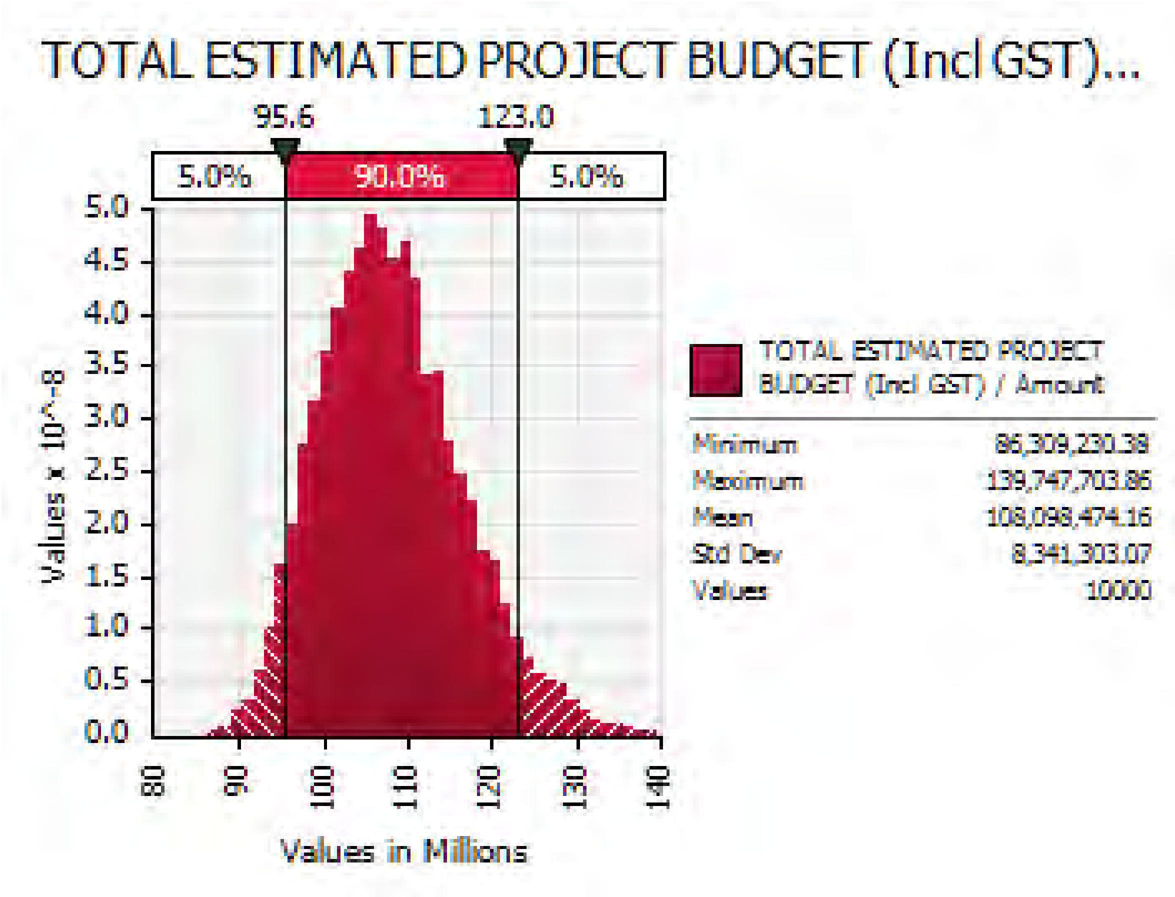

Figure 13-1 Risk based assessment of total estimated project costs

13.2 Concluding observations

Overall, the QPRC cost estimate is likely conservative, but (as noted in the estimate), given the project is probably five or more years from delivery, this conservative approach is appropriate. It is appropriate to proceed with the project on the basis of the QPRC derived project budget cost.

14 Stakeholders

Various engagement activities have been held with stakeholders from Federal, State (NSW and ACT) and Local Government, as well as QPRC business units.

The key stakeholder and regulatory agencies are listed in the Register provided at Appendix E.

The Project Management team holds the Register in full. The Register includes attendance at workshops and contributing comments. This will be a live document as the project progresses through the next phases, updated by the project management team.

14.1 Engagement

A preliminary briefing to regulators was held on 29 May 2014 that gave an overview of the project and the indicative timeframes for delivery.

A Masterplan briefing to regulators was held on 13 February 2015. This workshop provided an overview of the findings from the Masterplan and the proposed options to be taken through to concept design. The outcomes of this workshop have been incorporated into this Masterplan document.

The main items coming from the workshop included:

- Keen to investigate a regional / cross border arrangement
- Phosphorus discharge needs to be considered in light of the phosphorus budget for LBG
- Comfortable with the options proposed
- Need to consider recycled water
- Continue to liaise on Road Map options.

14.2 Community consultation

Community consultation for this project will be undertaken as part of QPRC's commitment to the Infrastructure Sustainability Rating Scheme and obtaining a certified "Excellent" rating for the new infrastructure.

QPRC subscribes to the foundations of public participation advocated by the International Association for Public Participation IAP². QPRC will undertake decision making by actively seeking community participation in the options process. QPRC will actively be responsive the publics suggestions and concerns in finalising the preferred option.

It is hoped that through this process QPRC will develop infrastructure that is designed, optimise environmental, social and economic outcomes, which includes considering and consulting on the social / public aspects of the decision process.

15 Interim and transition infrastructure requirements

It is acknowledged that the planning, design and construction of a new STP will take time. In the meantime, the existing plant must be kept operational, meeting licence requirements. As such, a review of current operations was undertaken and options for interim operating improvements were investigated. These options are summarised here and the technical memoranda are presented in Appendix J.

15.1 Inlet screens

The existing screens were not effectively removing screenings and, due to age, prone to failure. A review of the current screens was undertaken and the following recommendations and actions were made.

- The existing functional mechanically-raked bar screen be replaced with either a step screen or spiral sieve screen. Both types are suited to retrofitting in existing channels. Irrespective of the relative capture rates for these different screen types, the screens will capture a significantly higher volume of screenings than the existing screen with 20 mm aperture
- QPRC to further consider the offer from VoR Environmental with respect to the option of immediate delivery of a reconditioned 3 mm aperture Meva step screen compared to a 6 mm CFC700 spiral sieve screen with a compactor but with a delivery time of up to 18 weeks
- The offer from VoR Environmental is for supply and delivery only. The costs for the full installation should be further investigated
- When the William Boby screen in the west channel is being used, install stopboards at the discharge into the disused Grit Chamber No. 1 so that the flow is directed to the Vortex Flow Grit Trap
- Hydraulic analysis to be undertaken to assess the benefits of the Installation of a weir plate on the overflow from the main screen channel to reduce the volume of wet weather overflow to the manually raked bypass screen
- QPRC approach the ACT Government to allow the screenings to be disposed of at the Mugga Lane landfill

As a result of an in parallel to this review QPRC undertook a refurbishment of the existing screen. This refurbished screen was reinstalled in the channel with reduced aperture (12 mm) and is working effectively.

15.2 Final clarifiers

Scum is accumulating on the surface of the final clarifiers, which leads to the operators having to regularly hose the surface of the clarifiers to remove and break up the surface scum, in an attempt to control the build-up of scum. The operators have also removed a short section of the scum baffle in an attempt to alleviate this problem. It is reported that the depth of scum on the surface of the clarifiers exceeds the height of the outer scum baffle at times.

The existing scum surface skimmer/scraper and associated scum beach and chute are currently not operational and are in a condition of disrepair, such that they are ineffective in removing scum from the final clarifiers. Scum that may be removed from the clarifiers through the surface skimmer arrangement, gravity flows to the return activated sludge (RAS) pump station/s and is returned to the bioreactors with the RAS.

The scum overflowing the clarifiers with the effluent flow is arrested on the surface of a small inlet lagoon before the flow passes into the main tertiary lagoons.

In order to control the surface scum accumulation on the final clarifiers, the following options have been considered:

- Encourage scum to flow with the clarifier effluent to the Tertiary Lagoons

- Remove scum from the clarifiers by re-instating the existing final clarifier scum mechanisms and peripheral scum baffles, to effectively remove the surface scum from each of the clarifier surfaces
- Reduce potential for scum growth by operating at lower sludge retention time in the biological process.

15.3 Sludge Lagoons

Currently the sludge from the activated sludge process is wasted to either of two lagoons, where it is stored and stabilised prior to drying on the site's sludge drying beds. Only one of the sludge lagoons is fed over a period (approximately 6 to 12 months). When that lagoon is filled, then the sludge is directed to the other (empty) lagoon. The filled lagoon is then pumped out to the sludge drying beds, so that it is emptied prior to the other lagoon completely filling. When the sludge has sufficiently dried on the drying beds, it is removed and stockpiled on site.

The stockpile area is at capacity and an alternative needs to be found in the short-term. In addition, the sludge drying beds are at capacity, so that the sludge lagoons are filled before the sludge on the drying beds is sufficiently dried.

15.4 Timing

These interim measures should be undertaken as soon as possible.

16 Approvals

QPRC operates a STP on land bordering the Molonglo River within the ACT. The collection system for this STP is located in NSW and the discharge is to the Molonglo River, which flows to Lake Burley Griffin (LBG). The National Capital Authority, a Federal Government department, manages LBG. This regulatory inter-relationship makes the approvals process complex.

Infrastructure is required to ensure the capacity of the STP can meet the demands of the Queanbeyan community and reliably protect the environment and public health 50 years into the future and planning for this is underway.

The following defines the land on which the sewage treatment plant currently operates:

Block 27 Jerrabomberra (Rural Proposed):

- Block 2087 Jerrabomberra (Rural Registered).

The blocks (herein referred to as 'the site') are currently leased from the ACT Government by QPRC. It is understood that there are less than 20 years remaining on the existing lease title (lease expires 1 April 2023).

The boundaries of block 2087 and 27 Jerrabomberra are slightly different and clarification of the site boundaries should be sought prior to completing concept designs and applying for statutory approvals.

The following sections briefly identify the anticipated regulatory approval process for the development of a new sewage treatment facility within the current site boundaries.

A Regulatory Approvals Roadmap is provided in Appendix C. This would be updated during the project as required.

16.1 Planning

16.1.1 Development Application

The site is located in the ACT on Territory Land and is therefore subject to the requirements of the ACT *Territory Plan 2008*. The site is zoned as TSZ2: Services and NUZ4: River Corridor land uses under the Territory Plan.

The proposed activity requires an environment impact statement (EIS) under Schedule 4 of the ACT *Planning and* Development *Act 2007* (P&D Act) [4].

ACT Health (together with the NCA) regulates discharges to Lake Burley Griffin. The Minister responsible for the ACT *Public Health Act 1997* has the ability to declare the proposal impact applicable and therefore requiring an EIS to be undertaken.

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[4] *proposal for construction of a wastewater treatment plant (including a plant for the treatment of sewage or other effluent) that—*

(a) will be less than 1km from the boundary of a residential block or unit in a residential or commercial zone; or

(b) will be able to treat each day more than—

(i) 2 500 people equivalent capacity; or

(ii) 750kL; or

(c) will have capacity to store more than 1kt of sewage, sludge or effluent; or

(d) will incinerate sewage or sewage products; or

(e) will have a capacity to treat more than 100ML of wastewater (excluding stormwater) each year; but

f) is not—

(i) a plant for the treatment of stormwater; or

(ii) a small-scale wastewater treatment plant (including a plant for the treatment of sewage or other effluent but not including a small-scale plant prescribed by regulation); or

(iii) a residential on-site wastewater treatment system (including a septic tank)

It is unlikely that this will occur given that an EIS is already required and that the proposal will improve the quality of the inputs into the Molonglo River and other receptors. Nevertheless, consultation with ACT Health would likely be required as part of the EIS preparation.

The construction of a “sewage treatment facility” is not a prohibited activity in the zones (TSZ2: Services and NUZ4: River Corridor).

The Development Application (DA) would likely be assessed under the Impact Track. A completed EIS is required to be submitted with a Development Application submitted under the Impact Track. This applies to the whole site zoned TSZ2: Services and NUZ4: River Corridor (small areas bordering the Molonglo River).

Any development undertaken on the site must meet the requirements of the Transport and Services Development Code and the Non-Urban Zones Development Code.

At this stage, there does not appear to be anything to differentiate potential developable areas of the site in relation to the DA path. All areas are likely to require assessment under the Impact Track.

If the existing STP was to be refurbished, there *may* be scope for the proposal to be assessed under the Merit Track, but this would require further investigation.

Demolition/decommissioning of the existing infrastructure *may* be able to be assessed under Merit Track, as demolition is listed as a permissible activity in the Services Zone Development Table. These activities are however likely to be included in any EIS undertaken for the proposal. Inclusion of these activities in the EIS would likely be the most efficient approval path.

16.1.2 National Capital Plan

Consultation with the NCA and compliance with the provisions of the Federal Government’s *National Capital Plan* would likely be required. The NCA (together with ACT Health) regulate the discharge to Lake Burley Griffin. Specifically the requirements relating to Urban Areas, Broadacre Zones and Lake Burley Griffin, Hills Ridges and Buffers, River Corridors and Mountains and Bushland would likely need to be considered.

A Works Approval or Development Control Plan is unlikely to be required as the site is not located near any Designated Areas.

16.2 Environmental Approvals

16.2.1 Environmental Impact Assessment (EIA)

EIA is used to assess the impact of a project on the environment. Under ACT legislation, an EIS would be prepared as required for the STP upgrade DA (see Section 16.1.1 above) under the *P&D Act*. This would include various specialist studies that would be identified in a Scoping Document, which outlines what must be addressed in the EIS. The Scoping Document is prepared by the EPD.

In order to apply for a Scoping Document, a Preliminary Risk Assessment (PRA) must be completed in accordance with AS/NZS 14004:2004 Environmental Management Systems and AS/NZS ISO 13000:2009 Risk Management. The PRA must accompany the request for a Scoping Document.

The quality of the information provided with the Scoping Document application will determine the extent of work required to complete the EIS.

It is important that the application is not made until there is sufficient information to clearly understand the nature of the development and its potential impacts.

Similarly, if works are proposed in NSW (such as for the collection network), environmental approvals consideration would be required for this as well. It is possible that, depending on the scale of the works, QPRC could be the determining authority.

Continued engagement with EPD, ACT Government Stakeholders, NSW EPA and the NCA will be required throughout the preparation of the EIS.

16.2.2 Preliminary Environmental Assessment

Currently, there is not enough information known about the issues and constraints on the site and therefore the impacts likely to occur from the proposal to inform the Scoping Document. A Preliminary Environmental Assessment could be undertaken in the early Concept Design stages to enable sufficient information to be gathered for both the design and the Scoping Document application.

16.2.3 Environmental authorisation

The proposal is also classified as a *Class A* activity under the ACT *Environment Protection Act 1997* and will therefore require an Environmental Authorisation for the operation of the site. QPRC already has an Environmental Authorisation for the existing plant that is reviewed on an annual basis. The current Environmental Authorisation states "*1.1.5 The Authorisation holder shall seek the approval in writing of the EPA to install, construct or modify any equipment or works in or on the premises which would impact on the plant's capacity to achieve Authorisation conditions*."

It should be noted that the current Environment Authorisation is for Block 2087 Oaks Estate (now known as Block 2087 Jerrabomberra). Clarification of the site should be made in the Authorisation, including the applicability of the approval to Block 27 Jerrabomberra.

16.2.4 Environment Protection Agreement

An Environment Protection Agreement may be required for *Class B* activities (under the ACT *Environment Protection Act 1997*) carried out during construction on the site. This would be confirmed once further information regarding the design and construction of the proposed sewage treatment plant is known.

16.2.5 Waterway works licence

Works undertaken within the Molonglo River Corridor would likely require a Waterway Works License (ACT government). Further detail regarding the proposed design of the sewage treatment plant is required to determine the need for this approval.

16.2.6 River discharge licence

A licence allowing treated wastewater to be discharged to the Molonglo River would likely be required. QPRC has an existing licence with the ACT that will need to be confirmed and updated during the project.

16.2.7 Contaminated land management

As part of the EIS, a contamination assessment would likely be needed to determine the contamination status of the site and remedial actions that might be required.

Development of the site would be subject to the ACT *Contaminated Sites Environmental Protection Policy 2009* (EPP). It is likely the site is listed on the ACT Contaminated Sites Register; given sewage treatment plants are recognised in the EPP as a potential source of contaminants.

16.2.8 Matters of National Environmental significance

As part of the EIS, an assessment under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) would likely be required to determine whether the proposal would have a significant impact on Matters of National Environmental Significance.

A Bilateral EIS process can potentially apply to proposals that require both an Environmental Impact Statement (EIS) under the ACT *P&D Act* and also approval from the Department of the Environment under the *EPBC Act*. The Australian Government has accredited the ACT's EIS process through a bilateral agreement as meeting the environmental assessment requirements of the EPBC Act.

If an EPBC Act referral is submitted to the Department of the Environment and if the proposed action is determined to be a controlled action under the EPBC Act and requires an EIS under the ACT *P&D Act*, the ACT Government may invoke the bilateral agreement. If the bilateral agreement applies the subsequent scoping document and EIS assessment report will be prepared by the ACT with input from the Australian Government.

16.2.9 Waste management

The management of waste from the proposed development, including waste generated from construction, demolition of existing infrastructure and waste products from the operation of the site must be considered.

Early consultation with ACT NOWaste and the ACT EPA regarding waste management would be required, particularly given the current shortage of landfill space in the ACT.

It is understood that wastewater and sludge are currently managed on site. It is also understood that solids management is unlikely to be undertaken on site in the new STP design.

Additional approvals would likely need to be sought from EPD, QPRC, ACT NOWaste, ACT EPA and NSW EPA to allow management of biosolids to occur at the proposed end point. The current Environmental Authorisation states "*3.2 Reuse of sewage sludge in the ACT should be in accordance with the National Water Quality Management Strategy Draft Guidelines for Sewage Systems Sludge (Biodsolids) Management 1998*."

The concept design should be progressed to demonstrate how sludge would be managed (i.e. level of dewatering and treatment) such that biosolids could be able to be moved and processed (reused or disposed of) appropriately off-site. The EIS can likely be submitted prior to identifying the final end-point of the biosolids; however this will require further confirmation and consultation with the EPD and the relevant stakeholders.

In addition, approvals would likely be required to allow transportation of waste outside of the ACT.

16.3 Infrastructure approvals

Section 60 of the NSW Local *Government Act (1993)* requires DPI Water to approve:

A council must not, except in accordance with the approval of the Minister for Primary Industries, do any of the following:

a. As to works of water supply-construct or extend a dam for the impounding or diversion of water for public use or any associated works

b. As to water treatment works-construct or extend any such works

c. As to sewage-provide for sewage from its area to be discharged, treated or supplied to any person

d. As to flood retarding basins prescribed by the regulations-construct or extend any such basins.

DPI Water provide approval following a 5 Step process for a detailed design and construction procurement, as indicated in Figure 16-1. QPRC are required to involve DPI Water at each Step and seek their consultation and formal endorsement. Essentially this means that the following documents are submitted and approved:

- Masterplan and options report
- Concept design report
- Detailed design report.

(http://www.water.nsw.gov.au/Urban-water/Country-Towns-Program/Best-practice-management/Regulations-for-water/Water-and-sewage-treatment-works/Construction-of-a-detailed-design/default.aspx).

The NSW Government's Best-Practice Management of Water Supply and Sewerage Framework require local water utilities to prepare and implement a sound 30-year Integrated Water Cycle Management (IWCM) Strategy, which includes a Financial Plan. The IWCM, which must be submitted to and approved by DPI Water, is closely linked to the Section 60 approvals process. A 30-year IWCM Strategy addresses the complex linkages between elements of the urban water cycle (water supply, sewage and stormwater) and community expectations. This is done within the urban area and between the urban area and its water related physical and legislative operating environment. This multi-level, transparent and systematic approach encourages cost-effective integration of these urban water systems in consultation with the local community.

(http://www.water.nsw.gov.au/Urban-water/Country-towns-program/Best-practice-management/Integrated-Water-Cycle-Management/Integrated-Water-Cycle-Management/default.aspx)

This requirement is likely to be associated with any funding support requested by QPRC.

Step		Local water utility	NSW Office of Water
1	**Initial consultation**	• Write to the Office of Water about the problem identified and the proposal to investigate the need for water or sewage treatment works.	• Send an acknowledgement letter to the utility. • Provide advice to the utility about the options study required for the proposed works. • Meet with the utility for discussion if needed.
2	**Options study**	• Provide a draft options study report to the Office of Water. • Arrange revision and finalisation of the report, incorporating comments from the Office of Water.	• Review the draft options report. • Provide comments to the utility. • Meet with the utility to discuss the comments if needed. • Endorse the final report.
3	**Concept design**	• Provide a draft concept design report to the Office of Water. • Arrange revision and finalisation of the report, incorporating comments from the Office of Water.	• Review the draft concept design report. • Provide comments to the utility. • Meet with the utility to discuss the comments if needed. • Endorse the final report.
4	**Detailed design**	• Provide a draft detailed design report to the Office of Water. • Address all issues and design changes raised by the Office of Water.	• Assess key aspects of the detailed design to ensure that it has adequately addressed all issues and meets the requirements of a robust, safe and soundly based and cost-effective solution.
			• Provide comments to the utility and request essential changes. Meet with the utility if needed.
5	**Section 60 approval**	• Provide the amended detailed design report to the Office of Water.	• Review the design changes made by the utility. • Issue Section 60 approval.

Figure 16-1 Five step approval process for NSW Office of Water

16.4 IWCM

The NSW Government has promoted continuing performance improvement across local water utilities, with the aim of improving the quality and efficiency of services to the NSW community. Performance monitoring and reporting has been aligned with the National Water Initiative, which operates at a Federal level. The first benchmark performance report was released for the 2005/06 financial year.

Since that time, the performance monitoring framework and associated reporting approaches and mechanisms has continually improved, most recently with the changes to the Integrated Water Cycle Management (IWCM) component, to which this project will contribute.

The NSW Government, via the Office of Water, contends that local water utilities which follow the Best Practice Management Framework will demonstrate and achieve more effective and sustainable water supply and sewerage services. It follows that adoption and implementation of such best practice frameworks at a local water utility level, through mechanisms such as IWCM, will provide for this.

The Framework is a key driver for planning reform and continuous performance improvement. The 19 requirements of the Framework are prescribed in the Best Practice Management of Water Supply and Sewerage Guidelines, which sit across 6 key elements including:

1. Integrated Water Cycle Management
2. Strategic business planning
3. Regulation and pricing of water supply, sewerage and trade waste:
   - Pricing
   - Developer charges
   - Liquid trade waste
4. Water conservation
5. Drought management
6. Performance monitoring.

In its purest form, the Framework allows for public accountability of the local water utility to the communities it serves, and provides verification of agreed service delivery standards. In addition, the framework supports the intent of the Water Management Act 2000 to protect human health and the environment. The framework support comes from using triple bottom line accounting to achieve a balance between financial, social and environmental outcomes.

Going forward, the Best Practice Management Framework will likely underpin the current Fit for the Future reform program, which NSW local councils must comply with. The NSW Government suggests that regional Joint Organisations be established to provide a platform for local council collaboration to achieve regional outcomes and maximise efficiencies. Joint organisations will likely be established along consistent regional boundaries, to reduce duplication and facilitate collaboration and this may impact QPRC. Financial support will depend on Councils demonstrating being ‘fit for the future’ and able to deliver capital infrastructure, which can be successfully (sustainably) operated over the long term.

DPI Water has advised QPRC that it should prepare and implement an IWCM for the whole LGA.

http://www.water.nsw.gov.au/Urban-water/Country-towns-program/Best-practice-management/Integrated-Water-Cycle-Management/Integrated-Water-Cycle-Management/default.aspx

17 Basis of design outcome

The observations made throughout this masterplan are summarised in Table 17-1 and will form the basis of design for the STP, informing the Concept Design Stage.

Table 17-1 Basis of design

Masterplan Element	Design Basis Outcome
***Best for region* Solution**	Queanbeyan's location on the border of NSW and the ACT puts it in a unique position. The STP is located in the ACT on leased land and ACT Environment and Planning Directorate (EPD) (which includes the Environment Protection and Water Regulation Division), ACT Health and the National Capital Authority (NCA) regulate various aspects of the STP operations. Potential regional opportunities for wastewater management are subject to ongoing discussion with the ACT Government and Icon Water.
Future Growth	Growth is expected to occur in the middle portion of the LGA within the 10 – 25 year horizon. The southern third of the LGA is then expected to grow during the 25 – 50 year horizon. Provision for the first stage of the Queanbeyan STP Upgrade should be for an EP of 60,000. This provides for the 10 to 15 years' growth projection. It should be noted that the projections within this Masterplan do not make allowance for any ACT contribution to sewage flows, though depending on timing of actual increases, some flow may be able to be accommodated. The EP calculator was based on average water data for Queanbeyan LGA averaged over 2009-14.
Existing Sewerage Infrastructure	The existing Queanbeyan STP condition currently presents a risk to QPRC with numerous suggestions for both immediate and short-term improvement. Beyond operability and WHS issues, there will be a stronger focus on water quality and environmental discharges. Tighter discharge criteria are likely to be imposed in the future when licence conditions are re-negotiated.
Future Sewerage Infrastructure	• The South Jerrabomberra sewer trunk will need to be upgraded to meet future capacity: – Consider augmentation of the Jerrabomberra Trunk Sewer between manholes W8 and the inlet channel of the STP – Any further augmentation should be delayed until a final service strategy is decided for future development to the south of Queanbeyan – A survey and sewer gauging program should be implemented for the whole length of the trunk sewer (manhole W78 to the STP inlet channel) to enable a more detailed analysis of the sewer • Continue discussions with Icon Water around cross-border arrangements and a regional approach to sewage management. • A septic tank receival station should be included in the new plant.
Environmental Constraints	The following should be considered when determining the location for future STP(s): • Avoid heritage listed sites, scenic protection areas, and quarry buffer zone • Construction within the ANEF affected areas could be considered if appropriate as aircraft noise is unlikely to be an impact on STP operations • Avoid infrastructure within the Q100 flood level without proper flood protection or mitigation measures in place • Avoid bushfire prone areas or provide adequate protections, appropriate to STP operations • Consider and incorporate mitigation of environmental issues on existing site as part of concept design.

<table>
<tr><th>Masterplan Element</th><th>Design Basis Outcome</th></tr>
<tr><td>Water Quality</td><td>Adopt the following effluent discharge criteria and 100% river discharge as the basis of design outcome.
<table>
<tr><th>Parameter</th><th>Units</th><th>Performance</th><th>Statistic</th><th>Proposed Licence Limit (100%ile)</th></tr>
<tr><td>Total Nitrogen</td><td>mg/L</td><td>10
5</td><td>90%ile
50%ile</td><td>10</td></tr>
<tr><td>Total Phosphorus</td><td>mg/L</td><td>0.15
0.1</td><td>90%ile
50%ile</td><td>0.2</td></tr>
<tr><td>Faecal coliforms</td><td>cfu/100mL</td><td>30
200</td><td>Median
90%ile</td><td>60</td></tr>
<tr><td>BOD</td><td>mg/L</td><td>10
5</td><td>90%ile
50%ile</td><td>10</td></tr>
<tr><td>Suspended Solids</td><td>mg/L</td><td>10
5</td><td>90%ile
50%ile</td><td>10</td></tr>
</table></td></tr>
<tr><td>Sustainability</td><td>Set sustainability targets with the goal of obtaining IS design and as-built ratings of Excellent with a score in the range of 65 – 75% or better.
Undertake a recycled water study to determine the viability of reuse in the future which addresses impacts on:
1. Discharge to the Molonglo River
2. Molonglo River yield and downstream environmental flows
3. Aquatic species along the Molonglo River.</td></tr>
<tr><td>Solids Management</td><td>The solid management solution comparison showed that the most beneficial options were:
• Reuse for land reclamation
• Production of fertiliser for animal crops
• Production of fertiliser for human crops
• Use for horticulture and landscaping.
The concept design phase should develop and consider these options further, however if other feasible options become apparent then these may also be considered.
A regional strategy for solids management is required but is outside the scope of this project.</td></tr>
<tr><td>Treatment Technologies</td><td>
<table>
<tr><th>Treatment Step</th><th>Preliminary Option (to be confirmed at Concept Design stage)</th></tr>
<tr><td>Preliminary</td><td>Inlet works screenings and grit removal to be determined by choice of the secondary treatment process.</td></tr>
<tr><td>Primary</td><td>Equalisation tanks or Primary settling and possible use of mechanical belt sieve.</td></tr>
<tr><td>Secondary (one of)</td><td>BNR Bio-Reactor plus one of
• Membrane Bioreactor (MBR)
• Conventional Activated Sludge (CAS), e.g.
– Sequencing Batch Reactor/ Intermittently Decanted Aerated Lagoons (SBR/IDAL)
– Pasveer/Oxidation ditch</td></tr>
<tr><td>Tertiary (one of)</td><td>• Tertiary Filtration
• Refurbishing secondary clarifiers</td></tr>
<tr><td>Disinfection</td><td>UV
Chlorine (if required for regulatory purposes)</td></tr>
</table></td></tr>
</table>

Masterplan Element	Design Basis Outcome	
	Solids	Grit and Screenings - Landfill
	Biosolids (one of or a combination of)	• Land reclamation • Animal crop production • Landscaping – Composting Other options may be considered if they can be shown to be feasible through a regional approach.
Upgrade Approach	A Multi Criteria Assessment found that a “Build New” upgrade approach was preferred taking into account whole of life cost, constructability, operability, sustainability, future proofing and community acceptance and affordability. All options including build new, refurbishment and reuse options provided a whole of life NPV around $100 M. The total project cost estimate prepared by QPRC using @risk modelling showed a mean estimated project value of $108 M. The assessment of plausible refurbished and reused assets showed no significant capital investment saving compared to the build new option cost estimates. All estimates are preliminary and based on a range of caveats. There is no discernible significant difference within the sensitivity of the cost analysis at a Masterplan level. The selection of treatment technology (BNR – CAS v BNR – MBR) was not significant to the outcome.	
Approvals	*ACT Approvals* Under Schedule 4 of the ACT *Planning and Development Act 2007* (P&D Act) the proposed upgrade to the STP would require an environment impact statement (EIS). A Development Application (DA) would also be required and would likely be assessed under the Impact Track. The completed EIS is required to be submitted with the Development Application submitted under the Impact Track. This applies to the whole site zoned TSZ2: Services and NUZ4: River Corridor (small areas bordering the Molonglo River). *NSW Approvals* NSW approvals will be required for any works within NSW (such as the sewerage collection system). The NSW legislation would similarly require Development Approval and environmental consideration (such as contaminated lands and endangered species). It is possible that the approving authority for this work could be QPRC. Further detail of the scope of any works in NSW would be required to determine this. NSW Office of Water is required to approve the STP upgrade under Section 60 of the *Local Government Act (1993)*. *Federal Approvals* Any works approval sought needs to consider the *Environmental Protection and Biodiversity Conservation Act 1999*.	
	General Comments In 2015 the interim ACT and Region Catchment Management Coordination Group was formed by the ACT Environment Minister. This group includes EPD, and other ACT Government Stakeholders. The function of this committee is to implement an integrated catchment management approach in the ACT and Region, including improving water quality in Lake Burley Griffin. Continued engagement with EPD, ACT Government Stakeholders, NSW EPA and the NCA will be required regarding Lake improvement through an agreed approach and throughout the preparation of the EIS. A framework for a joint approach is agreed. Local Councils are required to produce an Integrated Water Cycle Management (IWCM) plan outlined by the NSW Office of Water.	

18 References

MWH (2008), *Queanbeyan Sewage Treatment Plant Future Needs Study Final Report.*

HWA (2011), *Queanbeyan Sewage Treatment Plant Upgrade Options Assessment Summary Report*.

Appendix A Population Forecast and EP Calculator

1.1 Introduction

The population of Queanbeyan has been assessed using two main methods of mathematical modelling and a combination of qualitative and quantitative analysis; these are discussed in detail below. The models have also been referenced to population forecasts undertaken by the forecast.id, which is based off Australian Bureau of Statistics (ABS) data. These various models have been performed so that a comparison can take place to ascertain the forecasts from the EP calculator.

1.2 Mathematical Modelling Overview

There are three possible course for a population to increase in a given area:

1) Super exponential (dark red line)
2) Exponential (Green Line)
3) Logistic Growth (blue line)

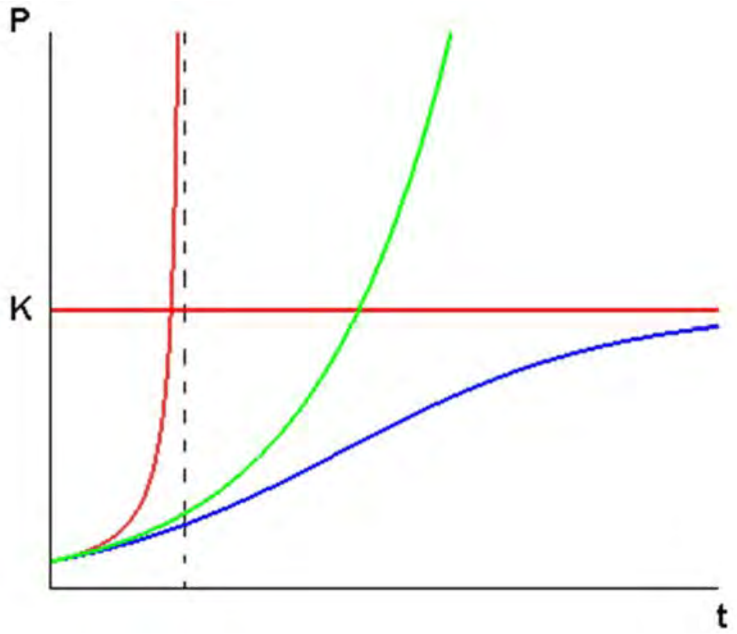

Figure 1 possible population growths. K = limiting factor, P = Population, t = time (years)

Super exponential growth is unrealistic and does not fit in with historic trends in Queanbeyan's History. Nor is there any foreseeable reason for this situation to take place (e.g. gold rush). Therefore this was not considered further.

Although an exponential growth in Queanbeyan to infinity is not practically possible due to resource constraints, this method of projection can possibly deliver a reasonable prediction for the short-medium term. Additionally first portions of the exponential growth closely match the Logistic Growth Curve, as can be seen from the figure below.

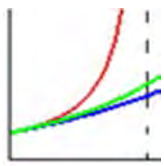

Figure 2 close early similarity between exponential and logistic growth (blue and green line

The Logistic Growth curve is the most realistic scenario as it places a limiting factor for population growth, as expected due to resource constraints. Resource constraint in this situation can be identified as the amount of population that can be held on the available land in the Queanbeyan LGA, assuming single dwelling density. It is governed by the following formula:

$$\frac{d}{d} = \frac{r\ (K - F)}{K}$$

P = Population

K = Maximum growth capacity

r = Growth rate

t = Time

1.3 Exponential Modelling

1.3.1 Modelling inclusive of Googong

The ABS performed Regional Population Growth projections for Queanbeyan in March 2011 using an approximate average growth rate of 2.25%. They repeated the growth projections again in April 2014 using an approximate average growth of 1.30%. The graph below shows the exponential modelling that was performed using these two growth rates as upper and lower bounds, respectively. It should be noted that the following numbers include Googong, which has its own Water Recycling Plant.

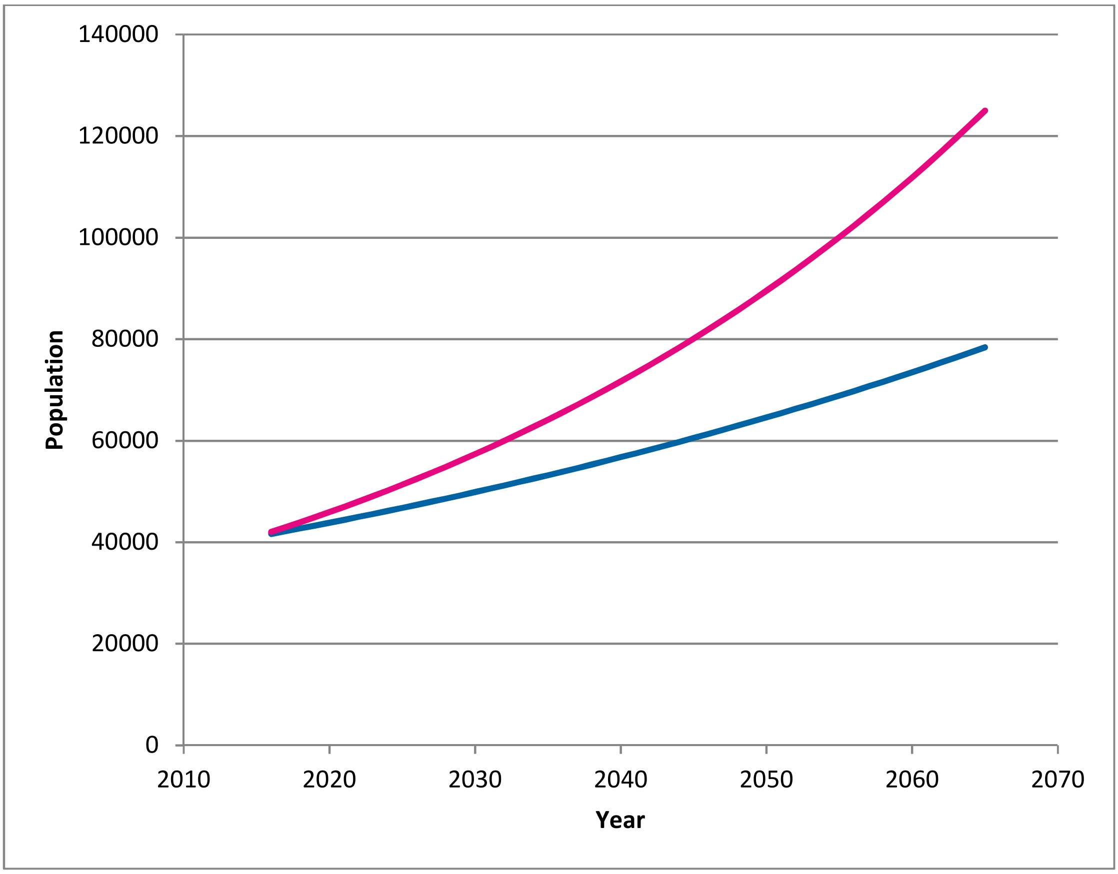

Figure 3 -Graph projecting population of Queanbeyan LGA using exponential growth (inclusive of Googong)

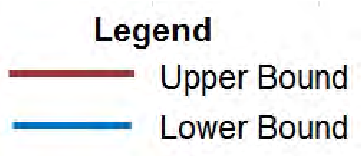

Table 1 population projection as per graph above

10 Year lower bound population projection	**46,770**
10 Year upper bound population projection	**51,346**
25 Year lower bound population projection	**56,769**
25 Year upper bound population projection	**71,690**
50 Year upper bound population projection	**78,405**
50 Year upper bound population projection	**125,037**

1.3.2 Population projection of Googong

To gain a further understanding on the population the new treatment plant/s will potentially have to service, the population of Googong needs to be disregarded. According to MWH's "Googong Integrated Water Cycle, Water and Wastewater Concept Design, Volume 1 – Main Report", Googong is expected to grow approximately at the following rate (note that the rates have been amended to reflect :

Table 2 projected growth in Googong

Year	Houses built in Googong	Googong Population*
2016	249	697
2017	505	1,414
2018	610	1,708
2019	831	2,327
2020	1031	2,887
2021	1223	3,424
2022	1476	4,133
2023	1702	4,766
2024	1928	5,398
2025	2166	6,065
2026	2405	6,734
2027	2644	7,403
2028	2897	8,112
2029	3237	9,064
2030	3422	9,582
2031	3713	10,396
2032	4050	11,340
2033	4247	11,892
2034	4587	12,844
2035	5010	14,028
2036	5226	14,633
2037	5475	15,330

2038	5558	15562

*1 House = 2.8 people

1.3.3 Modelling exponential growth excluding Googong population

By excluding the growth projections of Googong, whilst still applying an exponential growth and same upper and lower bound percentages (1.3% and 2.25 % respectively) the population projections are:

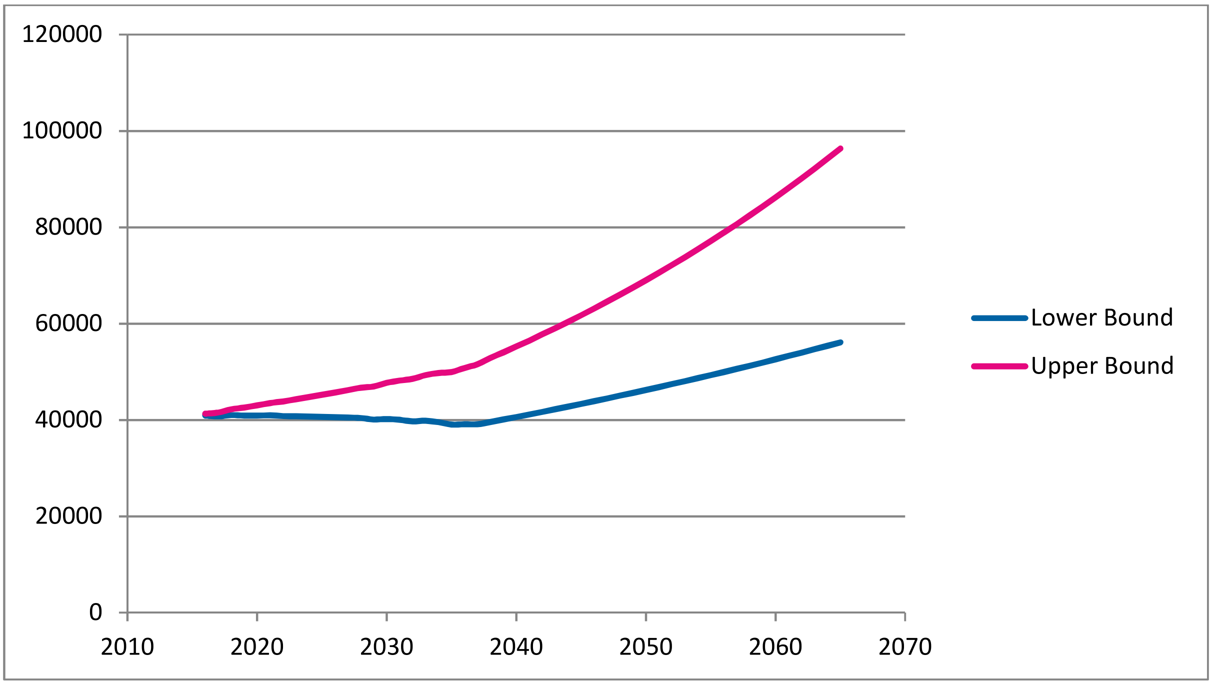

Figure 4 - Graph projecting population of Queanbeyan LGA using exponential growth (excluding Googong)

The decline in population on the lower bound indicates that the majority of the growth occurring in Queanbeyan LGA for the next 25 years is due to the growth in Googong. Though the lower bound is mathematically correct (growth in Googong is expected to occur faster than 1.3% therefore once the percentage of Googong's growth is subtracted from the total population of Queanbeyan, it produces a negative number), this is not realistic as Queanbeyan's population will most likely not decrease.

Table 3 population projections as per graph above

10 Year lower bound population projection	**40,705**
10 Year upper bound population projection	**45,281**
25 Year lower bound population projection	**41,568**
25 Year upper bound population projection	**55,419**
50 Year upper bound population projection	**72,501**
50 Year upper bound population projection	**96,659**

1.3.4 Modelling limiting factor growth (exclusive of Googong)

The limiting factor K is determined by the constraint of resources. In this case it is assumed that the resource constraint on population growth is the availability of land. It is assumed that a population of 150,000 represents mainly single density dwelling, would be the maximum capacity of Queanbeyan LGA. If medium density development is allowed throughout the LGA, it is assumed that 3 houses would which would have normally contained a total of approximately 9 residents would have to be demolished to build a 3 level apartment block with 4 units on each level, thus containing approximately 30 people. Therefore population density would approximately triple if all single density dwellings were to be converted to medium density dwellings.

Although theoretically, it would be possible for Queanbeyan to transform into a high density area (similar to Sydney CBD), this is unreasonable to assume. Therefore the limiting factor K for this scenario will be modelled using a maximum capacity of Queanbeyan 450,000 which represents a triple in single density population.

When this is placed into the abovementioned formula, the upper bound capacity does not reach maximum until approximately 2245 (applying the same upper and lower bounds of 2.25% and 1.3% growth).

It should be noted that the mathematical formula for the limiting growth factor cannot take into account a difference in population due to Googong and therefore this has not been modelled.

Table 4 - Population projection (including Googong)

10 Year lower bound population projection	**46,223**
10 Year upper bound population projection	**50,315**
25 Year lower bound population projection	**54,960**
25 Year upper bound population projection	**67,484**
50 Year upper bound population projection	**72,658**
50 Year upper bound population projection	**106,391**

1.4 EP Calculator modelling (Quantitative and Qualitative)

1.4.1 Current

The current EP numbers were obtained for QCC's water meter data. This data was separated into the type of connection (single dwelling, apartment, business etc.) which was then used to determine from the water consumption. An approximate EP was obtained using these numbers.

It is estimated that the STP is receiving approximately 45,737 EP's worth of flow.

Table 5 EP projection Inclusive/Exclusive of Googong

Timeframe	Year	EP Excluding Googong	EP Including Googong
Current	2015	45,737	45,917
10 Years	2025	53,885	59,949
25 Years	2040	76,972	92,535
50 Years	2065	101,362	116,925

1.4.2 EP to Population

Queanbeyan has a 2014 population of 40,805 as per forecast.id community profile. From the EP calculator, an EP of 45,737 was calculated. This difference can be explained as EP's tend to be higher than population, in this case by approximately 10%. Therefore this factor is applied for future scenario's as well to convert EP's into population. This presents us the following population projections:

Table 6 Population projections Inclusive/Exclusive of Googong

Timeframe	Year	Population Excluding Googong	Population Including Googong
Current	2015	41,163	41,325
10 Years	2025	48,496	53,954
25 Years	2040	69,275	83,281
50 Years	2065	91,226	105,232

Appendix B Growth Concentration

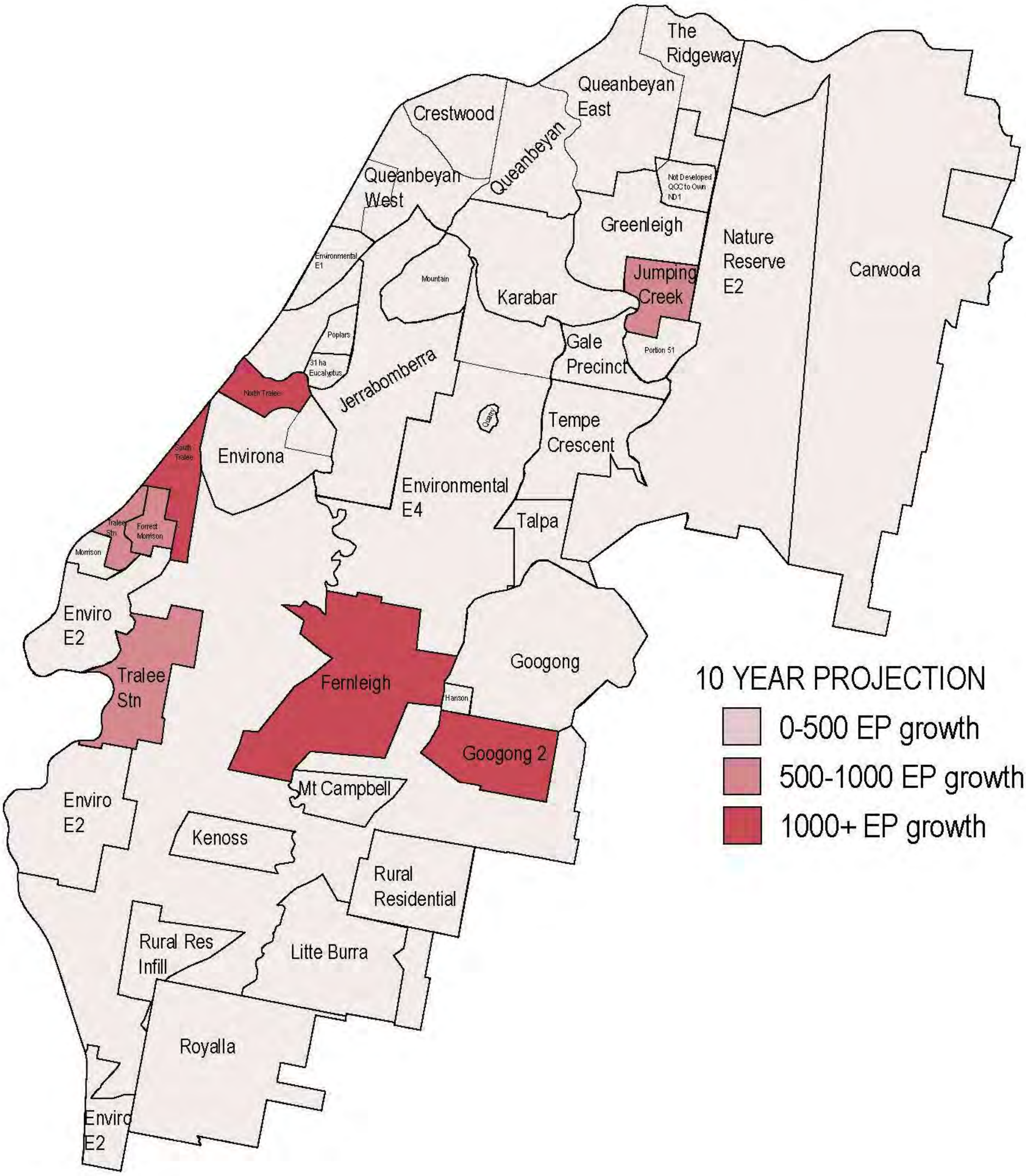

Figure 1 - Growth Concentration Projection for 2025

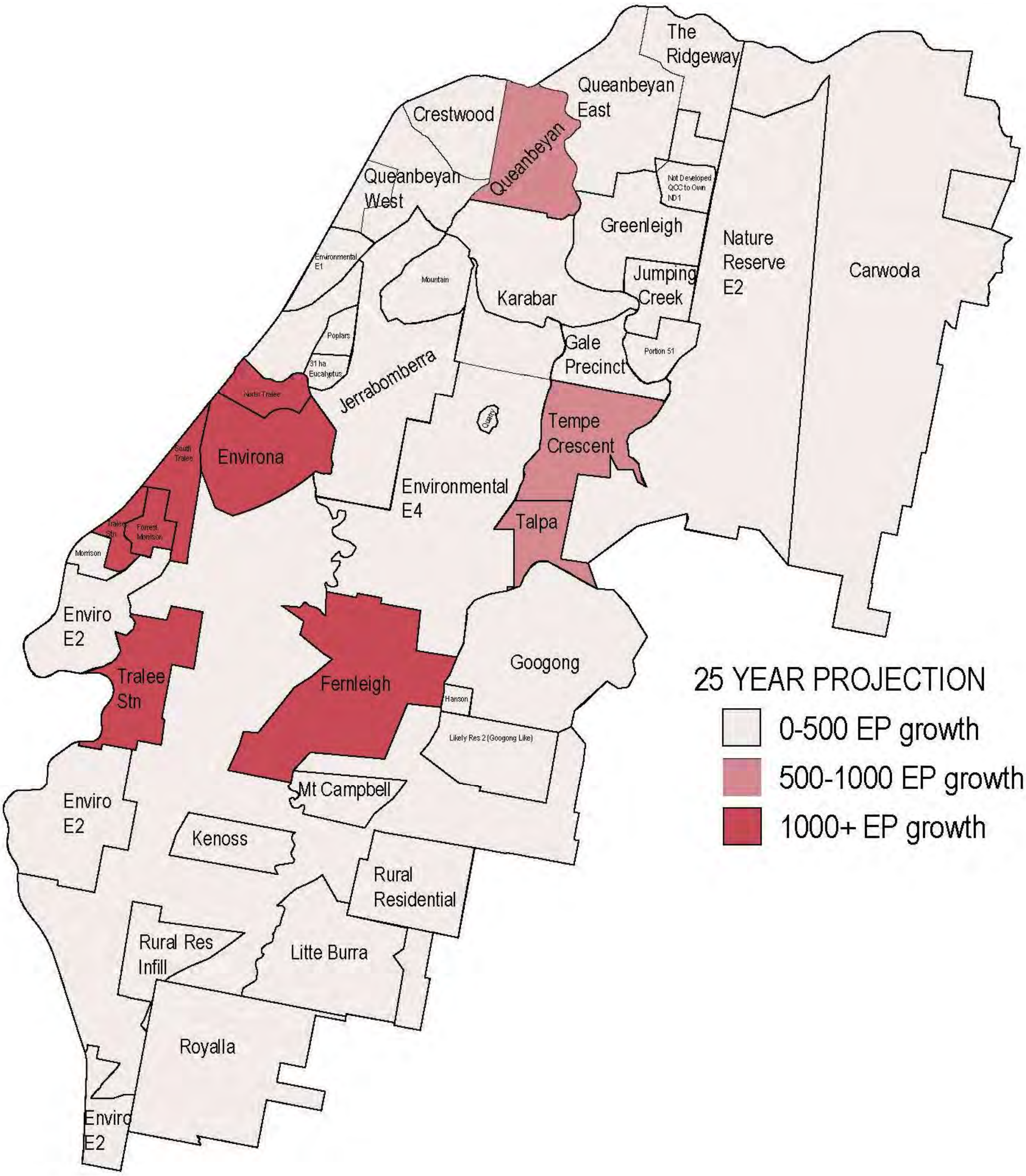

Figure 2 Growth Projection for 2040

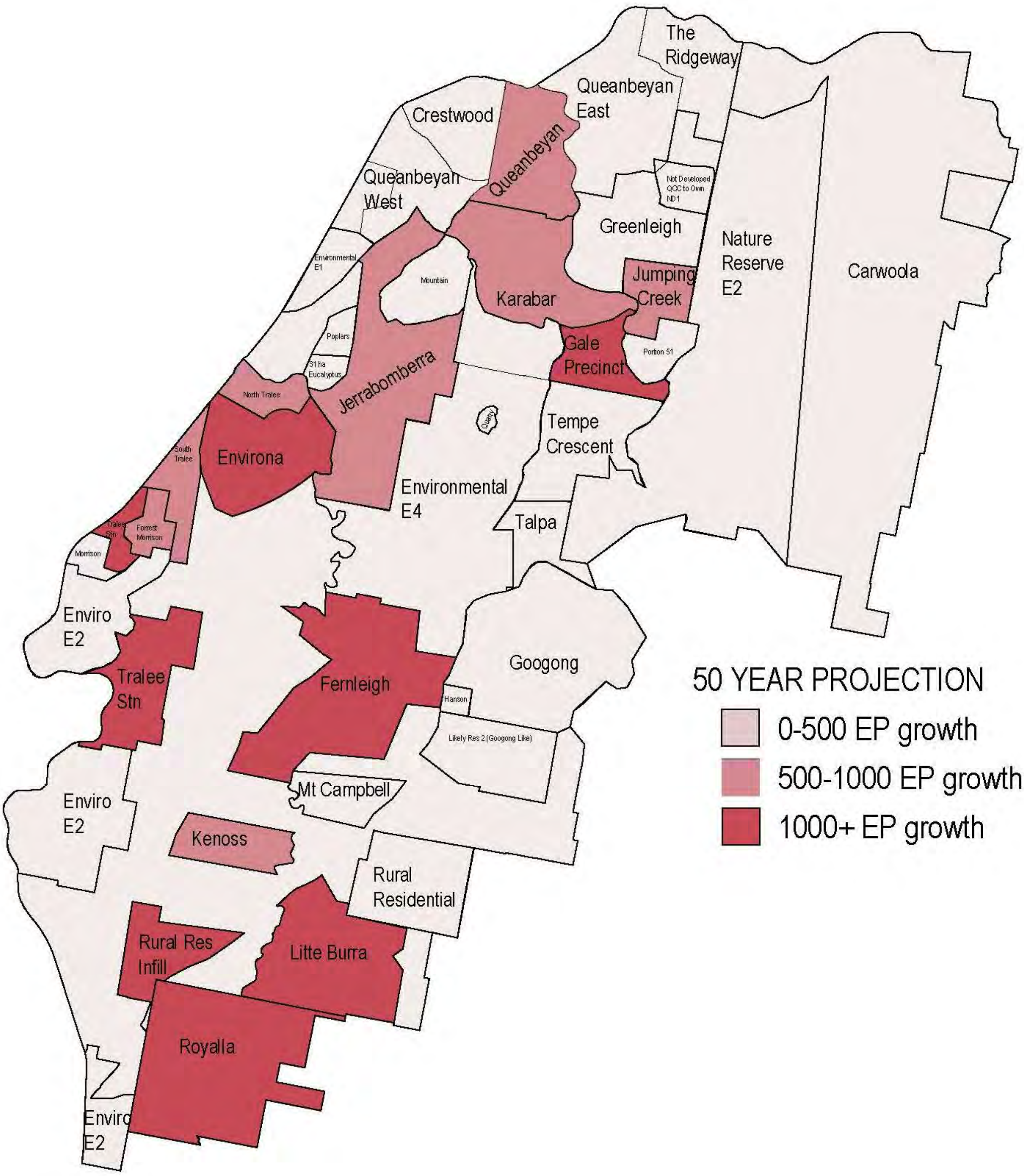

Figure 3 Growth Projection in 2065

This corresponds with the following urban densities:

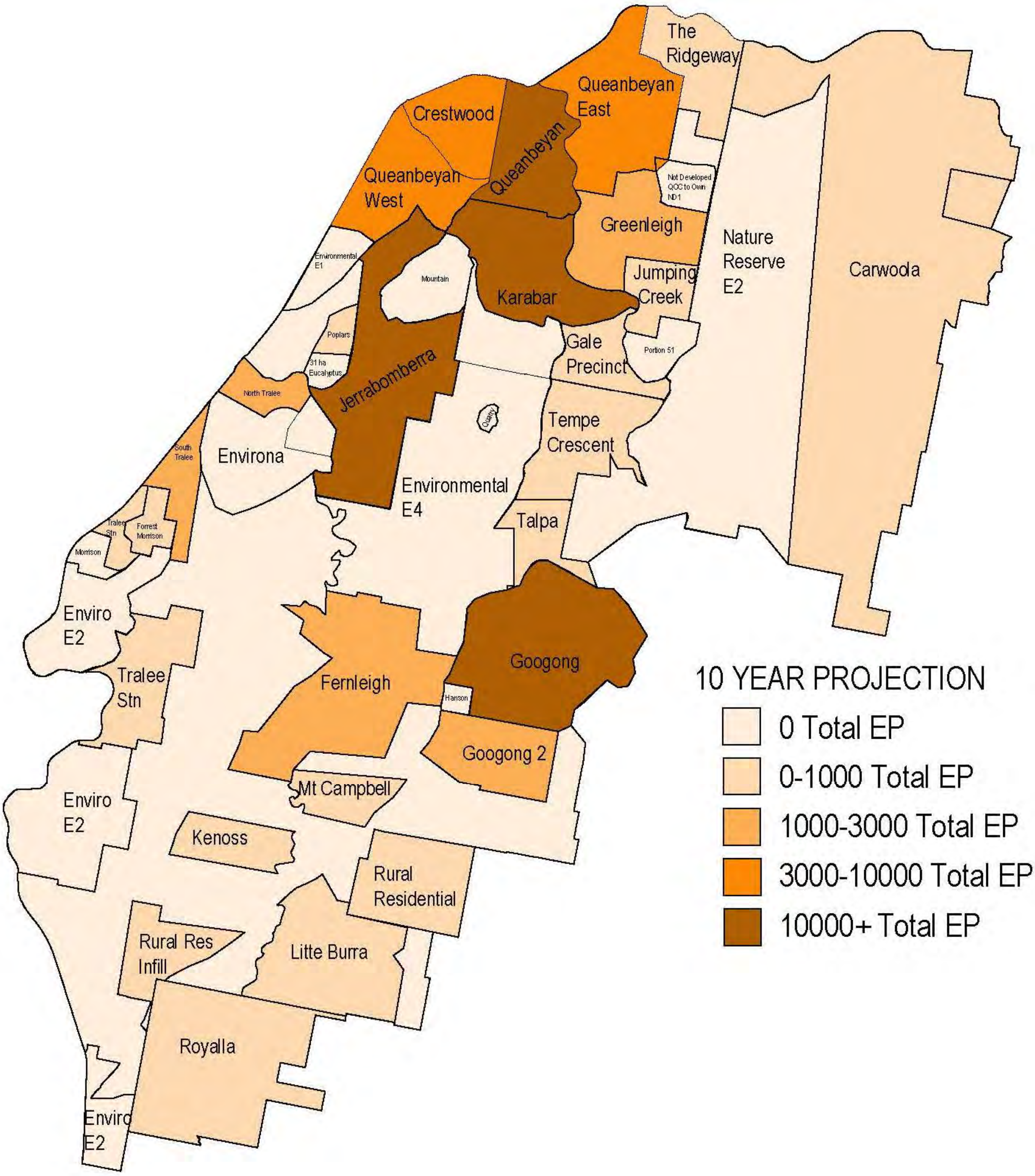

Figure 4 Projected urban densities for 2025

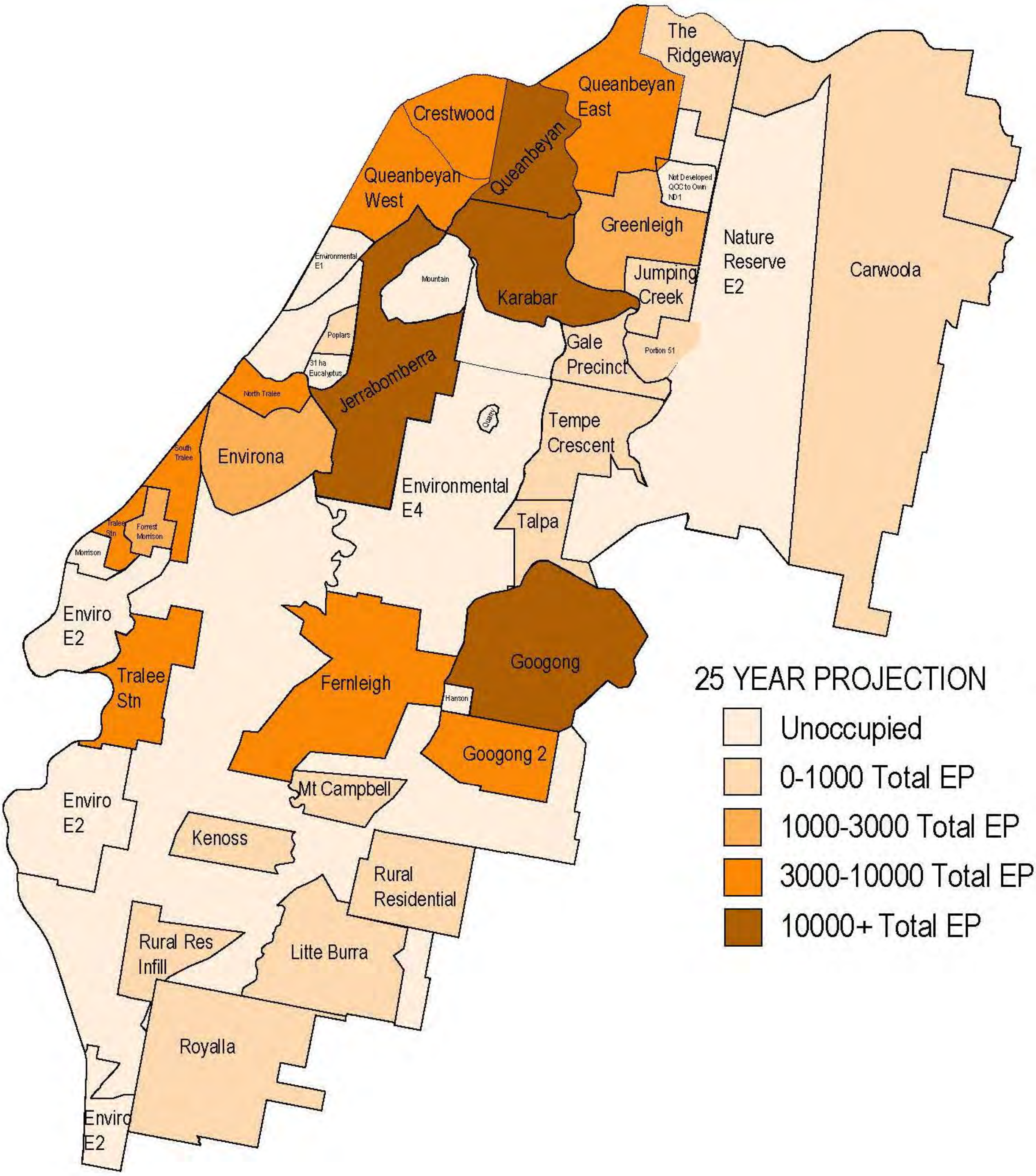

Figure 5 Projected urban densities for 2040

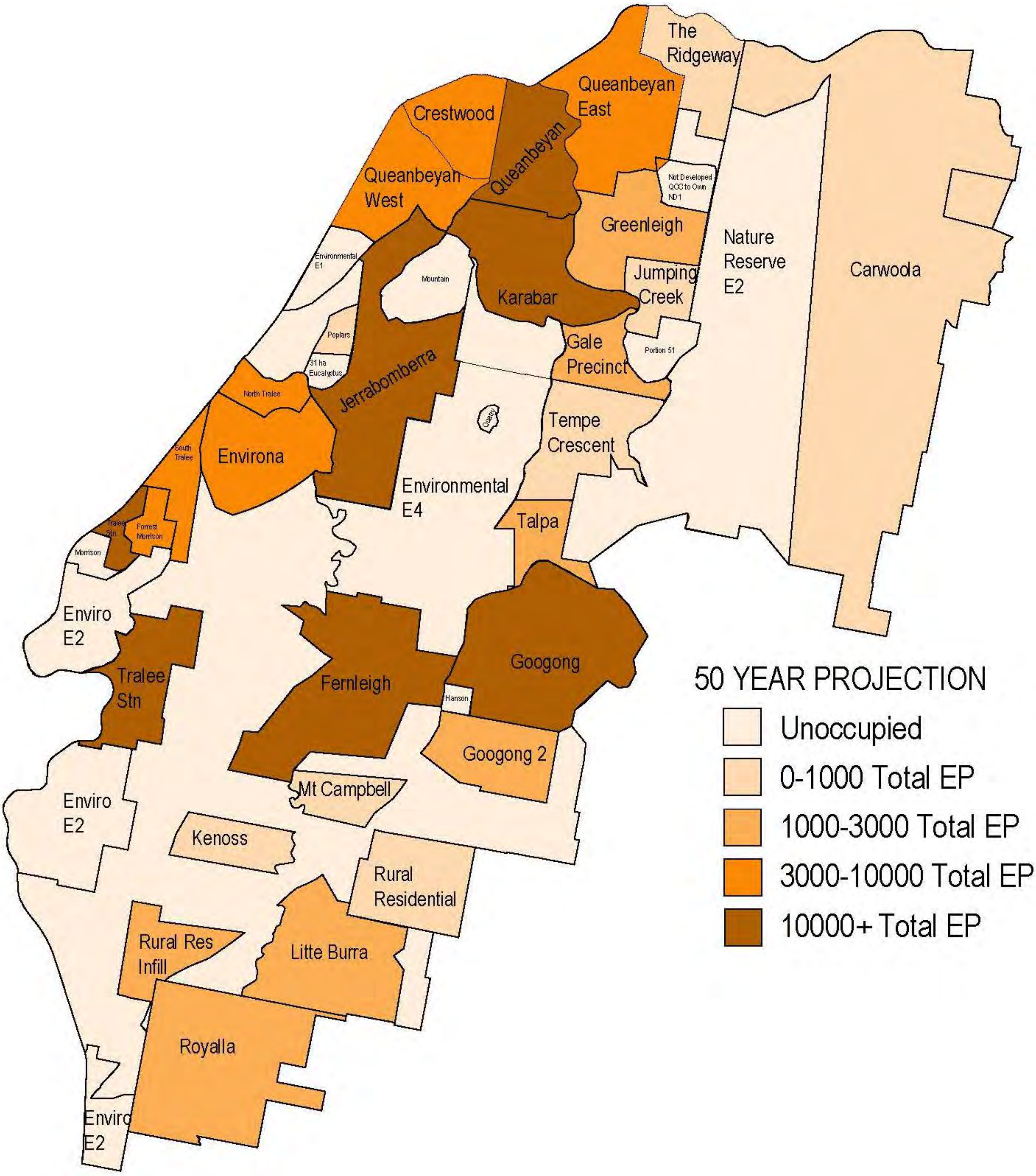

Figure 6 Projected urban densities for 2065

Appendix C Regulatory Roadmap

<table>
<tr><th colspan="2">Authority & Legislation</th><th>Master Plan</th><th colspan="3">Concept Design</th><th colspan="2">Detailed Design</th><th>Construction</th></tr>
<tr><td rowspan="5">Planning</td><td rowspan="3">ACT
Environment and Planning Directorate (EPD) – Planning and Land Authority
• Planning and Development Act 2007
• Planning and Development Regulation 2008
• Territory Plan</td><td rowspan="3">• Preliminary engagement with EPD</td><td colspan="5">Development Approval for STP (Impact Track):</td><td rowspan="3">• Comply with conditions of Development Approval
• Incorporate approval conditions into Statement of Requirement for Construction</td></tr>
<tr><td>EIS Scoping Document Request:
• Preliminary Risk Assessment (PRA)
• Submit Application Form 1M & PRA to EPD
• EPD has 30 days to provide Scoping Document
• Valid for 18 months</td><td>EIS Preparation:
• Confirmation of Scoping Document requirements
• Continued engagement with EPD
• Lodge Draft EIS with EPD</td><td>EIS Exhibition:
• Minimum 20 day public notification
• Revise EIS addressing concerns and any design changes
• Submit Revised EIS</td><td>EIS Approval:
• Planning consideration of revised EIS
• Receipt of EIS Adequacy Report (EISAR) – EIS complete
• Valid for 18 months
• Ensure mitigation & management measures are incorporated into the Detailed Design</td><td>Development Application:
• Meet with EPD to seek pre-application advice
• Lodge DA with drawings, plans, EIS & letter of completion and statement against relevant criteria
• Lodgement check 3-5 days
• Public notification and decision on DA (30-45 days from date of lodgement)
• Notice of decision</td></tr>
<tr><td colspan="5">Approval requirements for off-site disposal / reuse of bio-solids:
• Identify off-site disposal / reuse options including interim and long term options and local or regional solutions
• Identify planning and approvals requirements for options
• Engagement with ACT Government stakeholders
• Determine best option
• Commence approval process with EPD</td></tr>
<tr><td>NSW
Department of Planning & Environment
Queanbeyan City Council
• Environmental Planning & Assessment Act 1979
• Environmental Planning and Assessment Regulation 2000</td><td>• Confirm no NSW Planning requirements for STP site</td><td colspan="5">Development Approval for STP:
• No Development Approval from NSW Planning & Environment / Queanbeyan City Council required for STP

Approval requirements for off-site disposal / reuse of bio-solids:
• Identify off-site disposal / reuse options including interim and long term options and local or regional solutions
• Identify planning and approvals requirements for options
• Engagement with NSW Government stakeholders and Queanbeyan City Council (as required)
• Determine best option
• Commence approval process with Queanbeyan City Council and/or NSW Planning & Environment</td><td>• Continued engagement with Department of Planning & Environment and Queanbeyan City Council regarding off-site disposal / reuse of bio-solids (as required)</td></tr>
<tr><td>National
National Capital Authority
• National Capital Plan</td><td>• Preliminary engagement with National Capital Authority</td><td colspan="5">• Continued engagement with NCA as stakeholder
• No Works Approval or Development Control Plan required</td><td>• Continued engagement with NCA as stakeholder</td></tr>
</table>

<table>
<tr><th colspan="2">Authority & Legislation</th><th>Master Plan</th><th colspan="2">Concept Design</th><th>Detailed Design</th><th>Construction</th></tr>
<tr><td rowspan="3">Environment</td><td>ACT
Environment and Planning Directorate – Environment
• Environment Protection Act 1997
• Environment Protection Regulation 2005
• Nature Conservation Act 1980 (will be Nature Conservation Act 2014)
• Heritage Act 2004
• Lakes Act 1976
• Climate Change and Greenhouse Gas Reduction Act 2010
• Water Resources Act 2007
• ACT Waste Management Strategy 2011-2025
Territory and Municipal Services Directorate
• Tree Protection Act 2005
• Waste Minimisation Act 2001</td><td>• Preliminary engagement with stakeholders:
• EPD - Water
• EPD - Climate Change
• ACT EPA
• ACT NOWaste
• Conservator of Flora and Fauna
• ACT Heritage
• TAMS</td><td>Preliminary Environmental Assessment:
• Continued engagement with stakeholders
• Assessments:
▪ Contamination
▪ Flora and Fauna
▪ Archaeology and Heritage
▪ Air and Odour
▪ Noise and Vibration
▪ Geotechnical
▪ Surface & Groundwater Quality</td><td>Environmental Impact Statement:
• Prepare Preliminary Risk Assessment from Preliminary Environmental Assessment in accordance with As/NZS 14004:2004 Environmental Management Systems and AS/NZS ISO 13000:2009 Risk Management
• Submit EIS Scoping Document Request to Planning (see Planning Roadmap)
• Detailed assessment as per Scoping Document
• Ensure mitigation & management measures are incorporated into the Concept Design and Detailed Design
• See Planning Roadmap for EIS and Development Approval Process

Approval requirements for off-site disposal / reuse of bio-solids:
• Identify off-site disposal / reuse options including interim and long term options and local or regional solutions
• Identify planning and approvals requirements for options
• Engagement with ACT Government stakeholders
• Determine best option
• Commence environmental assessments (as required)</td><td>• Commence construction approvals (as required):
▪ Seek approval from TAMS for use of verges and other leased land during construction
▪ Tree damaging activity approval
• Confirm River Discharge Licence
• Update Environmental Authorisation
• Continue engagement with stakeholders</td><td>• Comply with conditions of Development Approval
• Incorporate approval conditions into Statement of Requirement for Construction
• Ensure mitigation measures are incorporated into Construction Management Plans
• Ensure Contractor has Environment Protection Agreement (if required)</td></tr>
<tr><td>NSW
Environment Protection Authority
• Protection of the Environment Operations Act 1997
• Note: Further legislation will apply for off-site disposal / reuse of bio-solids approvals</td><td>• Preliminary engagement with NSW EPA</td><td>Preliminary Environmental Assessment:
• Continued engagement with NSW EPA as stakeholder</td><td colspan="2">Environmental Impact Statement:
• Continued engagement with NSW EPA as stakeholder

Approval requirements for off-site disposal / reuse of bio-solids:
• Identify off-site disposal / reuse options including interim and long term options and local or regional solutions
• Identify planning and approvals requirements for options
• Engagement with NSW Government stakeholders
• Determine best option
• Commence environmental assessments (as required)</td><td>• Continued engagement with NSW EPA as stakeholder</td></tr>
<tr><td>National
Department of the Environment
• Environment Protection and Biodiversity Conservation Act 1999
National Capital Authority
• National Capital Plan</td><td>• Preliminary engagement with National Capital Authority</td><td colspan="3">Preliminary Environmental Assessment / Environmental Impact Statement:
• Continued engagement with NCA as stakeholder

EPBC Referral:
• Engagement with Department of the Environment
• Determine need for EPBC Referral
• Submit EPBC Referral (as required)
• Department of the Environment determine whether the project is considered a Controlled Action
• Commence bilateral EIS process (only required if project is considered a Controlled Action)</td><td>• Comply with conditions of EPBC Referral (if applicable)
• Continued engagement with NCA as stakeholder</td></tr>
</table>

	Authority & Legislation	Master Plan	Concept Design	Detailed Design	Construction
Infrastructure	ACT *None*				
	NSW NSW Office of Water • *Local Government Act 1993* • *Note: Based on the 5 Step process for a detailed design and construction procurement*	Step 1 & Step 2 Submission: • involve the Office of Water in the early stages of the options study • provide the draft options study report to the Office of Water for comment • discuss comments with the Office of Water if required • arrange amendment of the report if required • provide the final draft report to the Office of Water for endorsement	Step 3 Submission: • involve the Office of Water in the early stages of the concept design • provide the draft concept design report to the Office of Water for comment • discuss comments with the Office of Water if required • arrange amendment of the report if required • provide the final draft report to the Office of Water for endorsement • The concept design should include detailed consideration of environmental and all other relevant regulatory requirements. Supporting investigations and reports identified in the option study, such as an environmental impact statement	Step 4 Submission: • involve the Office of Water in the key aspects of process design beyond those included in the concept design report • provide the draft detailed design report to the Office of Water for comment • discuss comments with the Office of Water if required • arrange amendment of the report if required • provide the final draft report to the Office of Water for endorsement The detailed design should include information about: • process units • process and hydraulic flow (using diagrams) • process controls and instrumentation • wastewater management strategies Step 5 Submission: • Section 60 approval will be issued after the Office of Water has endorsed the amended detailed design	
		IWCM: • IWCM Issues Paper	IWCM: • IWCM Draft Strategy Paper • Typical residential bills defined • 30 year renewals plan • 30 year TAMP	IWCM: • Final IWCM Strategy • Financial Plan	
	• *Australian Guidelines for Water Recycling (AGWR) Phase 1, 2006* • *Note: If a recycled water product is generated*	Recycled Water: • Consider if recycled water product to be produced	Recycled Water: • Draft Recycled Water Quality Management Plan	Recycled Water: • Final Draft Recycled Water Quality Management Plan	Recycled Water: • Final Recycled Water Quality Management Plan
	National *None*				

	Authority & Legislation	Master Plan	Concept Design	Detailed Design	Construction
Health	**ACT** ACT Health • *Public Health Act 1997*				
	NSW NSW Health • *Public Health Act 2010* • *Local Government Act 1993*	Step 1 & Step 2 NOW Submission: • Involve NSW Health • NOW will generally seek NSW Health endorsement of the Step 1 and Step 2 submission	Step 3 NOW Submission: • Involve NSW Health • NOW will generally seek NSW Health endorsement of the Step 3 submission	Step 4 & Step 5 NOW Submission: • Involve NSW Health • NOW may seek NSW Health endorsement of the Step 4 and Step 5 submission	
	• *Australian Guidelines for Water Recycling (AGWR) Phase 1, 2006*	Recycled Water: • Consider if recycled water product to be produced	Recycled Water: • Draft Recycled Water Quality Management Plan	Recycled Water: • Final Draft Recycled Water Quality Management Plan	Recycled Water: • Final Recycled Water Quality Management Plan
	National *None*				

Appendix D Water Quality Objective Assessment

Queanbeyan City Council

13 March 2015

Queanbeyan Sewage Treatment Plant Objectives Review and Assessment

Water Quality Objectives

Queanbeyan Sewage Treatment Plant Upgrade Project

Water Quality Modelling

Client: Queanbeyan City Council

ABN: 12 842 195 133

Prepared by

AECOM Australia Pty Ltd
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13-Mar-2015

Quality Information

Document Queanbeyan Sewage Treatment Plant Upgrade Project

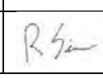
Ref

Date 13-Mar-2015

Prepared by Sam Knight / Ryan Signor

Reviewed by Ralf Sieberer

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
0	06-Nov-2014	Draft for Comment	Ryan Signor Project Director	*Signed original*
1	19-Dec-2014	Draft for Comment – preliminary	Ralf Sieberer Project Manager	*Signed original*
2	30-Jan-2014	Draft for Comment - penultimate	Ralf Sieberer Project Manager	*Signed original*
3	13-Mar-2015	Draft for Comment	Ralf Sieberer Project Manager	

Executive Summary

Background

The Queanbeyan Sewage Treatment Plant (STP) treats and discharges effluent to the Molonglo River which feeds into Lake Burley Griffin (LBG). It is operated by Queanbeyan City Council (QCC) in New South Wales under licence by the Australian Capital Territory (ACT) Environment Protection Authority (EPA).

QCC is currently master planning a new wastewater management strategy, including an upgrade of the STP at its present location. Options still being considered involve maintaining the centralised treatment strategy or decentralising some of the STP operations including provision for a new ancillary wastewater treatment plant discharging into Jerrabomberra Creek. The potential new sewerage infrastructure arrangements may impact upon the character and quality of the receiving water environments.

In support of the master planning, a water quality objectives study has been undertaken to investigate, model and examine the effects of current and future STP operations on receiving water quality for a range of possible treatment, effluent quality and release scenarios. The outcomes from this study will be used to inform the development of future effluent quality objectives which in turn will influence decisions on treatment options, technologies and operations of the new STP.

This report

This report presents the details and findings from the water quality objectives study. Water quality and flow data analyses have been undertaken to understand the present and historical conditions in the Molonglo River and in Jerrabomberra Creek, and how these may have been influenced by the STP.

The data analysis has informed the development of detailed models of the Molonglo River quality in the reach from the present STP to the LBG. The model was then used to understand the ‘baseline’ water quality of the river in the hypothetical absence of any STP discharging into the river. This baseline was superimposed with several test scenarios for various future STP loading, effluent quality and flow rate permutations to understand the impacts that future plant operations may have on receiving water quality. It is anticipated that the model outcomes can inform a discussion on future effluent quality and Molonglo River management objectives.

Should the case for a decentralised sewage management and treatment system be made as the master planning evolves, then future work may be necessary to undertake similar modelling work for the Jerrabomberra Creek study area, and how it may be impacted if a future treatment plant and/or sewage pump station were located nearby and discharging into it. The water quality and flow data analysis on the creek that is presented in this report can inform such a study, which would be reported separately.

Water quality data review outcomes

Prior assessments conducted that have looked at the impacts of the existing STP on Molonglo River and Lake Burley Griffin water quality have concluded the release of fully treated sewage effluent to the river can have both positive and negative impacts on the receiving environments. The impacts are summarised as follows:

- Positive impacts:
  - Effluent discharge from the STP contributes to baseflow and is considered a positive impact on the Molonglo River and downstream, including providing flows to Lake Burley Griffin. Since the construction of the Googong Dam, the STP is one the few sources of inflow into the lake in very low flow conditions
  - The STP discharges contain nitrogen in the form of nitrate, when nitrate from other sources are lacking. Nitrate entering the lake offsets potential reducing conditions occurring in waters at the bottom of the lake.
- Negative impacts:
  - The loading of phosphorus and BOD in the effluent discharge which can contribute to blue-green algae growth
  - STP operations can be affected by heavy rains or flood events. For these events, a series of by-passes are designed to protect the sewage process systems. The by-pass directs partially treated sewage to a series of maturation ponds where it is mixed with fully treated sewage prior to discharge. Under extreme flood conditions, faecal bacteria can be washed out from the maturation pond system. It is also

noteworthy that while leakage or spills of untreated or partially treated sewage contribute to faecal contamination in the waterways and single event discharges can potentially lead to lake closures, such events are infrequent and the long-term contaminant loads from the STP under by-pass conditions is likely to be quite minor compared to the large loads of faecal bacteria entering the catchment system from other sources (*e.g.* overland runoff from urban/industrial areas, domestic animals and grazing areas, *etc.*).

Water quality data was collated from the ACT Government, ACTEW Water and QCC with an aim to further test the outcomes from prior work and ascertain the STP impact. However the nature of available river water quality data collected upstream and downstream of the Queanbeyan STP does not enable clear conclusions to drawn on the impact of the STP on the Molonglo River, especially during STP diversion events. Upstream of the STP the urban and agricultural land-use influence river water quality, especially total nitrogen and faecal coliform concentrations. Downstream of the STP there is a greater percentage of total nitrogen and chlorophyll-a concentrations that are above relevant guideline concentrations, which may be influenced by STP inputs, but also by other land-uses in the vicinity of the downstream water quality site on the Molonglo River. During STP diversion events the small amount of matching river water quality data does indicate that there are increased faecal coliform concentrations in the effluent. However, there is a lack of before, during and after diversion river water quality data to draw conclusions of the effects of STP diversions on river water quality. Historically, diversion events from the STP have been associated with elevated faecal coliform concentrations in the Molonglo River, but there is a lack of data to empirically understand broader water quality responses during and immediately following these events.

What's the policy on effluent quality and managing impact on the river?

The water quality management policy to be applied to the STP upgrade opportunity is to be determined through discussions between QCC, ACT EPA, and other stakeholders. There may be three policy positions broadly considered, the adoption of one or the other will influence the determination of the water quality objectives associated with the STP upgrade. The policy options are:

1) That the STP upgrade should have associated effluent quality objectives that serve to meet or significantly approach upon the suite of healthy river criteria objectives for the Molonglo as set out earlier, or

2) The future population should be served by a STP in a way that will have negligible or beneficial impact on the receiving environment than is presently the case, or

3) Changes in the water quality of the receiving environment due to the STP upgrade can be justified on a 'whole community benefit' or a 'triple-bottom-line' economic basis.

Adopting any one of those positions needs to be considered in the context of what influence the STP is really having on current water quality. For instance, if other sources can be demonstrated to be having a far more significant influence on river water quality presently than the STP, it may not be reasonable or feasible to adopt the first listed position. A modelling approach was designed to assist with better understanding the possible policy position.

Water quality modelling needs and approach

The data analysis highlighted that suspended solids, dissolved oxygen and pH levels in the Molonglo River downstream of the STP are generally within recommended guideline levels under the STP's current operation. The suspended solids levels of the effluent have generally been more favourable than the background water quality in the Molonglo River, suggesting that the existing licencing conditions (and indeed plant performance) is providing adequately for managing solids content. A prior review has identified that the biological oxygen demand (BOD) may be having negative impacts in terms of algae growth potential in the lake; however no BOD data was forthcoming for the effluent and the dissolved oxygen levels in the river downstream of the STP tend to be within guideline values. Guideline exceedances were mainly associated with nutrient and coliform levels in the Molonglo River. Understanding the nutrient and faecal coliform impacts of the effluent on the receiving waters, and the complex impacts of future increases in the served population and discharge rates, required further investigation.

Detailed models of the Molonglo River quality in the reach from the present STP to the Lake Burley Griffin were modelled. The model was then used to understand the 'baseline' water quality of the river in the hypothetical absence of any STP discharging into the river. This baseline was superimposed with several test scenarios for various future STP loading, effluent quality and flow rate permutations to understand the impacts that future plant operations may have on receiving water quality.

Model findings and implications for effluent quality objectives

The models suggest that in the vicinity of where the Molonglo River enters the Lake Burley Griffin (even under future possible plant arrangements and EPs):

- Total nitrogen (TN) levels in the river can be perhaps managed to levels similar to the present and historical case even allowing for an increase in served population by adopting an effluent target in the range 5-10mg/L. Presently the STP achieves effluent TN with a mean of 16mg/L and 90^{th} percentile of 26mg/L
- If total phosphorous (TP) effluent targets of 0.1-0.2mg/L were adopted there would be insignificant to minor increases on TP content of the Molonglo River due to the influence of background levels of TP just upstream of the STP and other inputs downstream such as the turf farm, and the river and water quality processes. Note also that the present plant already achieves effluent TP levels with an average of 0.09 mg/L and 90^{th} percentile of 0.15mg/L
- The STP effluent is likely having little impact on the presence of coliforms at this site, owing to the relatively lengthy travel and residence times and the processes of microbiological decay. The scenario 1 model (which has the absence of the STP) results are very similar to those outputs for all other scenarios, indicating coliform sources closer to the location are likely to be much more influential. Achieving similar or greater levels of log-reduction of coliforms at the STP in future may not translate into observable improvements in coliform presence at this site. Again, note that the median faecal coliform measurement historically in the STP effluent is 28 CFU/100mL, while the median measured in the river just upstream of the STP has been 170 CFU/100mL, suggesting that outside of acute impacts of wet weather bypass event periods, the STP discharge is beneficial to the balance of faecal coliforms in the river.

By extension adopting the targets for effluent quality in the ranges listed above would suggest that there would not be significant increases in nutrient or coliform concentrations in the river water entering Lake Burley-Griffin, even allowing for future EPs. However if concentrations are maintained then the greater flows from the future plant could increase the overall loads of nutrients entering the lake, which is important particularly from the perspective of algal bloom potential.

Moving forward for setting water and effluent quality objectives

Noting that the STP is not the major contributor to river water quality as compared to other non-point sources then a reasonable objective for the future STP may be to:

1) Aim for adopting targets on effluent quality in the first instance so that the future population is served by a STP in a way that will have negligible or beneficial impact on the receiving environment than is presently the case
2) Determine through further design and analysis the costs and feasibility of technologies available to accommodate this objective
3) If necessary, commence discussions with stakeholders around whether there may be changes to the water quality of the receiving environment due to the STP upgrade that can be justified on a 'whole community benefit' or a 'triple-bottom-line' economic basis.

With regard to the first point above, the modelling outcomes indicate that, with regard to the nutrient river quality at the confluence with Lake Burley Griffin, a 'negligible or beneficial impact' outcome on water quality concentrations may be achievable by adopting effluent quality targets of 5-10mg/L for TN and 0.1-0.2mg/L for TP. These could be suitable as target median and 90^{th} percentile effluent concentrations respectively. The present licenced faecal coliform effluent objectives and performance has served adequately to provide a beneficial impact on measurable coliform concentrations in the Molonglo River. As such, moving forward, the historical performance of the effluent could be adopted as formal future targets for coliform presence in the effluent which would correspond to median of *ca.* 30 CFU/100mL and 90^{th} percentile of *ca.* 200 CFU/100mL. This is in accordance with some of the more stringent licence conditions at other STPs in New South Wales, would drive improvements in the presence of pathogenic organisms in the effluent and so the receiving environments and future rationale for alternate coliform (or other microbial indicator) levels may be dictated by a desire to treat water to levels appropriate for beneficial reuses and so to achieve log-reduction targets outlined in the *Australian Guidelines for Water Recycling.*

The present BOD and suspended/dissolved solids licencing conditions can be considered as starting points for discussions around future licencing conditions for a larger served population and discharge plant, noting that they presently impact the receiving water quality within current guideline limits.

Future monitoring

The current water quality and river discharge monitoring sites are generally suitable for the continuation of baseline and STP licence compliance data collection in Molonglo and Queanbeyan River catchments. Nonetheless, potential improvements that will allow for a better understanding of STP impacts on river health have been identified, including:

1) The distance between the STP and the most downstream water quality monitoring site on the Molonglo River at Dairy Flats Road is not suitable for detecting the direct effects of the STP on Molonglo River water, because of the possible effect of other land-uses (*e.g.* Industrial and urban areas, Fyshwick STP and Fyshwick turf farm). The site at Dairy Flats Road is still useful as a site to determine the effects of upstream land-use (including the QCC STP) on water quality at the mouth of Lake Burley Griffin, but not for a direct assessment of how the QCC STP affects river water quality. Baseline data collection the same water quality variables collected as a part of the ACT Government Water Quality Monitoring Program should also be collected at the Molonglo River Oaks Estate site directly downstream of the QCC STP

2) The frequency of water quality data collection at the current locations is not suitable for detecting the effects of flooding events and STP bypass events on river water quality. Water samplers could be installed at the following existing monitoring locations to detect the effects of pollutants during rising, peak and falling discharges (from the STP and in the river):

   - Molonglo at Yass Rd.
   - Queanbeyan at ACT Border
   - Molonglo at Oaks Estate
   - Molonglo downstream of Oaks Estate
   - Molonglo at Dairy Flat Road

   The automatic samplers could be triggered to collect samples during flood events and/or STP discharge events. Sampling units located at Molonglo at Yass Rd and Queanbeyan at ACT Border would account for the effects of upstream land-use on water quality. The Molonglo River at Oaks Estate site would account for the combined effects of the Queanbeyan and Molonglo catchments upstream of the STP on river water quality. The Molonglo downstream of Oaks Estate and Molonglo at Dairy Flat Road sites would account for the downstream effects of the STP on river water quality directly downstream of the STP and at the mouth of Lake Burley Griffin

3) To be up to date with current recreational guidelines water quality guidelines faecal coliform assessment should be complemented by or shift to the assessment of enterococci

4) AUSRIVAS macroinvertebrate community assessment currently only takes place upstream of the STP at the Molonglo at Yass Rd and Queanbeyan at ACT border sites. Macroinvertebrate communities are regularly used to assess the ecological functioning of rivers and using macroinvertebrate communities can give an indication of river water quality in weeks to months preceding sampling. It is proposed that an additional macroinvertebrate sampling site with the same frequency of sampling from the edge habitat to compliment upstream sites be located at the Molonglo D/S of Oaks Estate site. This additional macroinvertebrate site can be used to assess the effects of any STP related water quality effects of the ecological functioning of the Molonglo River compared to upstream sites. Sample collection days at this site should be matched to upstream ACT Government sites.

Table of Contents

1.0 Introduction

1.1 Background

The Queanbeyan Sewage Treatment Plant (STP) was constructed in the mid-1930s and has gone through numerous upgrades over the years, most recently in 1983/84. It serves residential and rural residential areas in the Queanbeyan City Council (QCC) Local Government Area (LGA). The STP treats and discharges effluent to the Molonglo River which feeds into Lake Burley Griffin (LBG). It operates under an EPA license condition number 0417 dated 11th October 2004 which establishes the current effluent discharge limits.

QCC is currently master planning a new wastewater management strategy, including an upgrade of the STP at its present location. Options still being considered involve maintaining the centralised treatment strategy or decentralising some of the STP operations including provision for a new ancillary wastewater treatment plant discharging into Jerrabomberra Creek. The potential new sewerage infrastructure arrangements may impact upon the character and quality of the receiving water environments.

In support of the master planning, a water quality objectives study has been undertaken to investigate, model and examine the effects of current and future STP operations on receiving water quality for a range of possible treatment, effluent quality and release scenarios. The outcomes from this study will be used to inform the development of future effluent quality objectives which in turn will influence decisions on treatment options, technologies and operations of the new STP.

1.2 This report

This report presents the details and findings from the water quality objectives study. Water quality and flow data analyses have been undertaken to understand the present and historical conditions in the Molonglo River and in Jerrabomberra Creek, and how these may have been influenced by the STP.

The data analysis has informed the development of detailed models of the Molonglo River quality in the reach from the present STP to the LBG. The model was then used to understand the 'baseline' water quality of the river in the hypothetical absence of any STP discharging into the river. This baseline was superimposed with several test scenarios for various future STP loading, effluent quality and flow rate permutations to understand the impacts that future plant operations may have on receiving water quality. It is anticipated that the model outcomes can inform a discussion on future effluent quality and Molonglo River management objectives.

Should the case for a decentralised sewage management and treatment system be made as the master planning evolves, then future work may be necessary to undertake similar modelling work for the Jerrabomberra Creek study area, and how it may be impacted if a future treatment plant and/or sewage pump station were located nearby and discharging into it. The water quality and flow data analysis on the creek that is presented in this report can inform such a study, which would be reported separately.

1.3 Report structure

The structure of the report is as follows:

1) A summary of the present STP processes and effluent quality, prior reviews of its impact on receiving water quality, and current QCC licencing conditions (Section2.0)
2) A statistical analysis of water quality data available from the Molonglo River and Jerrabomberra Creek reaches including an appraisal of exceedance of existing environmental and other water quality objectives (Section 3.0)
3) A description of the water quality modelling approach and outputs (Section4.0)
4) A discussion on the implications of the water quality modelling outcomes in terms of setting water quality objectives for the river environment and the future STP effluent (Section 5.0)
5) A review of future water quality monitoring needs (Section 6.0).

2.0 Queanbeyan's Sewage Treatment Plant

2.1 Operations and process

Current plant capacity is around 40,000 Equivalent Persons (EP) and in 2010 the Average Dry Weather Flow (ADWF) from the STP was around 11.5 ML/day. The STP catchment at 45,000 EP currently exceeds the plant capacity and over the next 25 years is expected to increase to 77,000 EP through additional residential development in the catchment. This is expected to increase the ADWF to around 19.3 ML/day. The current STP treatment consists of the processes described below:

Inlet works

Inlet works include bar screens, grit chambers, flow splitting and measurement flumes, lime and ferrous chloride dosing, return lines and stormwater bypass

Secondary treatment

Secondary treatment is provided by a combination of trickling filters and conventional activated sludge plants

Tertiary treatment

Clarified secondary effluent is treated by three maturation ponds with a small fraction being further treated by ultra-violet irradiation for use at a nursery

Biosolids are handled on site, transferred from the plant process areas to drying beds. The STP discharges treated effluent through a single pipe outfall directly to the Molonglo River.

2.2 Current licencing conditions

Effluent discharge is authorised under *Environmental Protection Act 1997* by the ACT Environment Protection Authority (EPA). The authorisation is reviewed annually. The most recent revision of authorisation, number 0417, is dated 11th October, 2004.

Schedule 1 of the authorisation ('Routine Operations') sets the following conditions:

- Effluent acidity in pH units shall not be less than 6.5 and not more than 8.5
- Discharge of Effluent shall not exceed the limits for the parameters listed in Table 1, Table 2 and Table 3.

Table 1 Currently licenced loadings and concentrations for monitored parameters in the Queanbeyan STP effluent

Parameter	Concentration 50th percentile	Concentration 90th percentile	Average daily load limit	Average performance period
	(mg/L)	(mg/L)	Kg/day	
Biochemical oxygen demand (5 days)	5	10	50	90 days
Suspended solids	8	20	90	90 days
Total dissolved solids	600	650	6000	12 months
Total nitrogen	30	35	300	12 months
Total phosphorus	0.2	0.3	6	90 days

Table 2 Currently licenced loadings and concentrations for thermotolerant coliforms in the Queanbeyan STP effluent

Parameter	50th percentile	80th percentile	Performance Period
Thermotolerant coliforms (CFU/100 mL)	200	1000	35 days

Table 3 Currently licenced maximum four-day rolling average total ammonia (mg/L) in the Queanbeyan STP effluent

Temperature of receiving waters	Acidity (pH of Receiving Waters)					
°C	6.5	7.0	7.5	8.0	8.5	9.0
0	2.53	2.53	2.53	1.53	0.49	0.16
5	2.36	2.40	2.40	1.44	0.47	0.16
10	2.24	2.20	2.20	1.37	0.45	0.16
15	2.15	2.16	2.17	1.33	0.44	0.16
20	1.49	1.49	1.50	0.93	0.32	0.12
25	1.03	1.04	1.05	0.66	0.23	0.10
30	0.73	0.74	0.75	0.47	0.17	0.08

2.3 Impact of effluent discharge on receiving environment

The Queanbeyan STP has been implicated with regard to the effect that its effluent discharges have on the quality and health of the Molonglo River. The *Molonglo River Rescue Action Plan* lists the STP as a specific threat to a series of assets in the river reach from Molonglo Gorge to Lake Burley Griffin, including threatened species habitat, the Jerrabomberra Wetlands, and the community's ability to engage with the river for recreation (Molonglo Catchment Group, 2010).

A recent scientific assessment (OCSE, 2012) concluded the release of fully treated sewage effluent to the Molonglo River can have both positive and negative impacts on the receiving environments, including Lake Burley Griffin. They are summarised as follows:

- Positive impacts:
  - Effluent discharge from the STP contributes to baseflow and is considered a positive impact on the Molonglo River and downstream, including providing flows to Lake Burley Griffin. Since the construction of the Googong Dam, the STP is one the few sources of inflow into the lake in very low flow conditions
  - The STP discharges contain nitrogen in the form of nitrate, when nitrate from other sources are lacking. Nitrate entering the lake offsets potential reducing conditions occurring in waters at the bottom of the lake.
- Negative impacts:
  - The loading of phosphorus and BOD in the effluent discharge which can contribute to blue-green algae growth
  - STP operations can be affected by heavy rains or flood events. For these events, a series of by-passes are designed to protect the sewage process systems. The by-pass directs partially treated sewage to a series of maturation ponds where it is mixed with fully treated sewage prior to discharge. Such events occur about once per year on average and typically last for several hours, although during wet years, multiple events may occur. STP diversions for 2003 to 2013 are described in Appendix A.. Under extreme flood conditions, faecal bacteria can be washed out from the maturation pond system. It is also noteworthy that while leakage or spills of untreated or partially treated sewage contribute to faecal contamination in the waterways and single event discharges can potentially lead to lake closures, such events are infrequent and the long-term contaminant loads from the STP under by-pass conditions is likely to be quite minor compared to the large loads of faecal bacteria entering the catchment system

from other sources (*e.g.* overland runoff from urban/industrial areas, domestic animals and grazing areas, *etc.*).

3.0 Statistical Analysis of Baseline Water Quality

The University of Canberra's Institute for Applied Ecology has reviewed the existing water flow and quality data available from within the vicinity of the study area. The purpose of the review was threefold:

1) To undertake a statistical analysis of water quality data of the Molonglo River and its tributaries (including the Queanbeyan River and Jerrabomberra Creek) from up and down-stream sites in the vicinity of the STP
2) Explore and describe (as far as possible from the available data) the event condition impacts of seasonal climate variance, rainfall-induced runoff events and the STP discharges respectively on water quality, and
3) Collate the data in such a way as to establish its suitability for the development of either empirical or physical water quality models that will assist to further understand the STP's impact on the river water quality and the establishment of treated effluent and water quality objectives.

The full data analysis report is provided in Appendix A. This chapter summarises the key features of that report.

3.1 Available water quality and discharge datasets

Point water quality and river discharge data for the Molonglo and Queanbeyan Rivers (upstream and downstream of the STP) were compiled from the ACT Government water quality monitoring program and ACTEW Water for the time period 1994-2013. Water quality variables collected by the ACT Government at monthly – bimonthly intervals included:

- Suspended solids
- Total nitrogen
- Total phosphorus
- Chlorophyll-a
- Faecal coliforms
- pH
- Electrical conductivity
- Dissolved oxygen
- Water temperature.

Less water quality data were available for Jerrabomberra Creek, because it is not included in the monthly-bimonthly ACT Government water quality monitoring program. Water quality and river discharge data for Jerrabomberra Creek downstream of Hindmarsh Drive were compiled from the ACT Government macroinvertebrate monitoring program and ACTEW Water for the time period 2000-2014. Water quality data collected by ACT Government in spring and autumn sampling periods related to:

- pH
- Electrical conductivity
- Dissolved oxygen
- Water temperature.

Daily effluent water quality and downstream river water quality were also compiled from the Queanbeyan City Council's own STP data set. These included:

- Data collected from the effluent only:
    - Suspended solids
    - Total nitrogen
    - Total phosphorus

- Electrical conductivity

- Data collected from the effluent as well as at the Molonglo River downstream of Oaks Estate:
  - Faecal coliforms
  - pH
  - Water temperature.

Daily mean flow rate data from 1990 were compiled from the Burbong, Oaks Estate (on the Molonglo River, maintained by ACTEW Water), Wickerslack Lane (Queanbeyan River, ACTEW Water) and Jerrabomberra Creek (ACT Government) hydro-monitoring stations.

The locations of all water quality and flow monitoring stations from which data was collated are at Figure 1.

3.2 Surface water quality guideline values

To provide a basis to compare the water quality data, the following surface waterway quality guidelines were consulted:

Table 4: Water quality guideline values for surface water relevant to the Molonglo River and its tributaries

Measure	Units	Guideline value	Value
Conductivity**	µS/cm	<350	Irrigation (noting that the Molonglo River serves as a source for a commercial turf farm)
pH*	N/A	6.5-8.5	Primary contact recreation
Dissolved oxygen *	mg/L	>4	Environmental values
Suspended solids**	mg/L	<25	Environmental values
Chlorophyll-a*	µg/L	<10	Aesthetic/view, also manages cyanobacteria bloom potential
Faecal coliforms**#	CFU/100 mL	<150 (median over bathing season)	Primary contact recreation
Total phosphorus*	mg/L	<0.1	Primary contact recreation
Total nitrogen**	mg/L	<0.25	Primary/secondary contact recreation, environmental values
N:P ratio	ratio	>12:1	Primary/secondary contact recreation, environmental values
Pathogenic free-living organisms*	organisms/100mL	0	Primary contact recreation
Total dissolved solids*	mg/L	< 500	Irrigation

Table notes: Values from the *Environment Protection Regulations SL2005-38* and ANZECC and ARMCANZ (2000)**.*

[#]The *ACT Guidelines for Recreational Water Quality* (ACT Health, 2010) and the *Australian Guidelines for Managing Risks in Recreational Waters* (NHMRC, 2008) are more recent and relevant guidance for determining water quality guidelines for primary contact (*i.e.* swimming); however these use enterococci as the primary indicator of water quality (no enterococci data was available from the data sources obtained). As faecal coliform data was available, the ANZECC (2000) guideline was adopted to enable some comparison with the data.

3.3 Assessment method

Three tasks were undertaken:

1) Generation of seasonal water quality statistics at each site which included: mean, median, 10^{th} percentile, 25^{th} percentile, 75^{th} percentile, 90^{th} percentile, maximum and minimum values

2) Water quality responses to stream discharges: Water quality data were compared to water quality guidelines values across different flow percentile categories (90 - 100, 75 - 90, 55 - 75, 45 - 55, 25 - 45, 25 - 10 and <10) to determine the effects of different flow discharges on river water quality at each site.

3) Review of available water quality data in the receiving environments during and after documented STP bypass events to determine whether any rapid water quality changes were apparent or could be attributed to the plant.

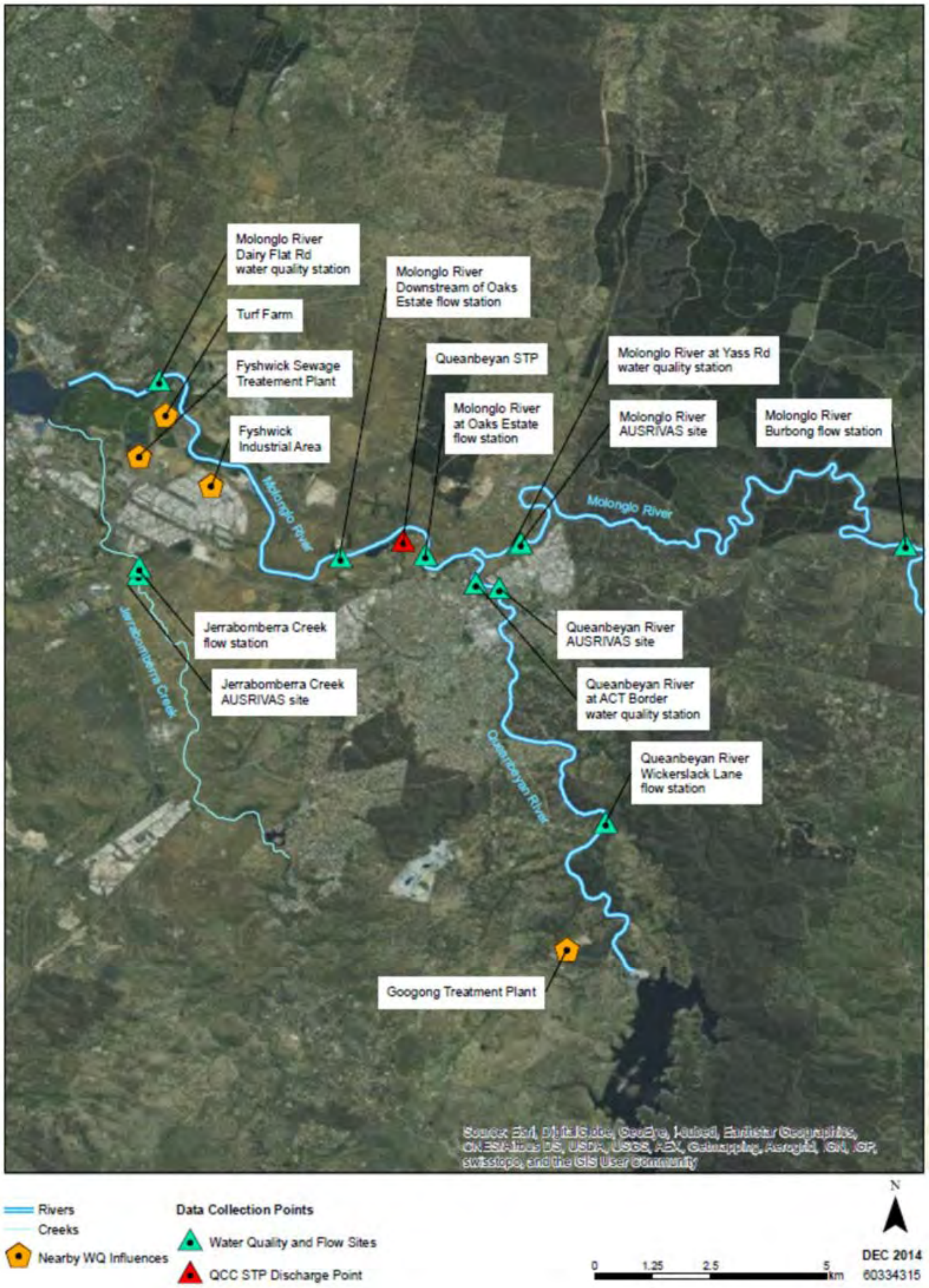


Figure 1 Water quality and flow data monitoring stations

3.4 Findings

3.4.1 Molonglo River water quality

General findings of the data analysis are provided below. The outcomes are summarised in turn for each water quality monitoring station:

- Molonglo Yass Rd (upstream of Queanbeyan STP and Queanbeyan River confluence):
    - Total nitrogen, electrical conductivity and faecal coliforms had the greatest exceedance of guidelines in the Molonglo River upstream of the Queanbeyan STP and Queanbeyan River confluence. Guideline exceedance for coliforms and nitrogen occurred across the entire spectrum of measured flows. Electrical conductivity readings tended to be above the guideline level at more moderate to very low flows (i.e. 55^{th} – 100^{th} percentile). The high total nitrogen and faecal coliform are likely because of adjacent urban land-use and grazing in the upstream catchment
    - At lower flows (75^{th} – 100^{th} percentile) a greater percentage of chlorophyll-a (an indication of active algal growth) and dissolved oxygen concentrations were outside of guideline levels
    - pH, total phosphorus and suspended solid values were more generally within guidelines values.
- Queanbeyan River at ACT border (upstream of Queanbeyan STP):
    - Total nitrogen and faecal coliform guideline exceedance trends in the Queanbeyan River at the ACT Border upstream of the STP were similar to the Molonglo River at Yass Rd
    - The percentage of electrical conductivity measurements exceeding the guideline level was much lower than the two Molonglo River sites. The greatest percentage of electrical conductivity readings above the guideline level occurred at moderate to very low flows (55^{th} – 100^{th} percentile)
    - At lower flows (75^{th} – 100^{th} percentile) a greater percentage of chlorophyll-a (an indication of active algal growth) and dissolved oxygen concentrations were outside of guideline levels
    - pH, total phosphorus and suspended solid values were more generally within guidelines values.
- Molonglo River at Dairy Flats Road (downstream of Queanbeyan STP):
    - The Molonglo River at Dairy Flats Road downstream of the STP had a greater of total nitrogen concentration exceeding the guideline level than upstream of the STP, with all measurements exceeding the guideline. The percentage of faecal coliform measurements above the guideline level was lower than the upstream site of STP sites. It should be noted that this site is also downstream of other land-use impacts such as an industrial area and a turf farm, therefore any changes in water quality compared to upstream sites may not be directly attributable to the Queanbeyan STP
    - The percentage of electrical conductivity measurements outside of guideline levels was similar to the upstream of STP Molonglo River site, with more measurements being outside of guideline levels at moderate to very low flows (55^{th} – 100^{th} percentile)
    - Compared to the upstream sites, the Molonglo River at Dairy Flats Road had a greater percentage of chlorophyll-a concentrations (an indication of active algal growth) above the guideline level. Similar to the upstream site, the greatest percentage of chlorophyll-a concentrations above the guideline level occurred at lower flows (75^{th} – 100^{th} percentile)
    - Less than 5% of suspended solid, total phosphorus, pH and dissolved oxygen measurements exceed guideline levels. At low to very low flows (75th – 100th percentile) a greater percentage of dissolved oxygen concentrations were below the guideline level.

Additionally, the data suggests that the N:P ratio in the river downstream of the STP is more favourable than upstream, supporting prior reports (*e.g.* OCSE, 2012) that have found the additional nitrogen from the plant may be a benefit to health of the river and LBG. That said the nutrient concentrations themselves are often above guideline levels.

3.4.2 Jerrabomberra Creek water quality

The amount of water quality data available to understand trends in water quality in Jerrabomberra Creek was low compared to the Molonglo and Queanbeyan Rivers. The majority of electrical conductivity measurements from Jerrabomberra Creek at Hindmarsh Drive were above the guideline level. The greatest percentage of electrical conductivity measurements above the guideline level occurred at moderate to very low flows (55^{th} – 100^{th} percentile). Less than 5% of pH measurements and no dissolved oxygen measurements were outside of guideline levels.

3.4.3 STP wet weather diversion impacts on the Molonglo River

River water quality data collected upstream and downstream of the Queanbeyan STP does not enable clear conclusions to drawn on the impact of the Queanbeyan STP on the Molonglo River, especially during STP diversion events. Upstream of the STP the urban and agricultural land-use influence river water quality, especially total nitrogen and faecal coliform concentrations. Downstream of the STP there are a greater percentage of total nitrogen and chlorophyll-a concentrations above guideline concentrations, which may be influenced by STP inputs, but also by other land-uses in the vicinity of the downstream water quality site on the Molonglo River. During STP diversion events the small amount of matching river water quality data does indicate that there are increased faecal coliform concentrations. However, there is a lack of before, during and after diversion river water quality data to draw conclusions of the effects of STP diversions on river water quality. Historically, diversion events from the STP have been associated with faecal coliform concentrations in the Molonglo River (*e.g.* OCSE, 2012), but there is a lack of data to empirically understand broader water quality responses during and immediately following these events.

3.5 Informing modelling needs

The data analysis has highlighted that suspended solids, dissolved oxygen and pH levels in the Molonglo River downstream of the STP are generally within recommended guideline levels under the STP's current operation. The suspended solids levels of the effluent have generally been more favourable than the background water quality in the Molonglo River, suggesting that the existing licencing conditions (and indeed plant performance) is providing adequately for managing solids content. The OCSE (2012) report identified that the BOD may be having negative impacts in terms of algae growth potential in the lake; however no BOD data was forthcoming for the effluent and dissolved oxygen levels in the river downstream of the STP tend to be within guideline values. Understanding the nutrient and faecal coliform impacts of the effluent on the receiving waters, and the complex impacts of future increases in the EP and discharge rates, require further investigation, and so these parameters were the foci of the modelling exercises described in the next section.

4.0 Effluent and Molonglo River Modelling

In order to have a better understanding of the impacts of the STP's effluent on the Molonglo River and Lake Burley Griffin, modelling was completed for a range of future loading scenarios and potential license limits. A detailed modelling report is included in Appendix B.

Figure 2 shows the location of the existing Queanbeyan STP, which discharges into the Molonglo River approximately 9.5 km upstream of Lake Burley Griffin. The lower half of this reach of the river is flooded by backwater from Lake Burley Griffin, and therefore maintains a water level the same as that in the lake. This has an impact on the channel's ability to process nutrients as the deeper water tends to move slower and reduces the instream vegetation.

A range of modelling tools has been used to assess the impact of the STP on the receiving water quality in the Molonglo River reach from the STP to Lake Burley Griffin. A spreadsheet based plume dispersion model was used to examine the dilution of the effluent plume, resulting in an estimate of the distance downstream at which the plume is fully mixed across the river section. 1-Dimensional (1D) hydrodynamic and ecological modelling was undertaken to assess the impact of the STP on the river water quality under present conditions and to estimate the likely impact of future increases in effluent flow rate and changes in effluent water quality.

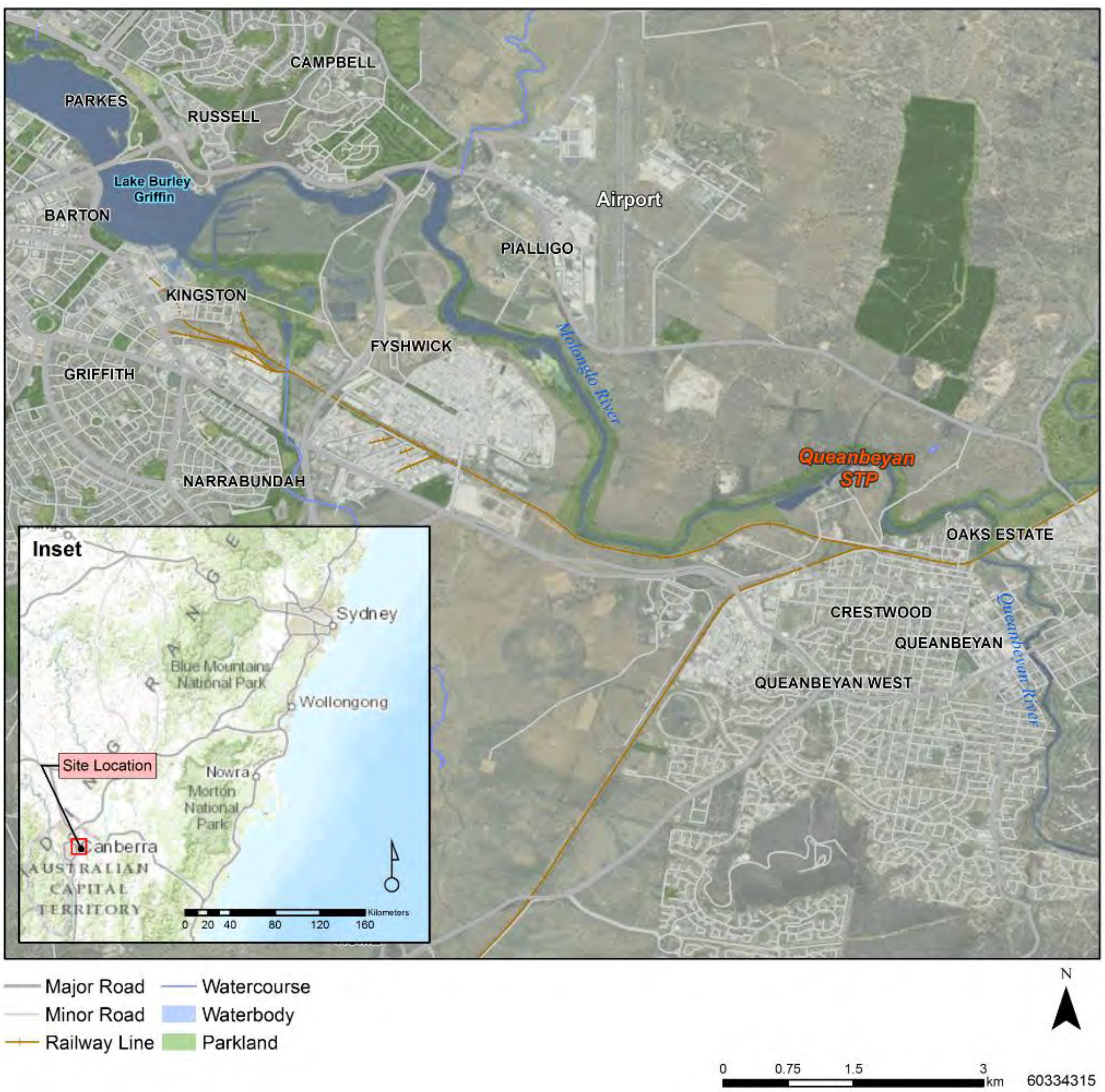


Figure 2 Queanbeyan STP locality

4.1 Molonglo River receiving water quality modelling

The Molonglo River receiving water quality modelling was aimed at identifying the impact of the STP on water quality within the Molonglo River using the DHI MIKE11 modelling suite. The software allows varying levels of ecological processes to be included in the model, in addition to the simple mass balance of nutrient concentration.

The water quality and discharge model inputs for the Molonglo River at the upstream model boundary and for the STP inflow were derived based on recorded data. There are several catchments between the STP and Lake Burley Griffin that impact the water quality within the river. The water quality model MUSIC was used to model the inflow and nutrient loads from these catchments.

The modelling approach involved first calibrating the model to reproduce the existing water quality conditions in the river. Once the model was calibrated, the discharge from the STP was removed from the model to establish a baseline water quality scenario. With an established baseline, current and future STP discharge rates and various effluent water quality scenarios were modelled to assess their impacts on the downstream water quality. The current study focused on modelling the presence of nutrients (total phosphorous [TP] and nitrogen [TN]) and faecal coliforms as an indicator of microbiological water quality.

4.2 Model extents and bathymetry

Figure 3 displays the model extents and cross-section layout for the MIKE 11 model. The model has cross-sections at key locations and spaced at approximately 200 metres along the Molonglo River.

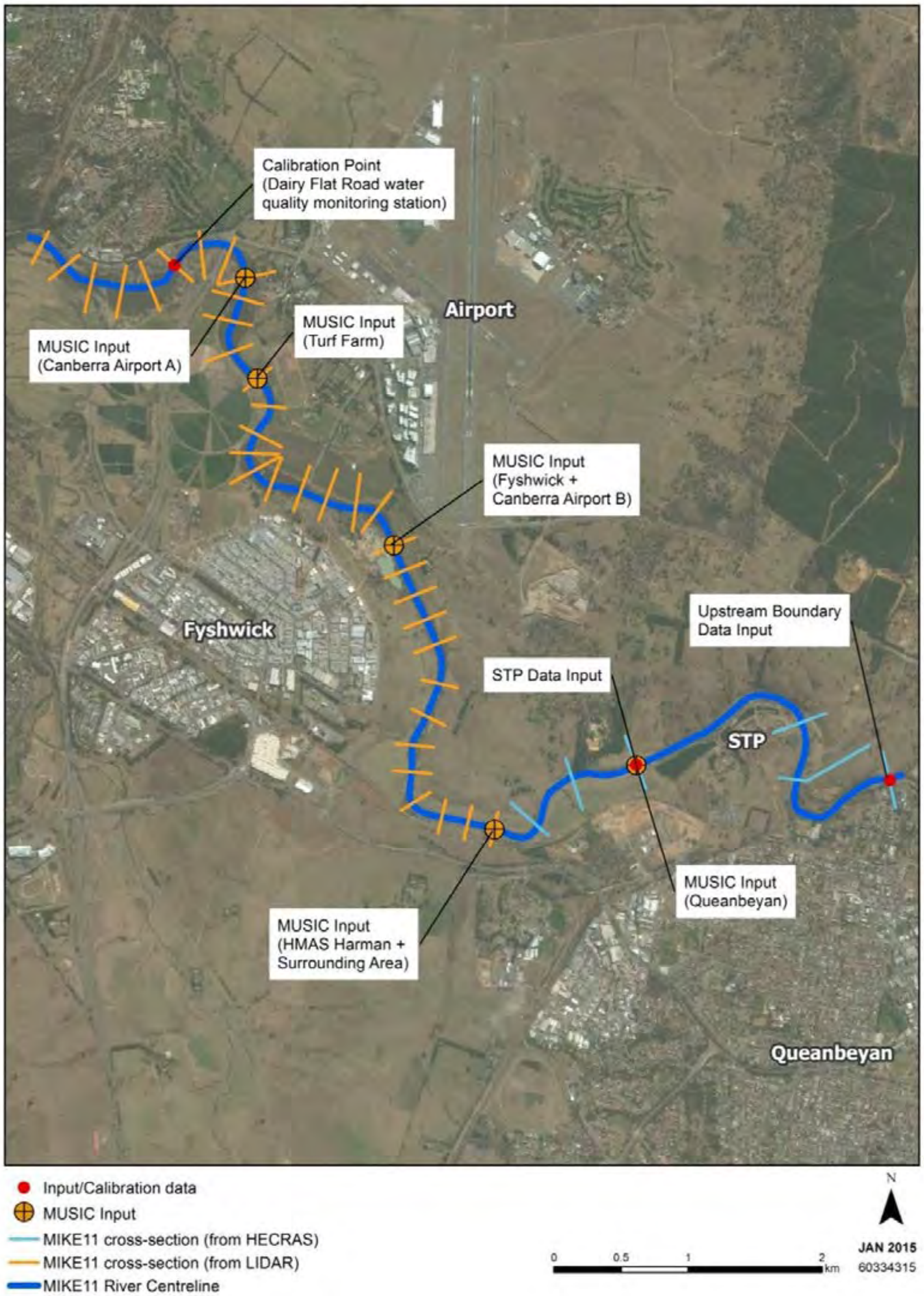


Figure 3 MIKE11 model extents, cross-section layout and source point locations

4.3 Catchment runoff water quality modelling (MUSIC)

There are a number of catchments that flow into the Molonglo River between the STP and Lake Burley Griffin. These catchments impact the water quality within the river. MUSIC was used to simulate catchment runoff and the associated nutrient loads by generating runoff and water quality data of typical runoff for different catchment characteristics. See Figure 3 for MUSIC node input locations. MUSIC model outputs include estimates of TN and TP, whereas the MIKE11 model requires the various forms of the nutrient that make up total nitrogen and total phosphorus as inputs. The components of total nitrogen and total phosphorus were estimated based on typical nutrient proportions given in literature. Refer to Appendix B for details of the assumed nutrient proportions and the MUSIC model calibration process.

As MUSIC does not generate faecal coliform concentrations based on land use inputs (as is the case for nutrients), synthetic datasets of faecal coliform levels were generated by assuming that the runoff concentrations from these catchments would be similar to that measured from the rural, per-urban and urban catchments upstream of the STP. The synthetic dataset was generated by fitting the data from nearby catchments to lognormal probability density functions, and using Monte Carlo random sampling techniques to generate a time series of concentrations, the details are at Appendix B.

4.4 Model calibration and sensitivity analysis

The performance of the model was calibrated based on the water quality at the downstream end of the model at the Dairy Flat Road water quality monitoring station site. Sensitivity analysis and calibration of the model has been performed for an eight year period from 2002 to 2010. This period was chosen due to the availability of higher quality data during this period. The water quality data recorded at the Dairy Flat Road water quality monitoring station was compared against modelled water quality, and model parameters and inputs varied to reproduce the recorded data.

The daily water quality, discharge and temperature data available for the STP was used to represent the STP in the model.

Due to the low resolution of the water quality data at the upstream boundary of the model (refer to Appendix B), detailed calibration of the model could not be undertaken. The available data did however allow the general trend of the model performance to be validated. Specifically, calibration was completed by varying the nutrient loads from the downstream local catchments, the denitrification rate of the nitrogen, and the proportional ratio of conservative versus non-conservative phosphorous.

4.5 Impact of STP on river water quality

4.5.1 Methodology

Following calibration of the model, various scenarios were modelled to assess the impact of changes to the discharge and water quality of the STP effluent on the downstream water quality. Each scenario was modelled for a 20 year period from 1985 to 2005. This period was chosen as it includes times of both flood and drought, and would therefore capture the impact of the plant on the river water quality under different river flow scenarios. The period also coincided with several wet weather by-pass events.

Flow and water temperature data from the Oaks Estate flow gauge was applied to the upstream boundary of the model, which provides daily river discharges and water temperature for the 20 year period. Insufficient water quality data is available for the upstream boundary, therefore a synthetic daily time series of TN, TP and faecal coliforms was generated based on the observed frequency distribution of the available quarterly data.

4.5.2 STP scenarios

Using the 20 year time series of input data, the MIKE 11 model was run for various scenarios in which the discharge rate and water quality of the STP were varied. The STP discharge rates were modelled at the current rate and that expected 25 and 50 years into the future. For each STP discharge scenario the TN concentration was modelled at 5, 10 and 20 mg/l, and TP was modelled at 0.1, 0.2 and 0.3 mg/l. Faecal coliforms concentrations were modelled using the synthetic time series, *i.e.* the effluent concentrations were held consistent and the EP and effluent flow rates were the only parameters varied among the scenarios. Table 5 presents a summary of the scenarios modelled.

Table 5 STP effluent discharge and water quality scenarios

Scenario	Equivalent Population (EP)	Discharge (m^3/s)	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Faecal Coliforms (CFU/100 ml)
1	0 (*i.e.* no STP)	0	Not applicable	Not applicable	Not applicable
2	45,000 (current)	0.133	5	0.1	Time series generated from fitting a lognormal probability distribution to historical effluent data and random sampling (log mean = 3.38, standard deviation = 1.27)
3	45,000 (current)	0.133	10	0.2	
4	45,000 (current)	0.133	15	0.3	
5	77,000*	0.223	5	0.1	
6	77,000	0.223	10	0.2	
7	77,000	0.223	15	0.3	
8	100,000**	0.291	5	0.1	
9	100,000	0.291	10	0.2	
10	100,000	0.291	15	0.3	

* Estimate for *ca.* 2040, ** Estimate for *ca.* beyond 2060.

The impacts of changes to the STP were assessed by comparing the statistics of the model results for the 20 year simulation period. Results were extracted and compared at the STP site (Location 1), at the Dairy Flats Road water quality station site (Location 4) and for two equidistant locations in between (Locations 2 and 3), as indicated in Figure 4.

Figure 4 **Locations where water quality model outputs were generated**

4.6 Results and discussion

Time series graphs of the modelled TN, TP and faecal coliforms for the ten scenarios, at the four locations shown in Figure 4, are presented in Appendix B. This report section contains some key summary points inferred following the modelling exercise. A comparison of TN and TP modelled 90th percentile concentrations at Dairy Flats Road is provided in Figure 5. Faecal coliform model outputs at all locations for the various scenarios and at each modelled location along the river reach are in Figure 6. Tables 7 to 10 present a comparison of the modelled mean and 90th percentile TN, TP and faecal coliform concentrations against the water quality guidelines presented in Table 4, for the four locations shown in Figure 4.

The models suggest that at Dairy Flats Road (even under future possible plant arrangements and EPs):

- TN levels in the river can be perhaps managed to levels similar to the present and historical case even allowing for an increase in EP by adopting an effluent target in the range 5-10mg/L. Presently the STP achieves effluent TN with a mean of 16mg/L and 90th percentile of 26mg/L
- If TP effluent targets of 0.1-0.2mg/L were adopted there would be insignificant to minor increases on TP content of the Molonglo River due to the influence of background levels of TP just upstream of the STP and other inputs downstream such as the turf farm, and the river and water quality processes. Note also that the present plant already achieves effluent TP levels with an average of 0.09 mg/L and 90th percentile of 0.15mg/L. At 0.1 mg/L of TP, the increased future effluent discharges may actually have a beneficial impact on TP levels in the river; as the discharges that could have lower TP levels than the background in the river would make a greater proportion of the river flow.
- The STP effluent is likely having little impact on the presence of coliforms at this site, owing to the relatively lengthy travel and residence times (typically 1 month) and the processes of microbiological decay. The scenario 1 model (which has the absence of the STP) results are very similar to those outputs for all other scenarios, indicating coliform sources closer to the location are likely to be much more influential. Achieving similar or greater levels of log-reduction of coliforms at the STP in future may not translate into observable improvements in coliform presence at this site. Again, note that the median faecal coliform measurement historically in the STP effluent is 28 CFU/100mL, while the median measured in the river just upstream of the STP has been 170 CFU/100mL, suggesting that outside of acute impacts of wet weather bypass event periods, the STP discharge is beneficial to the balance of faecal coliforms in the river.

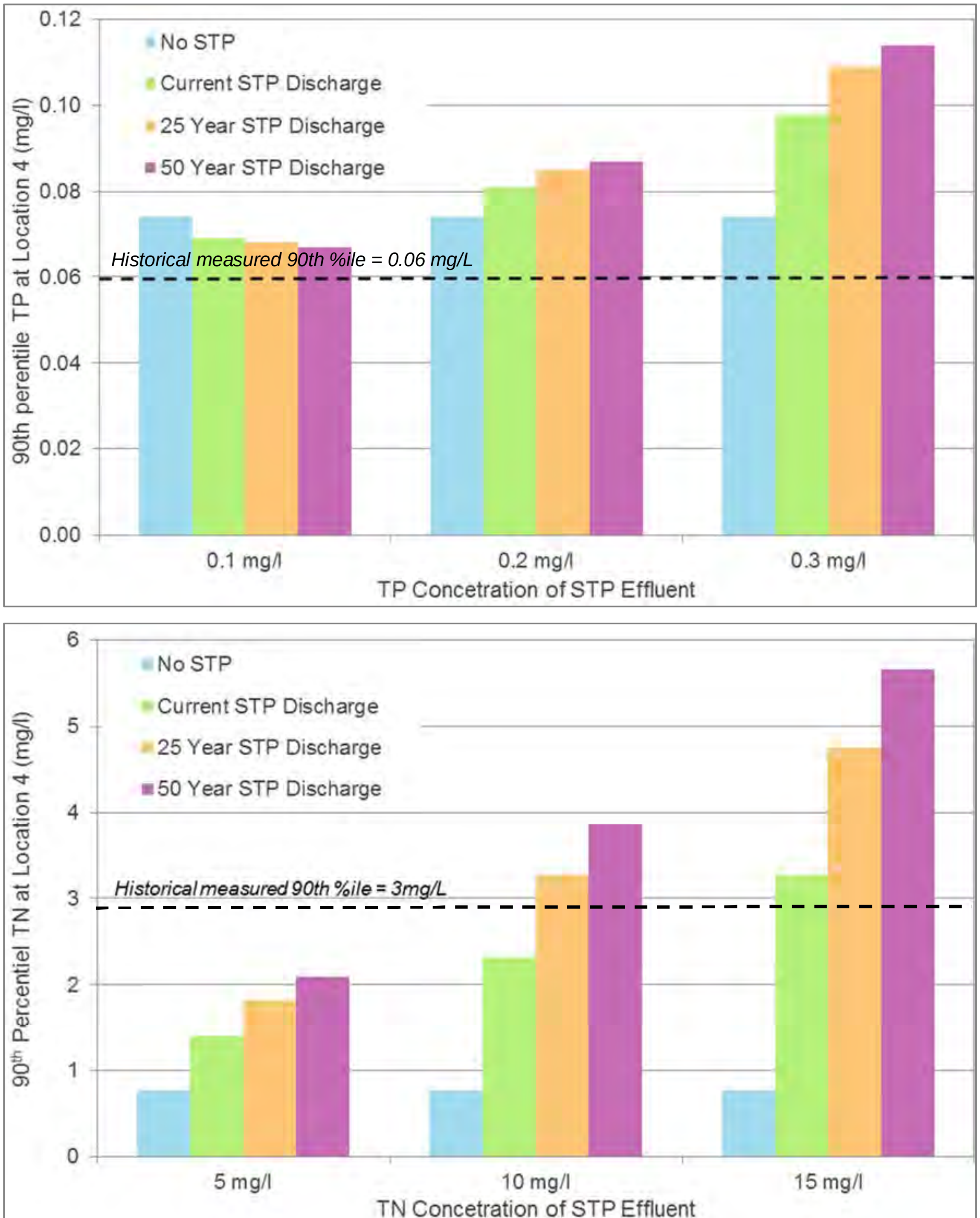
By extension adopting the targets for effluent quality in the ranges listed above would suggest that there would not be significant increases in nutrient or coliform concentrations in the river water entering Lake Burley Griffin, even allowing for future EPs. However if concentrations are maintained then the greater flows from the future plant could increase the overall loads of nutrients entering the lake, which is important particularly from the perspective of algal bloom potential. To illustrate, consider the EPA's 2005 Environment Protection Regulation (Table 4.8.2) concerning a target of <8,600kg/year of TP loading into Lake Burley-Griffin. A simplistic assessment (by multiplying average annual STP discharge rate and TP concentration) of the recent years of operation as well as for the various potential future scenarios modelled is presented in Table 6, and demonstrates the possible impacts of the future STP on TP loading into the lake. The values in Table 6 can also be considered against the currently licenced TP average daily load limit of 6 kg/day.

Table 6 Simplistic assessment of possible impact of STP on TP loading into Lake Burley-Griffin

Scenario (as per Table 5)	Equivalent Population (EP)	Average STP Discharge (m^3/s)	Average Effluent TP (mg/l)	TP load (kg/year)	TP load (kg/day)
1	45,000 (current)	0.113	0.09	321	0.9
5	77,000	0.223	0.1	703	1.9
6	77,000	0.223	0.2	1407	3.8
7	77,000	0.223	0.3	2110	5.8
8	100,000	0.291	0.1	918	2.5
9	100,000	0.291	0.2	1835	5.0
10	100,000	0.291	0.3	2753	7.5

* Estimate for *ca.* 2040, ** Estimate for *ca.* beyond 2060.

The comparisons of the model outputs at different locations along the river reach (see Appendix B and Figure 6) provide other insight. In the middle reaches the nutrient content is lower than at the most downstream location, indicating that the biological processes on the STP effluent nutrient loads have been effective at reducing the content before inputs from the Fyshwick industrial area and turf farm land areas. For the coliforms, the diminishing impact of the STP on the coliform presence in the river is apparent, and by the Dairy Flats Road location is perhaps negligible.



* Note that the 90th %ile value as estimated from the data is just an estimate with a certain confidence interval of the true value of that statistic. It is to be expected that the 90th %ile value from the model, with the much larger generated dataset, may differ slightly.

Figure 5 Summary of modelled 90th percentile concentrations of nutrients at Dairy Flats Road

Figure 6 **Summary of modelled 90th percentile concentrations of coliforms at all river reaches**

Table 7 **Comparison of water quality guidelines against modelled water quality for Location 1**

Scenario	Total Nitrogen (mg/L)		Total Phosphorous (mg/L)		Faecal coliforms (CFU/100mL)	
	median	90th %ile	median	90th %ile	median	90th %ile
Scenario 1	0.424	0.644	0.028	0.061	160	594
Scenario 2	1.304	3.149	0.046	0.079	139	514
Scenario 3	2.208	6.127	0.066	0.132	139	514
Scenario 4	3.124	9.111	0.085	0.186	139	514
Scenario 5	1.706	3.707	0.053	0.084	130	482
Scenario 6	3.070	7.319	0.082	0.151	130	482
Scenario 7	4.440	10.930	0.109	0.218	130	482
Scenario 8	1.958	3.946	0.057	0.087	125	461
Scenario 9	3.606	7.812	0.091	0.159	125	461
Scenario 10	5.257	11.688	0.123	0.232	125	461

Table 8 Comparison of water quality guidelines against modelled water quality for Location 2

Scenario	Total Nitrogen (mg/L)		Total Phosphorous (mg/L)		Faecal coliforms (CFU/100mL)	
	median	90th %ile	median	90th %ile	median	90th %ile
Scenario 1	0.426	0.707	0.027	0.068	130	509
Scenario 2	1.297	3.006	0.043	0.072	118	452
Scenario 3	2.160	5.793	0.063	0.117	118	452
Scenario 4	3.040	8.594	0.081	0.163	118	452
Scenario 5	1.686	3.535	0.049	0.075	113	428
Scenario 6	2.994	6.943	0.077	0.133	113	428
Scenario 7	4.315	10.379	0.103	0.191	113	428
Scenario 8	1.926	3.776	0.053	0.078	110	414
Scenario 9	3.517	7.465	0.086	0.141	110	414
Scenario 10	5.114	11.184	0.117	0.205	110	414

Table 9 Comparison of water quality guidelines against modelled water quality for Location 3

Scenario	Total Nitrogen (mg/L)		Total Phosphorous (mg/L)		Faecal coliforms (CFU/100mL)	
	median	90th %ile	median	90th %ile	median	90th %ile
Scenario 1	0.437	0.797	0.028	0.074	40	283
Scenario 2	1.102	1.942	0.033	0.070	45	280
Scenario 3	1.746	3.598	0.045	0.084	45	280
Scenario 4	2.383	5.251	0.055	0.107	45	280
Scenario 5	1.447	2.549	0.036	0.069	47	278
Scenario 6	2.455	4.885	0.053	0.089	47	278
Scenario 7	3.464	7.235	0.070	0.122	47	278
Scenario 8	1.668	2.880	0.038	0.069	49	276
Scenario 9	2.929	5.591	0.059	0.093	49	276
Scenario 10	4.199	8.305	0.082	0.133	49	276

Table 10 Comparison of water quality guidelines against modelled water quality for Location 4

Scenario	Total Nitrogen (mg/L)		Total Phosphorous (mg/L)		Faecal coliforms (CFU/100mL)	
	median	90^{th} %ile	median	90^{th} %ile	median	90^{th} %ile
Data (1995-2005)	1.2	3.0	0.03	0.06	11	31
Scenario 1	0.447	0.763	0.034	0.074	8	144
Scenario 2	0.791	1.400	0.035	0.069	9	146
Scenario 3	1.162	2.321	0.044	0.081	9	146
Scenario 4	1.519	3.270	0.051	0.098	9	146
Scenario 5	1.016	1.821	0.036	0.068	10	146
Scenario 6	1.634	3.277	0.049	0.085	10	146
Scenario 7	2.240	4.756	0.060	0.109	10	146
Scenario 8	1.186	2.087	0.038	0.067	11	146
Scenario 9	1.994	3.864	0.053	0.087	11	146
Scenario 10	2.790	5.655	0.066	0.114	11	146

5.0 Development of Water Quality Objectives

5.1 Water quality management

5.1.1 Molonglo River health and quality management

The STP's location in the Australian Capital Territory means that the overarching instrument for water quality management and control in the vicinity and downstream of the plant is the *Environment Protection Act 1997* and *Environment Protection Regulations 2005* (ACT). Other guidance for the setting of water quality objectives in the river and the downstream Lake Burley-Griffin is provided by the *Australian Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000) and the 2011 *Lake Burley Griffin Management Plan* that makes strong reference to the ANZECC Guidelines. Recreational water quality criteria are outlined in the *ACT Guidelines for Recreational Water Quality* (ACT Health, 2010) and the *Australian Guidelines for Managing Risks in Recreational Waters* (NHMRC, 2008).

In general, each of the regulatory and guideline documents outline a management process of determining the values (environmental, drinking, recreational, economic, irrigation, *etc*.) held by the waterways' communities, determining the water quality requirements to support the values, and working toward strategies to meet the objectives. The water quality objectives listed at Table 4, against which water quality data from the Molonglo and Queanbeyan Rivers was assessed, were derived with reference to each of the above listed documents. Some objectives are consistently exceeded, others less so. Strategies for enhancing and maintaining the water quality and environments are outlined in the 2010 *Molonglo River Rescue Action Plan* (Molonglo Catchment Group) and the 2012 *Lake Burley-Griffin Action Plan: A Healthier, Better Functioning Lake by 2030* (Lake Burley Griffin Task Force). Presently, the ACT Government is also progressing with its Basin Priority Program, a program being delivered in partnership with the Australian Government to improve the health of the waterways in the ACT region and its catchments. That program will require the derivation of a set of water improvement priorities and the determination of investment cases to realise the benefits. At this time the program has not generated any water quality objectives or priorities that may be considered relevant to this study.

5.1.2 The STP licencing conditions

Effluent discharge is authorised under *Environmental Protection Act 1997* by the ACT Environmental Protection Authority (EPA). The authorisation is reviewed annually. Upon determining the licencing conditions, consideration may be given to the receiving water environment, and determining rules that can assist to balance the environment while taking into account the nature of the STP system and the economic and community implications associated with the discharges.

5.2 What's the policy?

The water quality management policy to be applied to the STP upgrade opportunity is to be determined through discussions between QCC, ACT EPA, and other stakeholders. There may be three policy positions considered, the adoption of one or the other will influence the determination of the water quality objectives associated with the STP upgrade. The policy options are:

4) That the STP upgrade should have associated effluent quality objectives that serve to meet or significantly approach upon the suite of healthy river criteria objectives for the Molonglo as set out earlier, or

5) The future population should be served by a STP in a way that will have negligible or beneficial impact on the receiving environment than is presently the case, or

6) Changes in the water quality of the receiving environment due to the STP upgrade can be justified on a 'whole community benefit' or a 'triple-bottom-line' economic basis.

Adopting any one of those positions needs to be considered in the context of what influence the STP is really having on current water quality. For instance, if other sources can be demonstrated to be having a far more significant influence on river water quality presently than the STP, it may not be reasonable or feasible to adopt the first listed position. The next section describes some of the pertinent findings from the data review and modelling exercise and the implications for setting water quality objectives.

5.3 Recommendation

Modelling has assisted to enhance the understanding of the present and potential future impacts of the current and proposed future STP. In terms of influencing the setting of water quality objectives, noting that the STP is not the major contributor to river water quality as compared to other non-point sources, then a reasonable objective for the future STP may be to:

4) Aim for adopting targets on effluent quality in the first instance so that the future population is served by a STP in a way that will have negligible or beneficial impact on the receiving environment than is presently the case

5) Determine through further design and analysis the costs and feasibility of technologies available to accommodate this objective

6) If necessary, commence discussions with stakeholders around whether there may be changes to the water quality of the receiving environment due to the STP upgrade that can be justified on a 'whole community benefit' or a 'triple-bottom-line' economic basis.

With regard to the first point above, the modelling outcomes indicate that, with regard to the nutrient river quality at the confluence with Lake Burley Griffin, a 'negligible or beneficial impact' outcome on water quality concentrations may be achievable by adopting effluent quality targets of 5-10mg/L for TN and 0.1-0.2mg/L for TP. These could be suitable as target median and 90^{th} percentile effluent concentrations respectively. The present licenced faecal coliform effluent objectives and performance has served adequately to provide a beneficial impact on measurable coliform concentrations in the Molonglo River. As such, moving forward, the historical performance of the effluent could be adopted as formal future targets for coliform presence in the effluent which would correspond to median of 30 CFU/100mL and 90^{th} percentile of *ca.* 200 CFU/100mL. This would drive improvements in the presence of pathogenic organisms in the effluent and so the receiving environments and future rationale for alternate coliform (or other microbial indicator) levels may be dictated by a desire to treat water to levels appropriate for beneficial reuses and so to achieve log-reduction targets outlined in the *Australian Guidelines for Water Recycling.*

The present BOD and suspended/dissolved solids licencing conditions can be considered as starting points for discussions around future licencing conditions for a larger EP and discharge plant, noting that they presently impact the receiving water quality within current guideline limits.

6.0 Monitoring

6.1 Overview of current monitoring program

An overview of the relevant monitoring of the Molonglo River and other sites, and recommended amendments to the present program, is provided at Table 11. Further detail is provided below.

6.1.1 Water quality

Current water quality monitoring is conducted by the ACT Government upstream and downstream of the QCC STP. Water quality is sampled at different flow levels, rather than at fixed times. The aim of the sampling strategy is to provide a fully representative assessment of river health over time by taking account of the impact of flow on water quality. Samples are collected within four flow levels, measured by the flow percentile (5 – 29%, 30–49%, 50–69% and 70–89%). Upstream sites are located on the Molonglo River at Yass Road (station 410608) and the Queanbeyan River at ACT Border (station 410769). The downstream site is located on the Molonglo River at Dairy Flats Road (station 410601). Water quality point measurements taken at these sites include suspended solids, TN, TP, chlorophyll-a, faecal coliforms, pH, conductivity, dissolved oxygen and water temperature.

The quality of water discharged from the QCC STP is monitored daily by QCC. Daily water quality point measurements include suspended solids, conductivity, pH, temperature, ammonia. Weekly point measurements include phosphorus (total and ortho-phosphorus), nitrogen (total, nitrate and nitrite), total organic carbon, chemical oxygen demand, biochemical oxygen demand and faecal coliforms.

Directly downstream of the STP at Oaks estate pH, temperature and ammonia are measured daily. Faecal coliforms are measured every two weeks.

6.1.2 River discharge

River discharge is measured upstream of the STP on the Molonglo River at Burbong (station 410705) and on the Queanbeyan River at Wickerslack Lane (station 410760). River discharge at the STP is measured at Oaks Estate (station 410729) upstream of STP inflow.

6.1.3 Biological monitoring

Regular ACT Government AUSRIVAS macroinvertbrate monitoring of river condition only takes place upstream of the STP on the Molonglo River at Yass Road and at the Queanbeyan River at the ACT Border. Macroinvertebrate samples are collected each year in autumn and spring from the edge habitat.

6.2 Monitoring Program

6.2.1 Proposed new/addendum to monitoring program

The current water quality and river discharge monitoring sites listed the table below are generally suitable for the continuation of baseline data collection in Molonglo and Queanbeyan River catchments. Nonetheless, below we have listed some potential improvements that will improve the monitoring program from a science perspective and allow for a better understanding of STP impacts on river health:

1) The distance between the STP and the most downstream water quality site on the Molonglo River at Dairy Flats Road is not suitable for detecting the direct effects of the STP on Molonglo River water quality, because of the possible effect of other land-uses (*e.g.* industrial and urban areas, Fyshwick STP and Fyshwick turf farm). The site at Dairy Flats Road is still useful as a site to determine the effects of upstream land-use (including the QCC STP) on water quality at the mouth of Lake Burley Griffin, but not for a direct assessment of how the QCC STP affects river water quality. Therefore, baseline data collection the same water quality variables collected as a part of the ACT Government Water Quality Monitoring Program should also be collected at the Molonglo D/S of Oaks Estate site directly downstream of the QCC STP to compliment upstream of STP data collection

2) The frequency of water quality data collection at the current locations is not suitable for detecting the effects of flooding events and STP discharge events on river water quality. To detect the effects of such events on river water quality automatic water samplers could be installed at the following locations to detect the effects of pollutants during rising, peak and falling discharges (from the STP and in the river):

    - Molonglo at Yass Road

- Queanbeyan at ACT Border
- Molonglo at Oaks Estate
- Molonglo D/S of Oaks Estate
- Molonglo at Dairy Flat Road

3) The automatics samplers could be triggered to collect samples during flood events and/or STP discharge events. Sampling units located at Molonglo at Yass Rd and Queanbeyan at ACT Border would account for the effects of upstream land-use on water quality. The Molonglo River at Oaks Estate site would account for the combined effects of the Queanbeyan and Molonglo catchments upstream of the STP on river water quality. The Molonglo D/S of Oaks Estate and Molonglo at Dairy Flat Road sites would account for the downstream effects of the STP on river water quality directly downstream of the STP and at the mouth of Lake Burley Griffin.

4) To be up to date with current recreational guidelines water quality guidelines (e.g. NHMRC 2008, ACT Health 2014) faecal coliform assessment should include the assessment of *E. coli* and enterococci. The World Health Organisation (WHO, 2003) recommends the use of intestinal enterococci as the single preferred faecal indicator. Additionally, the National Health and Medical Research Council's (2008) G*uidelines for Managing Risks in Recreational Water and the ACT Guidelines for Recreational Water Quality* follow the WHO advice for using intestinal enterococci as the indicator of faecal pollution.

5) AUSRIVAS macroinvertebrate community assessment currently only takes place upstream of the STP at the Molonglo at Yass Rd and Queanbeyan at ACT border sites. Macroinvertebrate communities are regularly used to assess the ecological functioning of rivers and using macroinvertebrate communities can give an indication of river water quality in weeks to months preceding sampling. It is proposed that an additional macroinvertebrate sampling site with the same frequency of sampling from the edge habitat to compliment upstream sites be located at the Molonglo D/S of Oaks Estate site. This additional macroinvertebrate site can be used to assess the effects of any STP related water quality effects of the ecological functioning of the Molonglo River compared to upstream sites. Sample collection days at this site should be matched to upstream ACT Government sites.

6.2.2 Responsibilities for current and proposed future programs

The recommendations we have made for improving the QCC monitoring program should be considered within an adaptive management framework where water quality assessments are based on river health/water quality management objectives for the Molonglo River and water quality management objectives for the QCC STP. Within an adaptive management framework STP operations can be refined based on the results of the monitoring program.

The responsibilities of delivering a water quality monitoring program for the QCC STP lie primarily with QCC to report on their compliance with water quality objectives set by the ACT Government. There will need to be collaboration with the ACT Government to minimise overlap with monitoring programs and the ACT Government's obligation to manage water quality and river health within the ACT. A significant opportunity exists to integrate the proposed additional monitoring with the ACT water quality monitoring framework which is currently being reviewed.

Table 11 Water quality and river discharge stations within the study area including data collected and frequency of collection.

Station	Location	Data collected	Data collection frequency	Changes to monitoring recommended
Molonglo River at Burbong (station 410705)	Upstream of QCC STP	River discharge and level	Hourly	None
Molonglo River at Yass Road (station 410608)	Upstream of QCC STP	suspended solids, TN, TP, chlorophyll-a, faecal coliforms, pH, conductivity, turbidity, dissolved oxygen and water temperature	Across the year at different flow levels	Installation of an automatic water sampler to detect the effects of pollutants during rising, peak and falling discharges, and STP discharge events -

Station	Location	Data collected	Data collection frequency	Changes to monitoring recommended
				suspended solids, TN, TP, chlorophyll-a, enterococci Change faecal coliform sampling to enterococci and *E.coli*
		AUSRIVAS macroinvertebrate sampling	Yearly in autumn and spring	None
Queanbeyan River at Wickerslack Lane (station 410760)	Upstream of QCC STP	River discharge and level	Hourly	None
Queanbeyan River at ACT Border (station 410769)	Upstream of QCC STP	suspended solids, TN, TP, chlorophyll-a, faecal coliforms, pH, conductivity, turbidity, dissolved oxygen and water temperature	Across the year at different flow levels	Installation of an automatic water sampler to detect the effects of pollutants during rising, peak and falling river discharges, and STP discharge events - suspended solids, TN, TP, chlorophyll-a, enterococci Change faecal coliform sampling to enterococci and *E.coli*
		AUSRIVAS macroinvertebrate sampling	Yearly in autumn and spring	None
Oaks Estate (station 410729)	Upstream of QCC STP	River discharge and level	Hourly	Installation of an automatic water sampler to detect the effects of pollutants during rising, peak and falling river discharges, and STP discharge events - suspended solids, TN, TP, chlorophyll-a, enterococci
QCC STP discharge	At QCC STP final effluent pond	suspended solids, conductivity, pH, temperature and ammonia	Daily	None
		phosphorus (total and ortho phosphorus), nitrogen (total, nitrate and nitrite), total organic carbon, chemical oxygen	weekly	Change faecal coliform sampling to enterococci and *E.coli*

Station	Location	Data collected	Data collection frequency	Changes to monitoring recommended
		demand, biochemical oxygen demand and faecal coliforms.		
Molonglo D/S of Oaks Estate	Downstream of QCC STP	pH, temperature and ammonia	Daily	Collection of suspended solids, TN, TP, chlorophyll-a, faecal coliforms, pH, conductivity, turbidity, dissolved oxygen and water temperature to complement Act Government sampling at upstream of STP sites. Sampling should occur at the same time as upstream sites across the year at different flow levels Installation of an automatic water sampler to detect the effects of pollutants during rising, peak and falling river discharges, and STP discharge events - suspended solids, TN, TP, chlorophyll-a, enterococci
		Faecal coliforms	Weekly	None
Molonglo River at Dairy Flats Road (station 410601)	Downstream of QCC STP	suspended solids, TN, TP, chlorophyll-a , faecal coliforms, pH, conductivity, turbidity, dissolved oxygen and water temperature	Across the year at different flow levels	AUSRIVAS macroinvertebrate sampling yearly in autumn and spring matching sampling dates at ACT Government sites at upstream of STP Molonglo River at Yass Road (station 410608) and Queanbeyan River at ACT Border (station 410769) sites
				Installation of an automatic water sampler to detect the effects of pollutants during rising, peak and falling river discharges, and STP discharge events - suspended solids, TN, TP, chlorophyll-a,

Station	Location	Data collected	Data collection frequency	Changes to monitoring recommended
				enterococci Change faecal coliform sampling to enterococci and *E.coli*

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