4 Consideration of project alternatives

This chapter should be read in the context of the strategic need for the Project, discussed in Chapter 2. This chapter:

- Sets out the alternative water and wastewater systems that were considered for the Googong township.
- Establishes why a self-contained integrated water cycle, as proposed, is the only feasible alternative, given the Project objectives.
- Summarises the environmental costs and benefits of an integrated water cycle system versus a traditional system. It highlights the superior environmental outcomes that can be achieved by an integrated system incorporating the use of recycled effluent.
- Presents the integrated water cycle scenarios that were assessed and identifies the preferred scenario.
- Discusses the options assessed for the key elements of the system, including alternative wastewater treatment processes, excess recycled water discharge management and service water reservoirs.

4.1 Alternative water and wastewater systems for consideration

Two broad conceptual designs were considered for delivering water and wastewater services at the Googong township – the traditional model and the integrated water cycle model.

4.1.1 The traditional model

Traditionally, water and wastewater services have been provided as separate systems:

- The potable water system provides water for all domestic and commercial uses (possibly supplemented by rainwater tanks).
- Water used within the home, or other commercial or community premises, is then collected by the sewerage system. The sewage flows, via gravity mains and rising mains supported by sewage pumping stations, to a sewage treatment plant. The sewage treatment plant treats the wastewater to a standard deemed acceptable for discharge to the environment. Generally, discharge takes place to a stream, river or ocean.

Most systems of this kind produce treated sewage discharge with nutrients and other pollutants well above the ambient water quality into which they discharge. It is also historically the case that sewage collection systems are designed, and made from materials, that create significant infiltration into the system in wet weather events and possible exfiltration from the system. For this reason many traditional sewage treatment plants need to make special arrangements to discharge 'wet weather flows' directly into the environment as the plant size cannot treat the full wet weather inflow.

The water and wastewater system currently in operation at Queanbeyan is a traditional system with all of these characteristics.

4.1.2 The integrated water cycle model

An integrated water cycle seeks to meet the demand for different water needs by accessing all available water types in the system. In this way, effluent discharge and rainwater are considered to be valuable water sources for end uses that do not require potable water. In urban environments the benefit of this approach can be twofold:

- Potable water is only used for necessary end uses, which creates savings.
- Effluent discharge to the environment is reduced through recycling.

If balanced correctly, an integrated water cycle can create water savings and minimise environmental impacts typically associated with traditional systems.

4.1.3 Comparison of the two models

CIC assessed the traditional model and integrated water cycle model against the Project objectives and weighed up the environmental costs and benefits of each approach. Tables 4.1 and 4.2 summarise the qualitative outcomes of this assessment. It is assumed that the traditional model would be delivered by connection to the existing Queanbeyan sewage treatment plant at Mountain Street, Queanbeyan. It is also assumed that the integrated water cycle model includes re-using effluent in a self-contained system.

As a result of the assessments documented in Tables 4.1 and 4.2, it was concluded that an integrated water cycle management system would:

- Be the only concept able to meet key requirements for water savings.
- Meet other key project objectives.
- Produce the best net environmental outcome.

Section 4.2 discusses in detail the alternative integrated water cycle management scenarios assessed by CIC to service the Googong township.

Table 4.1 Assessment of a traditional system and an integrated water cycle against the Project objectives

Project objective	Does a traditional system meet the objective?	Does an integrated water cycle meet the objective?
Deliver essential water and wastewater services to Googong township residents.	Yes.	Yes.
Deliver water conservation outcomes targeting 70% savings.	No – a recycled water supply is required in an urban environment to meet this level of saving.	Yes – in the closed system investigated, savings have been estimated at >60%.
Ecologically Sustainable Development – minimise impacts on the local environment especially in relation to wastewater discharge.	No – the existing discharge quality from Queanbeyan sewage treatment plant is substantially lower than contemporary systems. No – the pipeline connection to Queanbeyan sewerage system would entail significant environmental impacts, including impacts on endangered ecological communities (White Box Yellow Box Blakely's Red Gum Woodland).	Yes – the recycled water scheme would greatly reduce the potential discharge to Queanbeyan River. Yes – a modern water recycling plant would produce excellent water quality outcomes when compared to older, traditional sewage treatment plants.
Produce effluent quality capable for reuse in the urban environment.	No – treatment processes at Queanbeyan sewage treatment plant are unable to meet urban recycled water quality standards.	Yes – the modern water recycling plant at the core of the integrated water cycle management system would produce effluent capable of reuse.
Protect the water quality of Googong Dam.	Yes.	Yes – there would be no construction works, discharge or recycled water application within the Googong Dam catchment area.
Gain endorsement from important stakeholders.	No – the DoP requires that water savings in the system for Googong township target 70% (this requirement is tied to rezoning for Googong township).	Yes – the system meets the needs of the DoP set out as part of the rezoning process for Googong township.
Economic feasibility.	No – the connection to Queanbeyan sewage treatment plant would be about 14km and includes difficult topography and augmentation through urban environment.	Yes – the system can be accommodated within the total Googong township budget.

Table 4.2 Analysis of the environmental costs and benefits of a traditional system and an integrated water cycle

Environmental factor	Traditional system	Integrated water cycle
Water quality and hydrology.	**Moderate/high cost** to the Molonglo River receiving environment due to the increased discharge from the Queanbeyan sewage treatment plant.	**Low cost** due to the reduced discharge volumes and management processes for discharge within the Googong township.
Human health.	**No cost/benefit** – the system would be managed to NSW Health guidelines.	**No cost/benefit** – the system would be managed to NSW Health guidelines.
Soils and groundwater.	**Low cost** – soils and groundwater would be exposed to uncontrolled periods of exfiltration from the sewerage system.	**Low cost** – the recycled water would be of a high quality to prevent negative long-term impacts from domestic and other irrigation into the Googong township environment.
Terrestrial ecology.	**High cost** – connecting the pipeline to the Queanbeyan sewage treatment plant would require significant clearing of habitat for endangered species and communities.	**Low cost** – construction would be within the Googong township boundaries.
Aquatic ecology.	**Moderate/high cost** – a traditional system would result in increased discharge of low quality water to the Molonglo River system.	**Low cost** – due to the reduced discharge volumes, high water quality and management processes for discharge within the Googong township; these would reduce impacts on the Queanbeyan River.
Resource conservation.	**No cost/benefit.**	**Moderate/high benefit** – the integrated water cycle management system would allow for a recycled water scheme, which would conserve potable water supplies.
Heritage.	**No cost/benefit.**	**No cost/benefit.**
Human amenity – noise, light, air, traffic, visual.	**No cost/benefit** – the existing Queanbeyan sewage treatment plant is well buffered from the surrounding community.	**Low cost** – the small footprint and compact design of the plant would allow for simple and effective screening through basic landscape measures..

4.2 Alternative integrated water cycle management scenarios – achieving potable water savings

4.2.1 How the alternative scenarios were identified

Eight complete water cycle management solutions for the Googong township were considered with the assistance of MWH Australia (consulting water infrastructure engineers). For each scenario, a simple water balance was undertaken to demonstrate the potential potable water savings that could be achieved. A base case scenario was identified that utilises commonly accepted design practices for new development. Additional scenarios were then assembled that incorporate various water sustainability measures.

4.2.2 Sustainability criteria used to assess the scenarios

Sustainability criteria were developed to enable the scenarios to be scored against environmental, social and economic outcomes to allow for a more holistic approach and to reflect key environmental, social and economic focus areas in the requirements of urban infrastructure. The sustainability criteria are listed in Table 4.3

Table 4.3 Sustainability criteria for comparing the water cycle management scenarios (MWH, 2006)

Environmental outcomes	Social outcomes	Economic outcomes
• Reduce surface water extractions. • Reduce energy use/greenhouse gases. • Protect aquatic ecosystems.	• Reliability/maturity of technology. • Protect public health. • Community acceptance.	• Low capital cost. • Low operating and maintenance costs for operating authority. • Low operating and maintenance costs for residents.

This approach allowed each scenario to be scored in terms of these environmental, social and economic outcomes. The scores were weighted at a ratio of 2:1:1 and combined to give a total weighted score, which is expressed as a percentage, as shown in Table 4.4 (the weighted sustainability score).

Table 4.4 Water cycle management scenarios (adapted from MWH, 2006)

Scenario		Meets system objectives*			Weighted sustain-ability score	Capital cost estimate ($M)
		1	2	3		
1	Conventional development	No	No	Yes	48%	120.8
2a	Mandated fixtures and landscaping	No	Yes	Yes	59%	123.4
2b	Mandated fixtures, appliances and landscaping	No	Yes	Yes	62%	123.4
3	Water efficient development with rainwater use	No	Yes	Yes	64%	140.2
4	Water efficient development with recycled effluent use	Yes	Yes	Yes	64%	135.7
5a	Water efficient development, rainwater, limited recycled effluent use	No	Yes	Yes	65%	145.3
5b	Water efficient development, rainwater tanks plus recycled effluent	Yes	Yes	Yes	69%	152.7

Scenario		Meets system objectives*			Weighted sustain-ability score	Capital cost estimate ($M)
6a	Water efficient development, rainwater tanks plus recycled effluent plus WSUD*** stormwater	Yes	Yes	Yes	68%	152.7
6b	Stretched water efficient development, rainwater tanks plus recycled effluent plus WSUD stormwater	Yes	Yes	Yes	>68%**	152.7
7	Alternative lifestyle	Yes	Yes	Yes	59%	180.6
8	Indirect potable reuse, some dual reticulation, rainwater harvesting	Yes	Yes	Yes	63%	151.5

**System objectives: 1. Target 70 per cent reduction in water demand with a minimum outcome of 50 per cent.*
2. Likely to gain stakeholder endorsement.
3. Protects Googong Reservoir.

***Estimate*

****Water sensitive urban design*

4.2.3 The preferred water cycle management scenario – scenario 6b

A stakeholder workshop was conducted in February 2004 involving MWH Australia, CIC and NSW and ACT regulatory authorities with the purpose of identifying the preferred scenario.

The workshop selected 6b as the preferred scenario, as it achieves the largest water savings and one of the highest weighted sustainability scores. This scenario has been further refined to enable at least a 60 per cent reduction in potable demand compared to that required for a traditional urban development (BASIX benchmarks).

Queanbeyan City Council has endorsed this option (letter from QCC Engineering Services to CIC, 8 September 2008) and confirmed that this alternative, and the supporting studies, meet the needs of water conservation that the DoP has set as a condition of rezoning for Googong township.

The scenario 6b incorporates the following features:

- Mandated low-flow showerheads.
- Mandated flow controls on taps.
- Landscaping controls.
- Mandated water-efficient clothes washers.
- Rainwater tanks for all residential development (with tank capacity to relate to dwelling type).
- Recycled water to be piped to residential development (for toilets, washing machines, and outdoor uses).
- Recycled water to be piped to non-residential development.
- Water-sensitive urban design.

Once the preferred integrated water cycle management system was selected, this enabled the water balance for potable water, recycled water and wastewater flows to be finalised. This in turn allowed detailed planning of the key infrastructure components of the system including the wastewater recycling plant, discharge management and the storage reservoirs. The options considered for these aspects of the water cycle management system are outlined in the following sections.

4.3 Alternative options for treatment and discharge

4.3.1 Wastewater treatment options

Effluent quality standards

Due to the need to reduce impacts on the receiving environment, and the requirement for recycled water as a non-potable water supply, a key design criterion for the water recycling plant has been to achieve high effluent quality standards. These quality standards need to take into account:

- The potential environmental impacts from discharge to the surface water-receiving environment – namely, the Queanbeyan River.
- The potential impacts on soil and groundwater environments on the site from recycled water use.
- Human health risks.

In particular, parameters have been specified for total nitrogen (TN) and total phosphorous (TP), with 50th percentile values of less than 10 milligrams per litre (mg/l) and 0.2 mg/L for discharge from the water recycling plant. Furthermore, parameters have progressively been set to minimise the concentrations of total dissolved solids (salt) in the effluent.

Treatment process options

To achieve these standards, an advanced tertiary treatment process is required. The options considered were:

- Conventional four-stage biological nutrient removal (BNR).
- Four-stage BNR with membrane biological reactor (MBR) technology.
- MBR package plants for the first stage of development and incorporated into ultimate design.

Key criteria to assess treatment processes

The following criteria were considered in deciding between a conventional BNR and a BNR four-stage with MBR technology:

- Land area required and ability to manage visual, noise and odour impacts.
- Technical capability to meet effluent quality standards and anticipated flow requirements.
- Certainty of environmental approvals.
- Cost (both capital and operating).
- Construction complexity and program length.

Table 4.5 summarises the advantages and disadvantages of both the reference case design and alternative design.

Table 4.5 Advantages and disadvantages of conventional BNR and BNR with MBR technology

Continuous BNR activated sludge plant		
	Conventional	**With MBR**
Advantages	• Less stringent screening – reducing the amount of screenings to be removed off-site. • Lower power costs. • Chemical use can be optimised in terms of carbon and chemicals for phosphorus removal.	• No secondary clarifiers required. • No separate ultrafiltration process. • Smaller land take. Total land take ~1.5 ha. • Simpler odour control. • Shorter start-up period. • Compact bioreactor design (major benefit if the plant is covered and odour controlled). • Single point chemical dosing for P removal. • Lower EP required than conventional for plant start up (smaller tank).
Disadvantages	• Land take required is outside that of site allocation. Total land take – 1.8ha. • Harder to cover and control odour. • Longer start-up period.	• Additional screening required. 1mm with macerator screen upfront. • High power and chemical costs.

Table 4.5 shows the advantages of using MBR technology. As well as offering a lower capital cost than the conventional four-stage BNR, the MBR has the advantage of not having a requirement for clarifiers, or a separate ultrafiltration process. It is also a more compact design.

In November 2008, CIC Australia, MWH and Manidis Roberts held a workshop to discuss the options and processes involved. In view of the findings summarised in Table 4.5, the workshop endorsed the selection of the preferred water recycling plant design as a BNR process employing MBR technology.

Disinfection processes to ensure that human health risks are mitigated

Each treatment process that was considered includes a two-step process to disinfect the recycled water. These processes include:

- Ultraviolet radiation (following microfiltration) to treat all recycled water output before it moves into the distribution system.
- Chlorine dosing of all recycled water output before it moves into the distribution system to ensure a sufficient disinfection residual is produced.

Together, these disinfection processes would effectively manage human health risks posed by microbiological organisms potentially existing in the recycled water supply.

Viability of the MBR package

Previous reports (MWH, 2007) suggest that package plants could be used in the early stages of development, and then integrated into the overall design. However, due to the high effluent standards to be achieved, 'plug in and play' and 'off the shelf' package plant technology is not appropriate for this application.

Two suppliers were approached with respect to providing a package plant to meet the consent conditions required, namely Siemens and GE. However, both independently stated that any ‘off the shelf’ package MBR system employed at the Googong township would need to be heavily modified and augmented to meet the anticipated licence requirements. Although the package plant system could be modified, it would not be cost-effective to do so. Consequently, it was concluded that the provision of package systems for the Googong township was not a feasible option for wastewater treatment.

4.3.2 Discharge options for excess recycled water

Traditional wastewater treatment methods, without effluent recycling, typically discharge all treated effluent to a receiving water environment such as a creek, river, estuary or ocean. The effluent recycling scheme proposed in the Project means that the majority of effluent would be re-used for irrigation in the urban and open space environment of the Googong township, or re-used in toilets and washing machines before being returned to the system. As a result, the volume of effluent that would be discharged to the environment would be substantially less than a traditional system; but discharges would still be required when demand for recycled water is low.

Several options were considered for discharging excess recycled water into the Queanbeyan River catchment including:

- A pipeline from the water recycling plant to discharge directly to the Queanbeyan River, which is the nearest river system. This would be the most conventional option..
- A pipeline from the water recycling plant to Googong Creek (around one kilometre upstream from the Queanbeyan River). This option would seek to utilise sections of Googong Creek to slow and further polish the recycled water before it eventually discharges to the Queanbeyan River system.
- A refined recycled water discharge scheme to maximise reuse on site through water-sensitive urban design. This option would utilise the upper reaches of Googong Creek, within the Googong township boundaries, and blend the excess recycled water with stormwater and retain it on site in retention ponds for further reuse. Under this scheme, eventual excess discharge would still occur via the lower reaches of Googong Creek to the Queanbeyan River system.

A balanced assessment – factoring the best approach to maintain the environmental values of the receiving environments, use of best-practice methods, and economic cost – identified a recycled water discharge scheme with maximum reuse on site as the preferred option. This option would integrate the discharge of excess recycled water into the planned stormwater management system. Discharge would occur during various times of the year, predominantly during winter months when demand for recycled water would be low. The stormwater management system would then assist in the further treatment of the excess recycled water. The treated stormwater leaving the site (including the excess recycled water) would eventually flow into Queanbeyan River.

Modelling of flows and water quality has been undertaken for this option, integrating the inputs and expertise of urban designers, engineers, groundwater and salinity specialists to assess that the stormwater leaving the site and flowing to Queanbeyan River would be of adequate quality (refer to Appendix B).

Emergency bypass systems for wastewater (implemented only in situations where primary and back-up systems fail) would also be required equally for each option, which would also feed to the Queanbeyan River system via Montgomery Creek.

4.4 Water supply and storage options

4.4.1 Water and recycled water storage

To help understand the recycled water storage requirements for the Googong township, different storage scenarios were considered and compared to identify the most practicable and cost-effective scenario. They included:

- Daily service water storage, which is required to service demands for a peak day events.
- Seasonal water storage. It may be viable to provide longer-term storage (that is, for several months) to supplement recycled water available during hot dry periods when recycled water demand outstrips recycled water production. Seasonal storage aims to reduce the need to use potable water to ‘top up’ the recycled water system.

After consideration of the requirements detailed in the Water Services Code of Australia (WSA 03), it was concluded that additional seasonal storage would not offer sufficient additional improvement in potable water savings to justify the substantial cost. For example, it was found that:

- 200 megalitres (ML) of seasonal recycled water storage would only provide at additional eight per cent reduction in potable water demand when compared to no seasonal storage.
- Economic costs for seasonal storage would be substantial as the recycled water would need to be stored in steel or concrete aboveground reservoirs. Underground aquifers capable of storing recycled water and suitable areas to construct earthen dams are not available within the Googong township boundaries, so these options could not be considered.

In view of these findings, the provision of daily service water storage has been accepted as the most practicable and cost-effective option, which is reflected in the design of the Project.

4.4.2 Bulk potable water supply options

Bulk potable water supply is available from the Googong water treatment plant adjacent to the Googong township site. This option has a low economic and environmental cost due to the small distance to the connection point through areas of low environmental value (existing road verges).

As this servicing option is most feasible, further options to connect to the ACTEW trunk potable water network, which are further away from the site, were not considered.

4.5 Further refinement of the concept design

In mid-2010, a thorough review of the concept design was undertaken as part of a value management exercise. The aims of this review were to:

- Reduce the capital costs of the water cycle project, especially in the early years.
- Investigate options for further staging of infrastructure elements, especially the water recycling plant.
- At least maintain all existing environmental outcomes such as effluent quality criteria.
- Specifically seek to improve the TDS (salt) concentrations in the recycled water output through further analysis of biological treatment processes to reduce total phosphorus.

4.5.1 Water recycling plant options

A number of options were considered for the water recycling plant including:

- Alternative layout arrangements.
  - The layout selected would optimise the footprint of the plant without compromising on its performance. The reduction in footprint would result in a decreased construction and operational impact through reductions in civil construction work, reduced runs of pipework between process equipment and a reduced requirement for pumping within the plant.
- Alternative process arrangements:
  - Removal of phosphorous from wastewater would be through a biological process (biological-P removal) rather than through addition of chemicals (chemical-P removal). The biological-P removal process was selected as it would provide the best overall outcome including improved environmental performance through reduced salt loading (in comparison with chemical-P removal), with negligible impact on capital and operational costs.
  - Arrangements and equipment for secondary processes – such as sludge treatment, odour control and disinfection – would be based on technologies and equipment that have been proven in similar applications.
- Alternative staging options.
  - The assessment of staging options has led to a solution that provides efficiency in the recycling plant at each stage of the development, with a minimum number of discrete stages of construction.
  - The staging of the plant would be carried out so that individual stages would be brought into operation before the plant reaches capacity and so that each stage of the works is incorporated into the final design for the completed plant.
  - This staging plan would greatly reduce the extent to which the plant needs to operated below its capacity during the development of Googong township and this would improve efficiency in operations, including potentially reduce chemical and power use.

4.5.2 Bulk water pumping station options

Pumping arrangements for bulk water were reviewed to identify a solution that optimises the design. The final concept adopted would reduce the overall footprint of the pumping station with minimal civil and structural works required for the pumps. The location of the pumping station has been selected on the basis of an optimal outcome in respect to the performance of ACTEW's network, which would minimise potential impacts due to water hammer impacts. As with the water recycling plant, the pumping station has been designed so that its capacity can be increased as the development proceeds and demands for potable water increase.

The bulk water pumping station has also been designed so that potable water used for 'topping up' the recycled water system is pumped to the water recycling plant and then pumped through the recycled water network to the reservoir. A suitable barrier would be provided where the potable water connects to the recycled water network to prevent cross-connection. This arrangement would avoid the need to duplicate the capacity to carry recycled water top-up in the potable water network from the water recycling plant to the reservoirs.

4.5.3 Potable and recycled water reservoir options

The options for storing potable and recycled water were reviewed. This included a review of the required capacity over the life of the development, which resulted in the adoption of an interim reservoir site (‘Hill 765’) to provide storage for the early stages of the development. The use of this interim site means that pumping would be greatly reduced during these early stages of the development. It also means that the potable and recycled water would spend less time in transport before being delivered to households. This would reduce both the energy needed for pumping and the quantity of chlorine dosing.

The interim storage reservoirs provided in Stage 1 would be removed once larger reservoirs are established on Hill 800 that would service the full development. These smaller interim reservoirs would potentially be suitable for dismantling and reuse.

Other locations for the interim storage reservoirs were considered, including locations within or near the footprint of Neighbourhood 1A (NH1A). The location at Hill 765 was selected because it would provide gravity feed to all areas of the NH1A development whereas other locations would require large elevated storages that would require more energy consumption and negatively impact on visual amenity.

4.6 Summary of the preferred option

An integrated water cycle management system has been chosen as the basis for the Project to service the Googong township. The system – combining recycled effluent for urban uses, rainwater tanks, stormwater reuse and water-sensitive urban design – would produce at least a 60 per cent saving in potable water and reduced environmental impacts compared to a traditional system.

The key elements of the preferred scenario are:

- Wastewater recycling plant. The basis for the plant is a four- or five-stage treatment process with membrane biological reactor technology (MBR) as its core. The treatment process would produce effluent of a quality suitable for urban recycling purposes and acceptable environmental impacts. Human health risks would be primarily mitigated through use of UV radiation treatment and chlorine dosing. The plant would be staged to ensure efficient operating capacity as the Googong township population builds.
- Discharge management. The discharge management scheme would manage excess recycled water primarily on site in conjunction with the stormwater management plan. This approach would be superior to a traditional wastewater system in which effluent is discharged directly to receiving waters.
- Potable and recycled water storages. It is proposed to use daily peak service reservoirs to meet WSA 2003 standards. Longer-term seasonal storage is not considered viable. The location of permanent reservoirs would be accommodated within the site at a point that provides sufficient head pressure to service the Googong township. Interim reservoirs were determined to be suitable to service the early stages of the township.
- Connection to bulk potable water supply. The preferred option is to connect to bulk potable water at the Googong water treatment plant adjacent to the Googong township site.

Chapter 5 describes the proposed Project in detail.