7 Water quality and hydrology

Water Quality and Hydrology – the EA shall include an assessment of water quality impacts arising from the construction and operation of the project. With respect to construction, risks associated with laying pipelines, including across watercourses, erosion and sedimentation controls and management of any discharges from the project to prevent impacts to nearby watercourses must be addressed. With respect to operation, details of the disinfection systems and the quality of the recycled water must be provided. Details on the proposed use(s) of the recycled water and how this will be managed, particularly with respect to runoff into waterways and the need for buffer zones, must be provided. Details on the impacts and management of wastewater and infrastructure must be provided, including impacts from discharges from the recycled water plant. Where relevant, wet weather effluent storage requirements, the location of infrastructure within riparian areas and details of any dry and wet weather sewage overflows must be provided. Consideration must also be given to water cycle management plans for the area.

The Director General's Requirements (DGRs) require an assessment of water quality impacts arising from the construction and operation of the Project.

During times of low recycled water demand, excess recycled water would be discharged into the stormwater management system and Googong Creek before ultimately reaching the Queanbeyan River. This chapter considers Australian, NSW and ACT water quality guidelines with regards to the Queanbeyan River and demonstrates that the Project would be consistent with these guidelines.

Ambient water quality data is provided as part of a preliminary aquatic environmental assessment, with predicted water quality modelling presented in the water balance report (Appendix C).

The assessment shows that the existing waters of the Queanbeyan River are already slightly disturbed, so the discharge of residual excess high quality recycled water is unlikely to have any significant impact on ambient water quality in the river.

Specific modelling, management and mitigation measures have been recommended to ensure that ambient water quality and the relevant guidelines are met throughout the construction and operation of the Project. The assessment in the chapter addresses the potential impacts from the ultimate stage of the Project, with further detail provided for Stage 1 of the Project.

7.1 Water quality objectives and guidelines

7.1.1 NSW water quality objectives

The *NSW Water Quality and River Flow Objectives* (the 'NSW water quality objectives') set out agreed environmental values and long-term goals for the State's surface waters. They contain:

- The community's values and uses for rivers, creeks, estuaries and lakes.
- A range of water quality indicators to aid in the assessment of whether the current condition of the waterways supports those values and uses.

7.1.2 ANZECC guidelines

The NSW water quality objectives are consistent with the agreed national framework for assessing water quality, in terms of whether the water is suitable for a range of environmental values (including human uses), as outlined in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)* (the 'ANZECC (2000) guidelines'). While the NSW water quality objectives provide environmental values for NSW waters, the ANZECC (2000) guidelines provide the technical guidance to assess the water quality needed to protect those values.

According to the NSW water quality objectives, the Queanbeyan River below Googong Dam is considered a controlled river with reduced flows. It is characterised as being affected by diversions of flow from the Googong Reservoir to Queanbeyan and Canberra. Some high flows and most low to moderate flows are considered to be substantially reduced for most of the year. Some flows are released into the river for environmental purposes from the Googong Reservoir. The water quality objectives for this section of the Queanbeyan River under the ANZECC (2000) guidelines, as outlined in this chapter, relate to the protection of aquatic ecosystems and primary and secondary contact recreation.

The ANZECC (2000) guidelines for aquatic ecosystems provide trigger values for physical and chemical water quality guidelines for ecosystem management. Queanbeyan River is considered slightly to moderately disturbed (as per Section 3.1.3 of the guidelines). The trigger values for these types of ecosystems, for south-east Australian upland streams (more than 150-metre altitude), are shown in Table 3.3.2 of the guidelines, and reproduced below in Table 7.1.

Table 7.1 Relevant water quality guidelines/trigger values

Water quality indicator	Guideline value
Chlorophyll *a* (mg/L)	N/A
Total nitrogen (TN) (mg/L)	< 0.25 (upland river)
Oxides of nitrogen (NOx)(mg/L)	< 0.015 (upland river)
Ammonium (NH_4)(mg/L)	< 0.013 (upland river)
Total phosphorus (TP) (mg/L)	< 0.02 (upland river)
pH	6.5–7.5 (upland river)
Dissolved oxygen (DO) (mg/L)	8.2–10 at 20°C (upland river)
Conductivity (µS/cm)	30–350 (upland river)
Microbiological faecal coliforms (cfu/100mL)	150 (primary contact)
Total algae (cells/mL)	15,000–20,000 (primary contact)
Cyanobacteria	15,000–20,000 (primary contact)

Source: ANZECC (2000)

In addition to the water quality indicators listed in Table 7.1, the ANZECC (2000) guidelines also contain parameters for the protection of visual amenity, recreation (primary and secondary) and (livestock and homestead) water supply.

These trigger values only apply to ambient waters (not effluent) and are not designed to be threshold values, but to be used with professional judgment, to provide the initial assessment of the state of a water body. They are to be used in conjunction with desired levels of protection of the particular ecosystem type. A water quality result that is above the trigger value for any particular parameter indicates that a 'potential risk' exists and that further site-specific investigations should occur.

The ANZECC (2000) guidelines discuss methods of deriving water quality values appropriate to particular ecosystems. Where there are no objectives set, reference data can be used, in which case the ANZECC (2000) guidelines refer to an 80th percentile value. However, the guidelines note that the choice is arbitrary and should consider professional advice.

For the purpose of assessing the impact of proposed operational discharges of excess recycled water into the Queanbeyan River (via the stormwater system and Googong Creek), the 80th percentile of flows and river water quality data have been selected to derive a trigger value. However, to describe the existing environment, in terms of both water quality and aquatic ecology, 75th percentile and maximum values were used in the assessment undertaken by Ecowise (refer to the footnote at Table 7.2).

As noted in the following sections, the water quality in the Queanbeyan River is already mostly above ANZECC (2000) guideline trigger values for total nitrogen and total phosphorus. In light of this, the Department of Environment, Climate Change and Water (DECCW) has, on several occasions, referred to the need to maintain 'ambient water quality' as a result of any proposed development or action (in this case, the discharge of excess recycled water into the environment). This advice will be applied to Section 7.5.3 when analysing results of water quality modelling.

7.2 Existing environment

This section includes a map of the catchments within and adjacent to the study area (Figure 7.2) and a map showing the relevant existing and proposed water quality monitoring sites (Figure 7.3). This section also discusses the existing land uses and impacts within the catchment, focussing on sources of nitrogen and phosphorus. Existing water quality values at key sites are also provided.

7.2.1 Drainage and hydrology

Information in this section draws on a riparian corridor assessment prepared by Brown Consulting (2008). Drainage in the study area consists of a number of small ephemeral and semi-permanent creeks, farm dams and depressions. Records show that the area has a mean annual rainfall of less than 600mm, with summer thunderstorms and drought as common features (Bureau of Meteorology).

The study area drains via four main catchments, as shown in Figure 7.2 and outlined below.

Queanbeyan River

The majority of the land within the study area drains to the Queanbeyan River below the Googong Dam. The river is 70km in length and is a tributary of the Molongolo River north of the existing Queanbeyan urban area. These waters eventually flow to Lake Burley Griffin (Willana, 2007).

Flow in the Queanbeyan River has undergone considerable change since the construction of the Googong Dam in 1977. Prior to the installation of the Dam, natural flow in the river was unregulated and the base flow at the Wickerslack Lane monitoring site (see Figure 7.3) was about one cubic metre per second. Since damming of the river, the base flow has been regulated to a minimum average flow of about 0.1 cubic metres per second (Ecowise, 2008).

The ACT Government has developed guidelines on environmental flows that apply to the Queanbeyan River to provide sufficient water to sustain the river's ecological health. Decisions to release environmental flows from the Googong Dam take into account the status of riparian corridors, rights of existing water users, water levels in Lake Burley Griffin (during periods of drought), and the need to reduce algal blooms (CRC, 2004).

Montgomery Creek

Montgomery Creek is the major watercourse within the study area, and flows from the southern boundary to the eastern corner of the study area, joining the Queanbeyan River just below Googong Dam. It can be broken up into three main parts:

- The external catchment south of the study area, which has an area of 224 hectares.
- Upper Montgomery Creek within the study area, which has an area of 199 hectares. This section is a flat plain, climbing rapidly to the western edge of the Project site. It has been cleared and is well grassed with few scattered trees. Part of this catchment has been used for agricultural production, although its current use is for grazing. There are some remnant beds and banks in this section but the watercourse is discontinuous and has been modified. There are a number of small dams through this section of the catchment.
- Lower Montgomery Creek within the study area, which has an area of 237 hectares. Unlike the section upstream, this lower section is characterised by steep side slopes of up to 25 per cent, particularly in the lowest part of the creek. Figure 7.1 shows the general landscape of this lower section of Montgomery Creek. The bed and banks of the creek are well defined with much of the creek located on the underlying rock. The creek consists of a series of rock pools linked by a riparian vegetation. There is a small waterfall about halfway downstream of this section.

Figure 7.1 General landscape of the lower reaches of Montgomery Creek

Googong Creek

Googong Creek drains the north-western portion of the study area and is the second largest catchment in the study area (164 hectares). Note that this is an unofficial name for the creek, which is currently unnamed. Googong Creek runs through the site from the western boundary at Old Cooma Road, across the site in a north-easterly direction, under Googong Dam Road (via a culvert) and then continues in a northerly direction to the Queanbeyan River (refer to Figure 7.2).

The creek has two distinct characters, divided to the north and south, separated by Googong Dam Road. The watercourses in the southern section of the creek generally consist of grassy swales draining to a number of farm dams. There have been some modifications to the catchments with diversion banks constructed to enlarge the catchment of dams. Generally, within this section of the creek there is little evidence of bed and bank formation.

At Googong Dam Road there is a culvert under a major embankment, which blocks the creek. The embankment blocking the creek and the large dam immediately upstream form a de facto detention basin at this location. It is considered extremely unlikely that the roadway would be overtopped in any storm event. This culvert consists of twin 1500mm diameter pipes.

Within the downstream section of the creek to the north of Googong Dam Road, preliminary investigations have shown that the creek is well formed with definable beds and banks.

Jerrabomberra Creek

Jerrabomberra Creek is a small catchment within the study area (20 hectares).

The watercourse in the south-western corner of the site is a minor tributary of Jerrabomberra Creek. This catchment drains to a culvert under Old Cooma Road.

The catchment falls from Hill 800 to the western boundary, and is almost entirely cleared (there are only occasional scattered trees). There is no evidence of bed or bank formation within the low points, with the catchment drained via unformed grassy swales.

Googong Reservoir

Googong Reservoir catchment is large, extending to the east and south of the study area, but only a small portion of the catchment (33 hectares, or less than 0.05 per cent of the total Googong Reservoir catchment area) is within the study area.

This area is excluded from development and is zoned as E2 Environmental Conservation (under the Queanbeyan LEP).

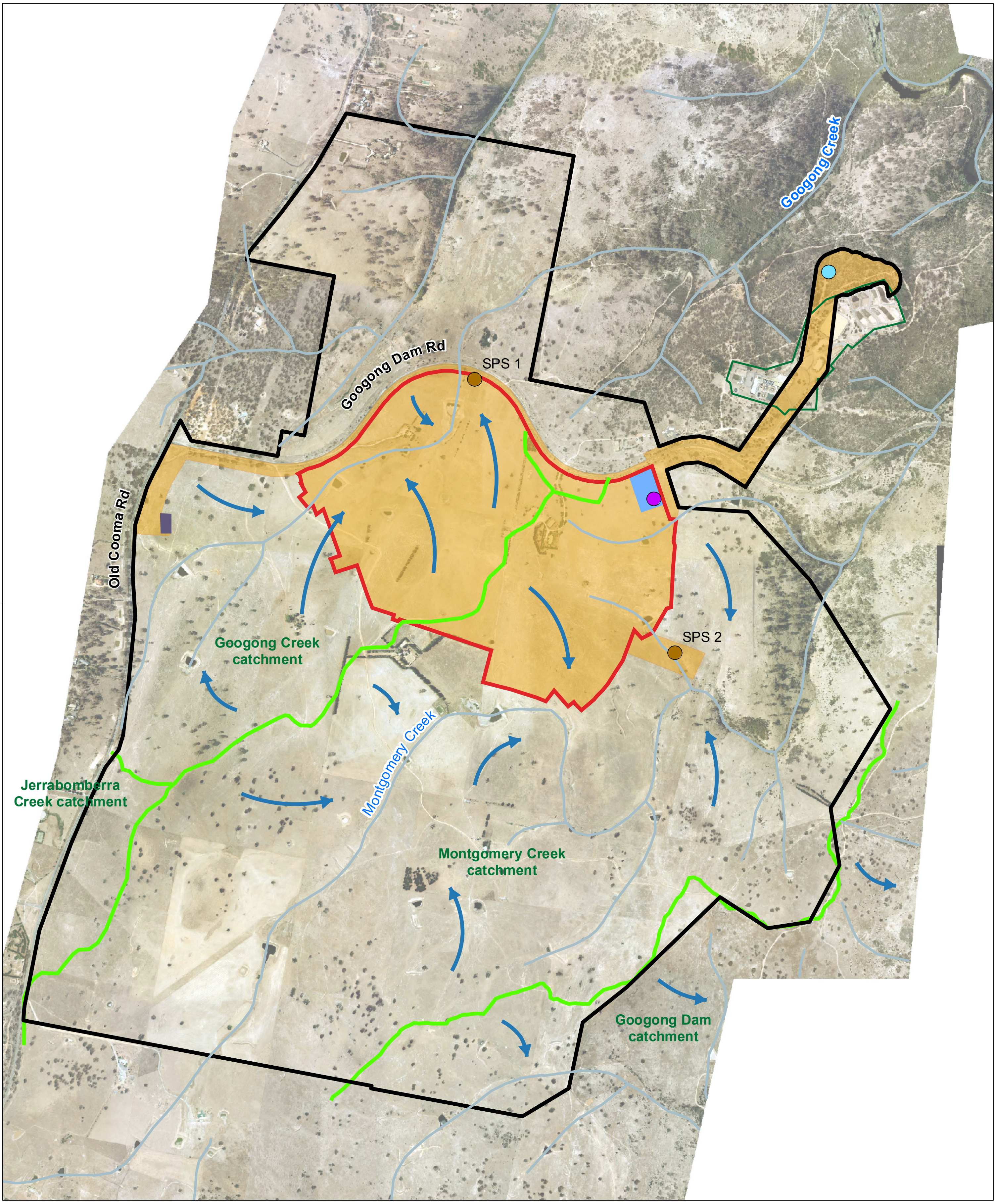
The watercourses within the site that drain to the reservoir are fairly similar to the rest of the site in that they have generally been cleared with scattered trees. The site is generally steeper than the other parts of the site, except for the lower section of Montgomery's Creek.

7.2.2 Existing surface water quality

During the early planning phase of the Googong township, Ecowise conducted a preliminary assessment of the current water quality in the Queanbeyan River (Ecowise, 2008). Data was obtained from ACTEW, which is based on ACTEW's ongoing monitoring program within the Queanbeyan River. The monitoring sites adopted by ACTEW include:

- Upstream site (QBN 704) – one kilometre downstream of Googong Dam.
- Wickerslack Lane site (QBN 703) – four kilometres downstream of where the proposed recycled water discharges (within stormwater flows) would meet the Queanbeyan River via Googong Creek.
- Downstream site (QBN 679) – located at the ACT border.

Figure 7.3 shows the location of these sites along the Queanbeyan River.



Googong Environmental Assessment

Proponent CIC Australia

Date 20 August 2010

Drawing no. 08003g_ea_fig07-2

Source Ecowise, Biosis, JEA

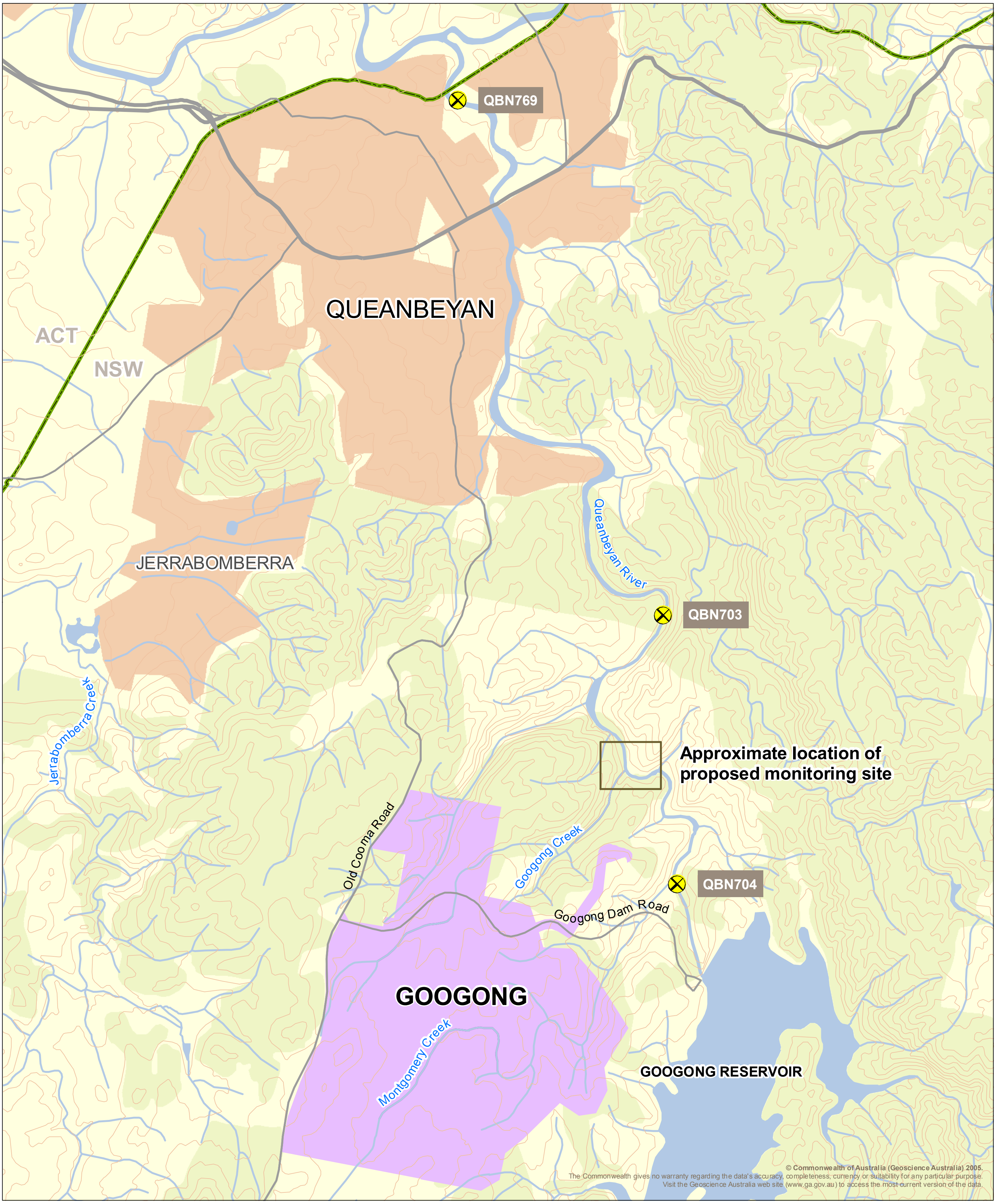
- Bulk water pumping station
- Recycled water pumping station
- Sewage pumping station
- Watercourse
- Surface water catchment
- Surface water flow line (indicative)
- Neighbourhood 1A
- Existing ACTEW Googong water treatment plant site
- Water recycling plant
- Interim reservoir area
- Subject site
- Study area

1:20,000

0 150 300 450 600m

Figure 7.2 Catchment areas

Maunsell Roberts



Googong Environmental Assessment

Proponent CIC Australia

Date 20 August 2010

Drawing no. 08003g_ea_fig07-3

Source Geoscience Australia, Ecowise

Figure 7.3 Water quality monitoring sites on Queanbeyan River

Maunsell Roberts

Recent available water quality information for these sites is provided in Table 7.2 for data obtained between 1994 and 2008. **Bold** font indicates results that are above or outside the range of the ANZECC guideline trigger values provided in Table 7.1.

Table 7.2 Water quality at monitoring sites on Queanbeyan River

Indicator	ANZECC guideline	Upstream site (QBN 704)		Wickerslack Lane site (QBN 703)		Downstream site (QBN 679)	
	Upland river	75th %ile**	Max	75th %ile**	Max	75th %ile**	Max
Nutrients							
Total nitrogen (mg/L)	<0.25	**0.51**	**0.54**	**0.62**	**1.7**	**0.63**	**1.7**
Total phosphorus (mg/L)	<0.02	0.02	**0.023**	**0.031**	**0.18**	**0.052**	**0.13**
N:P ratio	N/A	41	55	34	66	20	80
NH_4 (mg/L)	<0.013	0.0098	0.011	0.009	**0.16**	**0.028**	**0.19**
NOx (mg/L)	<0.015	**0.034**	**0.037**	**0.018**	**0.87**	**0.077**	**0.71**
Physio-chemical							
Temperature (°C)	N/A	21.4	25.8	22.7	25.4	19.5	24.2
Turbidity (NTU)	N/A	2.3	9.4	3.0	10	7.3	59
pH	6.5–7.5	**8**	**8.9**	**7.8**	**8.1**	7.4	**8.2**
DO (mg/L)	8.2–10 @ 20°C	9.6	**12**	9.9	**12.7**	8.7	**12**
Conductivity (µS/cm)	30–350	140	150	200	340	295	**490**
Suspended solids (mg/L)	N/A	-	-	5.4	15	7.3	37
Microbiological							
Faecal coliforms (cfu/100mL)*	150	1	58	8	8	**365**	**14,000**
Algae							
Chlorophyll (µg/L)	N/A	4.5	15	6.7	16	7.5	22
Total algae (cells/mL)*	15,000–20,000	7,500	**260,000**	NA	NA	1,200	14,000
Cyanobacteria (cells/mL)*	15,000–20,000	1,700	**260,000**	NA	NA	77	320

** Primary contact.*

*** The 75th percentile calculation is adopted as a matter of course by Ecowise in its professional water quality assessments, for comparison with ANZECC (2000) trigger values.*

Impacts from other discharges along Queanbeyan and Molongolo Rivers

Wastewater from Queanbeyan and Canberra is treated at existing sewage treatment facilities that discharge into the Molongolo River downstream of the intersection of the Queanbeyan and Molongolo Rivers. These are the Lower Molongolo Water Quality Control Centre (operating downstream of Canberra) and the Queanbeyan Sewage Treatment Plant.

Annual ACT Water Reports (DECCW, 2009) provide an analysis of water quality along the Queanbeyan River and Molongolo River system. The most relevant sites to the Project are on the Queanbeyan River at the ACT border (Site 769, shown on Figure 7.3) and on the Molongolo River at Dairy Flat Bridge (Site 601, about 7km downstream from Site 769). Land uses along the rivers between Site 769 and 601 include Queanbeyan Sewage Treatment Plant, Queanbeyan town centre, Molongolo George Recreation Reserve and Canberra International Airport. Water quality data for 2008-09, and long term averages for these sites, is presented in Table 7.3 below. This indicates the impact upon this river system of existing sewage discharges and other land uses downstream of the Googong township.

Table 7.3 Water quality in the Queanbeyan and Molongolo River system

Parameter	Queanbeyan River at ACT Border		Molongolo River at Dairy Flat Bridge	
	2008-2009	Long term average	2008-2009	Long term average
Total Nitrogen (mg/L)	0.41	0.53	4.00	1.47
Total Phosphorus (mg/L)	0.03	0.04	0.05	0.10
Conductivity (µS/cm)	310.00	216.21	493.33	247.50

7.2.3 Summary of ambient surface water quality in Queanbeyan River

The ambient surface water quality in the Queanbeyan River is already mostly above the ANZECC guideline trigger values for total nitrogen (by a factor of at least two) and total phosphorus (by a factor of at least 1.5). Cyanobacterial blooms, exceeding the guidelines (ANZECC, 2000) for recreational water were recorded at the Googong Dam site upstream of the proposed discharge point during the summer of 2002–3 (December 2002 and January 2003) and again in December 2003. Cyanobacterial blooms are a response to elevated summer temperatures and nutrient enrichment (mainly phosphorus) and are often exacerbated by low flows or stagnant water conditions.

Therefore, the ambient surface water quality is already at times higher than ANZECC (2000) guideline values for upland rivers. With the proposed discharge of recycled water being primarily in months where there is high flow and dilution in the river, it is anticipated that the surface water quality would not materially impact ambient values recorded during the preliminary assessment. Predicted impacts of the change in flow regimes and change in water quality is provided in the following sections.

7.3 Monitoring of water quality

A monitoring program would be conducted during pre-construction, construction, commissioning and operation to ensure that ambient water quality is maintained, or improved. This would include water quality monitoring downstream of where Googong Creek meets the Queanbeyan River at a new monitoring location shown in Figure 7.3. Monitoring would commence about 12 months prior to the construction phase and continue throughout the life of the project.

Monitoring of water quality would follow the adaptive management process outlined in Section 6.3.

7.4 Construction impacts and mitigation measures

Relevant impacts that may influence water quality, from a whole-of-catchment perspective, are related to pollution of surface water and changes to existing flow regimes. No direct impacts are anticipated on drinking water supplies as a result of the construction of the Project, as all works would be outside the Googong Reservoir catchment.

The creeks within the study area are ephemeral and, as a result, the potential for surface water pollution is only applicable to watercourses that are experiencing water flow at the time of construction.

Construction activities that may affect surface water quality include:

- Laying of pipelines across or near watercourses.
- Vegetation clearance and soil disturbance.
- Accidental spills of fuels and chemicals.

The potential impacts discussed below should be considered in relation to the nature and staging of the construction of the Project, as well as in the context of the disturbed existing environment of the study area and the approved rezoning of the land.

7.4.1 Laying pipelines across or near water courses

Activities associated with the laying of pipelines that could result in impacts on water and hydrology include trenching, vegetation clearing and stockpiling of excavated material. These activities are listed in detail in Section 5.5.2.

These construction activities have the potential to impact on water quality by:

- Transferring increased quantities of fine sediment to receiving streams. This could have the following impacts:
  - Interference with the gill function in fish and filter-feeding organisms.
  - A reduction in the euphotic zone (the is the uppermost layer of a body of water and receives sufficient light for photosynthesis and the growth of green plants) and retardation of aquatic plant function.
  - Increased turbidity, which interferes with visual feeding.
  - Siltation, reduction in stream habitat and removal of water sources for riparian fauna.
  - Increased nutrient loads, which causes algal blooms.
- Polluting streams with fuel or chemicals used in construction.

7.4.2 Vegetation clearance and soil disturbance

Changes in waterway channel or bank form may result from loss of riparian vegetation and lead to increased erosion potential or geomorphologic impacts. This would be particularly evident in areas of good, intact native riparian vegetation. The extent of erosion and sedimentation is dependent on bank and streambed material, flow velocity and existing vegetation, as well as the proximity of construction activities to waterways.

7.4.3 Accidental spills of fuels and chemicals

Accidental spills of fuels, oils and/or construction materials (eg concrete) can affect aquatic flora and fauna if the spills reach water bodies via runoff. Depending on the severity of the spill, these have the potential to have acute effects or longer-term, chronic effects on aquatic environments.

7.4.4 Mitigation and management measures

During construction, the following mitigation and management measures would be implemented to maintain surface water quality:

- Bank restoration techniques would be adopted where practicable. Techniques include:
  - Stabilising (where required) by establishing rocks, sandbags, and/or matting to prevent scouring. These would be placed to conform as far as possible with existing contours.
  - Re-spreading topsoil over the area from where it was removed.
  - Installing matting that is infused with seedlings in order to keep the soils stable while it settles.
- Soil and water management plans would be implemented for the construction phase via a construction environmental management plan (CEMP). It would be prepared in accordance with *Managing Urban Stormwater: Soils and Construction* (NSW Government, 2004), also referred to as The Blue Book. It would include measures for:
  - Diverting ‘clean’ surface runoff around and away from working areas to prevent erosion.
  - Directing ‘dirty’ runoff from work areas into sediment control devices (such as geotextile sediment fences, gravel socks or geologs), installed downhill of disturbed areas, particularly near watercourses and around stockpiles.
  - Appropriately containing water pumped from trenches, and disposing it through sediment socks or settlement control devices to allow sediment to settle out prior to discharge to the environment.
  - Discharging trench water to stable ground, away from the streambed.
- A spill response procedure would be developed in the CEMP. This would address fuels, lubricants and other chemicals. It would include design of bunded areas, and staff training processes. The spill response procedure would include directives to:
  - Locate spill response equipment at each work site.
  - Undertake maintenance or refuelling of mobile equipment and vehicles no closer than 150 metres from any surface water body.
  - Locate storage sites away from the vicinity of any waterway.

7.5 Operational impacts and mitigation measures

The potential operational impacts assessed in this section should be considered in the context of the approved rezoning of the site to create the Googong township and the strategic objectives of the Project. It is also important to note the staging and gradual development of the township, which allows an adaptive management process to be implemented following the collection and interpretation of data.

7.5.1 Uses of recycled water

The proposed uses of recycled water at Googong include:

- Irrigation of public spaces, such as sporting fields, recreational areas and streetscapes.
- Watering of household gardens.
- Non-potable uses within the household, such as toilet flushing and clothes washing.
- Discharge of excess recycled water through the stormwater management system.

It is important to note the integrated nature of water management proposed at Googong. For example, household garden watering would use a combination of recycled water and rainwater, stored in tanks at each property.

The impacts of recycled water use and its application to soils are assessed in detail in Chapter 9.

Water balance and modelling for the Googong township was carried out by MWH (2009) and Brown Consulting (2008), which is included at Appendix C. This assesses both the quality (nutrient loads/concentration) and quantity (predicted flows) of water to be released from the water recycling plant and the predicted impact that this would have on the environment.

7.5.2 Wet weather effluent storage and overflows

Wet weather storage and overflows are described in the Concept Design Report (Appendix B).

Wet weather storage and overflow frequencies have been designed in accordance with the relevant guidelines (Water Services Association (WSA) 02 Sewerage Code and WSA 05 2005 Sewage Pumping Station Code). Emergency storage volumes are calculated at four hours at peak dry weather flow (PDWF). For the sewage pumping stations (SPS) for Stage 1 of the Project, for example, the emergency wet well storage volumes are 655m^3 and 560m^3 for SPS1 and 2 respectively. The WSA 02 Code has also been used as the basis for overflow frequencies, with the sewerage system being designed to a three-month average recurrence interval containment standard.

Furthermore, the bioreactors within the water recycling plant have been sized to accommodate and treat all wet weather flows and emergency flows to WSA 02 standards. This factor, in combination with a reduced infiltration sewerage system (discussed below), makes this water cycle system lower impact compared to many existing systems, which bypass wet weather flows at some point to the environment. These design criteria have allowed for potential wet weather overflow risks to be addressed at multiple points in the system.

Dry weather overflows

In terms of dry weather overflows, the concept design has assumed the installation of a conventional gravity sewerage system, with a moderate leakage (infiltration) rate based on WSA 02-2002-2.2 guidelines. It has been recommended by MWH that CIC and Queanbeyan City Council consider the use of a reduced infiltration sewerage system in the detailed design of the system, which would reduce infiltration of sewage into the environment compared to more conventional systems. It should be noted that discussions to date with CIC and Queanbeyan City Council have supported the installation of reduced infiltration sewerage systems.

7.5.3 Impacts on surface water quality

To estimate the impact of the overall Project (and Stage 1 of the Project) on receiving water quality, the output from a series of MUSIC models (software used to model urban stormwater) was analysed to estimate the change in pollutant loads for total nitrogen, total phosphorus and total suspended solids that would occur as a result of the Googong township. This was achieved by:

- Running a MUSIC model to estimate the pollutant load contribution from existing land uses.
- Running a series of MUSIC models (for different scenarios and stages of development) to estimate the pollutant loads resulting from the Googong township as a whole.
- Comparing the results of the above two steps to determine the likely change in pollutant loads.
- Estimating the impact of the change in pollutant loads on the historical water quality (based on data obtained for the Wickerslack Lane site immediately downstream from the development) using a simple mass balance.

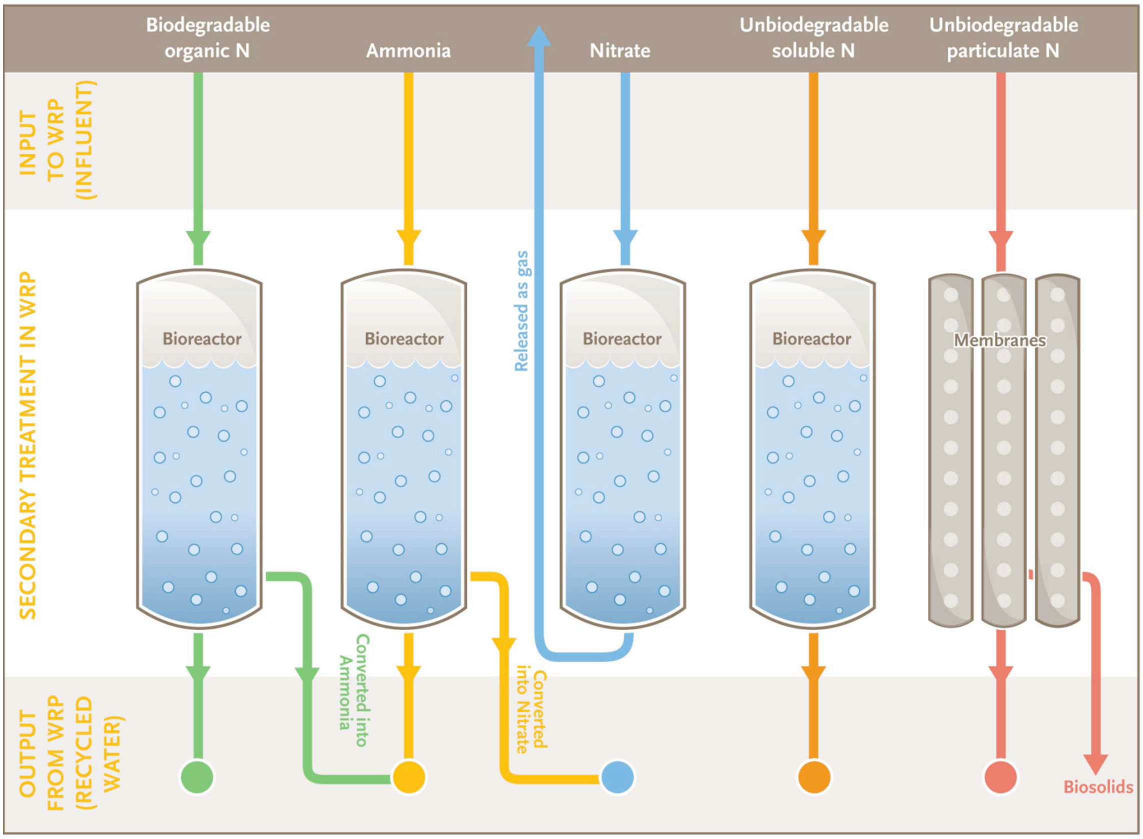
The modelling considers the periodic discharge of recycled water and the impact of the rainwater harvesting and water-sensitive urban design (WSUD) measures to be employed in the new development area. Water quality estimates were prepared at the confluence of the Googong Creek with the Queanbeyan River. Recycled water quality parameters are those given in Table 5.3, with the main parameters of concern being total nitrogen, total phosphorus, total suspended solids and total dissolved solids (salt).

Total nitrogen

Total nitrogen is made up of several main components, as shown in Figure 7.4. The treatment process in the water recycling plant treats each of these different forms of nitrogen in the flowing ways:

- High levels of ammonia from the influent are converted to nitrate in the bioreactor.
- Nitrate, created from oxidation of ammonia in the bioreactor, is released as nitrogen gas to the atmosphere.
- Biodegradable organic nitrogen is converted to mostly ammonia in the bioreactor.
- The insoluble fraction of unbiodegradable organic nitrogen is retained by the membranes and leaves the system as biosolids (which can then be used as fertiliser).
- The soluble fraction of unbiodegradable organic nitrogen is unable to be treated, so it passes through the water recycling plant and into the recycled water. As the Project is a closed loop system (where a portion of the recycled water is returned to the water recycling plant through each cycle), this fraction gradually builds up over time. Models indicate that this fraction would be recycled and reach equilibrium at about 3mg-N/L (milligrams of nitrogen per litre). It is important to note that, being non-biodegradable, it would not affect downstream aquatic flora and fauna, as it is unable to be used by species.

Figure 7.4 Secondary treatment of nitrogen in the water recycling plant



Balance between total phosphorus and total dissolved solids

To reduce the salt load in effluent as far as practicable, the proposed biological phosphorus removal process would minimise the use of salts (particularly sodium and/or chloride) in the sewage treatment process. The average total phosphorus is expected to be 0.2mg/L. The average total dissolved solids value is expected to be 650mg/L, with an 80th percentile of 680mg/L.

Results of water quality modelling

Water quality has been modelled at three locations: Googong Creek (upstream at Googong Dam Road), Googong Creek (downstream before the confluence with Queanbeyan River) and Queanbeyan River (Wickerslack Lane).

Table 7.4 (adapted from Appendix C) details the results of the MUSIC modelling for both Googong Creek locations. The scenarios shown in the table are:

- The existing pollutant load, which can be considered as the undeveloped case.
- The expected pollutant load of development without the implementation of water-sensitive urban design measures.
- The expected pollutant load of the proposed development, which is development with water-sensitive urban design and the integrated water cycle (including excess recycled water discharge).

The water sensitive urban design measures proposed for the Googong township as part of the stormwater management strategy would be effective in reducing annual pollutant loads before being released into the Googong Creek. This data indicates that as a result of implementing this stormwater strategy, total suspended solids and gross pollutant loads would be lower following development of the township than they currently are, both at Googong Dam Road and at the confluence of Queanbeyan River.

Table 7.4 also shows that:

- There would be a slight increase in total nitrogen and total phosphorus loads compared with the existing situation, but the water-sensitive urban design measures would be effective in reducing these loads.
- The increases in loads would be consistent with, and exceed, the stormwater management objectives in Section 5.4.

Table 7.4 Impact of development on receiving water quality (adapted from Appendix C)

Water quality parameter	Existing environment (modelled)	Development without WSUD	Development with WSUD and integrated water cycle
Googong Creek (at Googong Dam Road)			
TSS (kg/year)	37,800	171,000	9,500
TP (kg/year)	43	150	71
TN (kg/year)	738	2,030	897
Gross pollutants (kg/year)	1,950	24,800	0
Annual flow (ML/year)	179	680	908
Googong Creek (at confluence with Queanbeyan River)			
TSS (kg/year)	64,300	202,000	41,100
TP (kg/year)	72	184	105
TN (kg/year)	1,193	2,580	1,640
Gross pollutants (kg/year)	4,750	29,200	4,390
Annual flow (ML/year)	329	851	1,080

It has been noted that there are slight differences between annual flows (at Googong Dam Road) in this table, and those in Figure 7.5 (ultimate development), resulting from inherent differences between the two models used.

Table 7.5 details the theoretical water quality modelling carried out for the Queanbeyan river, using the daily MUSIC modelling results (inclusive of recycled water discharge), mass balances (combined Googong Creek, Montgomery Creek and Queanbeyan River) and daily water quality monitoring results (when available).

Several significant assumptions are associated with this theoretical assessment. These include:

- The limited water quality data available for the Wickerslack Lane Site, with between 19 and 24 measurements taken of each of the modelled parameters between 2000 and 2006.
- The MUSIC models are not calibrated to receiving water conditions.
- The assessment does not allow for in-stream processes (physical, biological and chemical) in the Queanbeyan River and Googong Creek.
- Complete mixing occurs.

Despite the assumptions, the results provide the available baseline for consideration. The modelling results shown in Table 7.5 indicate that the water quality of total nitrogen (80th percentile) would meet ambient water quality for NH1A and exceed ambient by about 0.1mg/L at ultimate development. For total phosphorus, ambient quality is 0.03 mg/L, would be exceeded by 0.01mg/L for NH1A, and 0.02mg/L for full development. The ANZECC guidelines have been provided in this table, however are not used as a baseline due to the preference for using ambient water quality as a base reference (see Section 7.1.2).

Overall, the theoretical water quality results indicate the proposed development results in similar nutrient levels compared to ambient conditions in the Queanbeyan River.

Table 7.5 Theoretical total nitrogen and total phosphorus concentrations in the Queanbeyan River (at Wickerslack Lane)

Data source	Statistic	Water quality parameter		
		TN (mg/L)	TP (mg/L)	TN:TP ratio
ANZECC guideline (trigger value)	N/A	0.25	0.02	-
Number of samples	N/A	24	23	23
Ambient water quality	80th percentile	0.7	0.03	35.2
Ambient water quality	Max	1.7	0.18	66.0
Theoretical NH1A development	80th percentile	0.7	0.04	34.1
Theoretical NH1A development	Max	2.6	0.17	65.0
Theoretical ultimate development	80th percentile	0.8	0.05	31.4
Theoretical ultimate development	Max	1.3	0.14	55.2

Assessing impacts of total dissolved solids (salt)

Additional modelling has been carried out to estimate the salinity impacts on surface water quality. The level of total dissolved solids in recycled water at an 80th percentile is 680mg/L. Modelling was undertaken by Brown Consulting (Appendix N) and takes into account all proposed water-sensitive urban design treatments and integrated water cycle parameters.

To assess the results against ANZECC (2000) guidelines and the ambient water quality, the total dissolved solids values (in milligrams per litre (mg/L)) were converted to electrical conductivity (µS/cm) by dividing by an empirical factor of 725 (which lies in the middle of the recommended range of 550–900) to get dS/m, then multiplying by 1000 to get µS/cm (DEC 2004). Table 7.6 shows predicted the conductivity water quality estimates at Googong Dam Road.

Table 7.6 Predicted electrical conductivity values at Googong Dam Road.

TDS concentration of effluent at WRP (80th %ile) (mg/L)	ANZECC guideline (µS/cm)	Ambient water quality (80th %ile) (µS/cm)	Average (µS/cm)	Summer average (µS/cm)	Autumn average (µS/cm)	Winter average (µS/cm)	Spring average (µS/cm)
680	30–350	205	323	214	351	396	304

The ANZECC (2000) guideline for conductivity of slightly disturbed ecosystems in south-east Australia (upland rivers) is in the range of 30–350µS/cm (refer to Table 7.1), with the ambient water quality being 205µS/cm. Therefore, the above conductivity concentrations indicate that, during the different seasons of the year, the discharge of excess recycled water into the stormwater system is likely to result in concentrations that are within this guideline and above ambient water quality.

It is important to note that the above concentrations are for flows upstream at the Googong Creek (Googong Dam Road). It is not possible to model further downstream Googong Creek, or the Queanbeyan River for total dissolved solids, as this falls outside the capability of the MUSIC model. Therefore, it must be taken into consideration that total dissolved solids levels would be further diluted prior to entering Queanbeyan River as flows from the downstream and undeveloped areas of the Googong Creek catchment mix with the flows from the Googong township. Further dilution would also occur when these flows enter Queanbeyan River. Hence, while total dissolved solids concentrations would at times exceed the ambient water quality at Googong Dam Road, the flows entering Queanbeyan River would be unlikely to do so due to this dilution effect.

As the recycled water system and stormwater system are dynamic and interrelated, there would be some fluctuation on a daily, monthly, seasonal and annual basis. In the early years of the township, when total recycled water discharges are very low, these fluctuations would be measured over these time periods, so that a better understanding of the system could be gained. From this, further management of flows can be carried out across seasons to ensure that dilution is maximised.

Therefore, the potential impacts as a result of the levels of discharge of total dissolved solids are unlikely to be significant. Consequential impacts to aquatic ecology as a result of changed nutrient levels (including higher total dissolved solids levels) and flows are discussed in Section 11.2. The potential impact of increased salt levels on the soil profile, and groundwater system is addressed in chapters 9 and 10, respectively.

Chlorine residual

As chlorine would be added to the recycled water at the water recycling plant, there would be a level of residual chlorine within the excess recycled water discharged into the stormwater system. As the water would have travelled some distance between the chlorine dosing location and the discharge point, the level of chlorine at the discharge point would have been reduced. Given that excess recycled water within the stormwater system would be further diluted and chlorine would continue to dissipate through the stormwater management processes, potential impacts are expected to be negligible.

7.5.4 Impacts on surface water quantity (flows)

Table 7.7 provides a summary of the likely flows resulting from the township (including discharge of excess recycled water to the environment as well as stormwater flows) in Stage 1 of the Project (NH1A) and at ultimate development. The table also shows that at ultimate development about 38 per cent of recycled water discharge would not be re-used within the township.

Table 7.7 Summary of excess recycled water discharge (flows) from NH1A and ultimate development

Water cycle component	Minimum (kL/d)	Maximum (kL/d)	Average (kL/d)	Recycled water discharge (% of total recycled water produced from the WRP)
Recycled water discharge – NH1A	0	1,245	227	35
Recycled water discharge – Ultimate	0	5,950	1,183	38

Seasonal variations of flows in Googong Creek

Table 7.8 shows the predicted changes to flow in the Googong Creek at the confluence with the Queanbeyan River at the completion of Stage 1 of the Project and at ultimate development. All flows are based on rainfall data at Queanbeyan Bowling Club (1967-2007) and MUSIC model scenarios for the existing case and the developed case (with water sensitive urban design) (refer to Appendix C). The model used is likely to show an overestimate of flows, as it does not take into account local farm dams. The minimum flow data for all cases and seasons indicates that the creek would remain dry for some periods throughout the year, meaning that the ephemeral nature of the creek would be maintained.

The main impact to the existing flow of the Googong Creek would be increased seasonal variation, demonstrated by a large variation between 50th and 80th percentiles at the completion of Stage 1. The 50th percentile figures show that there would be an overall decrease in flows during summer and autumn in Stage 1 of the Project, due to a high level of recycled water/stormwater re-use across the development for irrigation. The creeks would remain mostly dry in summer. The increase in flow of Googong Creek would be largest during winter and spring, when lower recycled water requirements would result in increased volumes being discharged.

The 80th percentiles indicate a large amount of variability, a direct impact of high rainfall variability among the highest 20 per cent of data recorded. For the completion of Stage 1 there would be about a two fold increase in the flows (at 80th percentile). The main impact of increased flow on water quality would be higher turbidity levels and higher levels of mixing throughout the water profile increasing levels of dissolved oxygen. Potential impacts of higher flows and flow variability on aquatic ecology are covered in Section 11.2.

Table 7.8 50th and 80th percentile seasonal flows (including stormwater and recycled water) in the Googong Creek at the confluence with the Queanbeyan River

Stage	Summer (kL/day)	Autumn (kL/day)	Winter (kL/day)	Spring (kL/day)
Existing creek flow (50th percentile)	14.46	15.55	28.51	32.83
Existing creek flow (80th percentile)	174.53	185.76	463.10	492.48
Creek flow at completion of Stage 1 of the Project (50th percentile)	0	6.05	38.88	18.14
Creek flow at completion of Stage 1 of the Project (80th percentile)	0.7	279.93	705.02	895.97

Flows in the Queanbeyan River

Table 7.9 shows a comparison of the existing flows in the Queanbeyan River (at the Wickerslack Lane site) with the expected flows at the completion of Stage 1 of the Project at Googong Creek at the confluence of Queanbeyan River (Figure 7.3). This gives a perspective on the proportion of flows from the Googong Creek at both the existing case and at the completion of Stage 1 of the Project. This indicates that the proportion of flows from the township, on average, represents a very small percentage of the total flows in the Queanbeyan River.

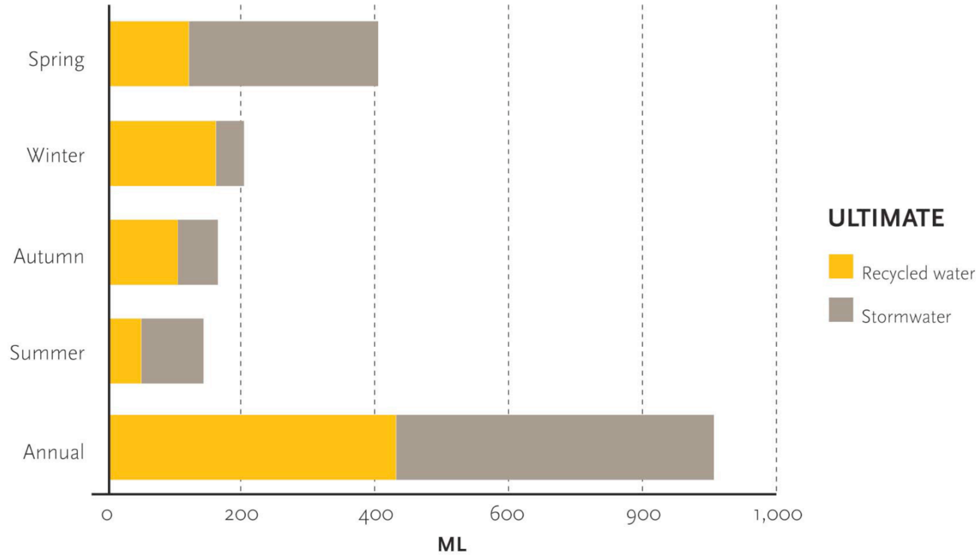
Table 7.9 Comparison of flows in the Queanbeyan River, pre- and post-development

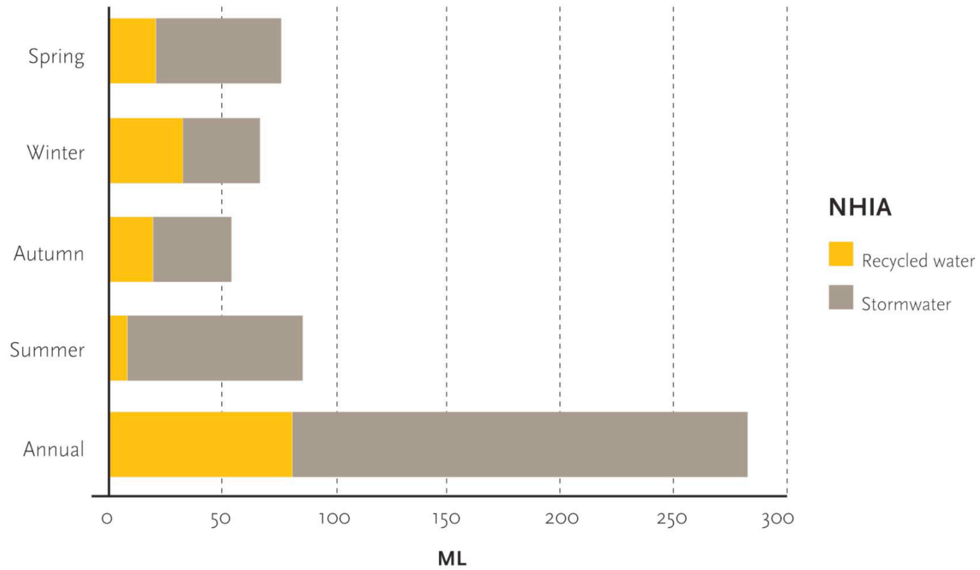
Site	Typical range of 50th %ile (kL/day)
Queanbeyan River (Wickerslack Lane monitoring site)	4,700–15,900
Modelled estimate of Googong Creek flows - existing	15–33
Modelled estimate of Googong Creek flows - at the completion of Stage 1 of the Project	0–39

Source: Adapted from Ecowise (2008)

Figure 7.5 shows how the proportion of recycled water in the stormwater system varies throughout the year. The stormwater management system includes basins, bio-retention ponds and other water-sensitive urban design measures that work together to regulate flows and treat stormwater, prior to flows leaving the site. In the case of the discharge of excess recycled water to the environment, this includes a series of measures including a large pond immediately south of Googong Dam Road.

Figure 7.5 Recycled water discharge as a proportion of total flows in the stormwater system.





Impact of hydrology on water quality

The increased flow and variation of flow (likely to be enhanced in winter and spring) would potentially modify the nature of the creek, largely in terms of movement of pebbles and rocks. Enhanced sediment transport would increase overall turbidity levels and mixing within the water profile. The creek banks and gullies would be subject to increased erosion risk. As a mitigating measure, stream bank vulnerability would be monitored, with stabilisation management measures being required. Impacts of changes to hydrology on aquatic flora and fauna are covered in Section 11.2.

It is difficult to make a detailed assessment of the hydrological impacts on Queanbeyan River due to the limited availability of data. On average, the daily discharge possible to the Queanbeyan River at ultimate Project development would be 1.18kL/day (see Table 7.7). Given the similarity of the water quality of discharge to ambient quality of the Queanbeyan River (see Table 7.4), these flows could be considered as environmental flows able to replace the planned releases from the Googong Dam for this purpose.

Effect of rainwater tanks

There is an inherent trade-off between the adoption of rainwater tanks and the volume of discharges of excess recycled water to the environment (refer to Appendix C). That is, the maximum and average recycled water discharge would be higher for NH1A and the ultimate development with rainwater tanks than the same scenarios without rainwater tanks. This trade-off is acknowledged and further considered in the assessment of soil and groundwater impacts resulting from recycled water application on land.

7.5.5 Disinfection systems

The recycled water would be treated via an inline disinfection system prior to release from the water recycling plant. This would involve ultraviolet (UV) irradiation of the recycled water stream within the disinfection building on the water recycling plant site. The recycled water would then enter a chlorination tank that would provide residual disinfection and prevent regrowth of micro-organisms within recycled water pipelines. The operation of the disinfection system would not pose any significant environmental risk given its containment within the water recycling plant site.

7.5.6 Operational mitigation and management measures

Mitigation and management measures would focus on continuously improving the quality of recycled water discharged into the existing environment, and minimising the quantity of discharge through the employment of an integrated recycled water management system.

An irrigation strategy for the township would be developed to document the application of recycled water and interactions with natural rainfall on soils and stormwater. This strategy would be progressively developed as part of the development applications for subsequent land subdivisions provided to Queanbeyan City Council under Part 4 of the EP&A Act and would outline any implementation of buffer zones.

The results of water balance modelling (MWH, 2009) clearly show that there are trade-offs in the management of the water cycle throughout the site. The use of rainwater tanks would reduce stormwater discharges and also increase the total volume of potable water saved, but they would also increase the recycled water discharge volumes.

The potential for increased salinity and sodicity relates to additional levels of total dissolved solids that would be applied to the land through the reuse of recycled water. Modelling to assess this impact was carried out by Agsol (2009) (see Appendix D). The results, management and mitigation measures, as they directly relate to the impact of increased total dissolved solids on the land, are addressed in Chapters 9 and 10, respectively.

In addition, Section 9.4.1 presents general mitigation and management measures in relation to soils that would be implemented during operation.

7.6 Conclusion

The key conclusions from this assessment are that:

- There would be some inevitable changes to the water quality and flows of watercourses as a result of the Project. This is due largely to the decision to discharge within the boundaries of the Googong township, to ephemeral creek lines, where water-sensitive urban design can be used to provide further environmental management before later discharge of residual volumes eventually to the Queanbeyan River.
- The Project would be likely to result in water quality with similar nutrient levels and lower suspended solids levels than the ambient conditions in the Queanbeyan River. As such, the discharges from the Project could be considered as environmental flows.
- The proposed discharge management strategy within the site, and including water-sensitive urban design elements and retention within the basin at Googong Dam Road, would effectively manage risk from salt. The concentration of salt in the basin adjacent to Googong Dam Road would remain within the upper limits of ANZECC guidelines.
- Water quality parameters would be managed and maintained via continued monitoring on the Queanbeyan River and in the retention basin at Googong Dam Road, as well as by regulated licence controls placed on the discharge quality of water being produced from the water recycling plant under the *Protection of the Environment Operations Act 1997*.
- Mitigation and management measures are reinforced in the statement of commitments (WQ1–WQ5) in Chapter 18.