WATER SERVICES ASSOCIATION
OF AUSTRALIA

Refilling the Glass

Exploring the issues surrounding water recycling in Australia

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Contents

Overview of WSAA

The Water Services Association (WSAA) is the peak body of the Australian urban water industry. Its 29 members and 27 associate members provide water and sewerage services to approximately 15 million Australians and to many of our largest industrial and commercial enterprises.

WSAA was formed in 1995 to provide a forum for debate on issues important to the urban water industry and to be a focal point for communicating the industry's views. WSAA encourages the exchange of information and cooperation between its members so that the industry has a culture of continuous improvement and is always receptive to new ideas.

The functions of WSAA are:

- be the voice of the urban industry at the national and international level and represent the industry in the development of national water policy,
- facilitate the exchange of information and communication within the industry,
- undertake research of national importance to the Australian urban water industry and coordinate key national research for the industry,
- develop benchmarking and improvement activities to facilitate the development and improved productivity of the industry,
- develop national codes of practice for water and sewerage systems,
- assess new products relating to water, sewerage and trade waste systems on behalf of the water industry,
- jointly oversee the Smart Approved Watermark Scheme for products and services involved in conserving water use
- coordinate annual metric benchmarking of the industry and publish the National Performance Framework with the Federal and State Governments.

Appreciation

I am grateful to Peter Donlon, Technical Director, Water Services Association of Australia who co-authored this paper with me and to Associate Professor Greg Leslie, UNESCO Centre for Membrane Science and Technology, University of New South Wales who undertook a peer review of the penultimate draft.

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What is water recycling?

Water recycling is the multiple use of water that is treated to a standard appropriate for its intended beneficial use.

For urban communities, recycled water is a rainfall-independent source of water that can:

- Provide a source of water for non-drinking purposes such as commercial and industrial processes, for irrigating parks, gardens and other open spaces, and flushing toilets.
- Be blended back into dams and groundwater aquifers to supplement drinking water supplies subject to appropriate management and control.
- Avoid the need to invest significant sums of money upgrading wastewater treatment plants that discharge into inland rivers and creeks.
- Reduce the discharge from wastewater treatment plants to rivers and oceans.
- Provide a source of water for irrigation of agriculture and horticulture crops.
- Result in the beneficial use of nutrients.

Why WSAA prepared this paper

Australia is one of the most urbanised countries in the world and reliable supplies of water for urban Australia are vital for the nation's continued economic growth and prosperity.

Recycled water will be an increasingly important source of water for our cities to meet the demands of population growth and increasingly unreliable rainfall patterns due to climate change.

Development of recycled water as a new source of water will depend on a balanced assessment of the issues associated with its use.

This paper informs communities on the issues associated with recycled water, and enables them to embrace change, contribute to discussions on our future water resources, and ensure sustainable water resource outcomes for our cities for future generations.

Executive summary

Our water supplies under pressure

Australia's mainland capital cities (with the exception of Darwin) and many regional centres have experienced water restrictions of varying magnitudes for many years. These restrictions range from permanent water saving rules to bans on outdoor water use. Restrictions of this severity and duration have made urban Australians more aware of the fragility of the water supply systems that serve them.

There was a time when it was considered that our cities could 'live within their means' and accommodate population growth by implementing water conservation measures.

However, even with these water conservation measures, the decade-long drought coupled with rapidly increasing populations has put pressure on the water supply systems that supply our cities. With the exception of Perth, our capital cities are almost totally reliant on large dams for their water. Long-term climate change trends may permanently affect the quantity and reliability of inflows to water storages that supply urban Australia.

In the context of increasingly unreliable rainfall and changed social, political and environmental circumstances, it is unlikely that the traditional supply solution of building dams will be the sole means to provide the security of supply our cities demand.

New solutions that consider the total water cycle are required.

The diversification of water sources to include a portfolio of rainfall-independent water sources are 'pushing the boundaries' on what has generally been accepted as a traditional water supply system. Water sources such as desalination, water recycling, rainwater tanks, groundwater and water trading between rural and urban areas are being explored as options to secure water supplies for our growing cities.

This position paper discusses the issues involved in the use of recycled water as a source of water for our cities.

An increasingly important water source

There is a long history of recycled water use in Australia, particularly in irrigated agriculture.

As the severity of the impacts of climate change have begun to be understood, there have been calls to increase the use of recycled water for irrigation and expand the use of recycled water for other purposes such as commercial and industrial processes, horticulture and for garden watering and toilet flushing in new urban developments.

Besides providing an important rainfall-independent water supply for cities, recycled water can reduce discharges to the environment by capturing water and nutrients that would otherwise be discharged from wastewater treatment plants and stormwater drains. Recycled water can also be used to provide improved environmental flows to urban waterways and for other public amenity purposes such as parks and garden watering.

Recycled water will play an increasingly important part in securing the reliability of our urban water supplies. There are also proposals to blend recycled water with drinking water for drinking purposes by supplementing flows into dams and infiltration into aquifers that form the water supply for our cities and towns. However, it is important to understand its position as part of a suite of measures that will be required to achieve sustainable water supplies. Recycled water should not be viewed as the panacea to solving our water challenges.

Like all demand and supply options, recycled water has benefits and limitations. The limitations of recycled water such as high transport costs and the need to manage the by-products from recycled water production, are less well understood or appreciated than those of other supply measures such as dams and desalination.

Key messages

This position paper makes the following important points in relation to recycled water as a water source for Australian cities:

- The costs and benefits of recycled water options need to be considered on a case-by-case basis against all other options. A systematic and transparent process is required to evaluate all potential water resource options (including water conservation measures, desalination, new dams, water trading as well as recycling) and ensure community confidence in the decision-making process.

- The use of recycled water for non-drinking purposes will continue to increase, as it has for the past 10 years. Since 1999/2000 the volume of water recycled by urban water utilities has doubled. Per capita, Australia already recycles more than two and a half times the amount of water recycled in European countries and internationally is viewed as an innovator and world leader in this field.

- Recycled water for non-drinking purposes has gained widespread community support. However, the opportunities for large scale non-drinking recycling to significantly reduce demand on drinking water supplies will be limited (mainly new growth areas and large scale industry close to wastewater treatment plants) due to the prohibitive costs of building new pipe networks.

- The capital cities in urban Australia currently use 1,660GL of water per year. Non household consumption represents less than 30% of this total. Unless recycled water can be used to supplement the drinking water supply, non drinking water uses for recycled water will be limited to much less than the 30% of water used for non household purposes. Before recycled water is used to supplement drinking water supplies, extensive discussions with the community will be required to ensure there is a common understanding of the issues involved.

- If recycled water is used for supplementing drinking water supplies, it must be placed in an environmental buffer such as a river, aquifer or existing storage dam before it is further treated prior to entering the water distribution system. The environmental buffer allows additional purification processes to occur, reducing risk as part of a multi-barrier approach which is adopted for traditional water supply systems. In most major cities in Australia, this would involve building long and expensive pipelines and pumping would consume significant amounts of energy.

- WSAA does not support direct drinking water recycling due to the absence of an environmental buffer, consequently raising the risk profile unacceptably.

- Using recycled water to supplementing existing drinking water supplies requires several additional key areas to be considered. These are:
  - Having well-designed treatment processes using reliability engineering principles operated and maintained over its lifetime.
  - Ensuring the utility has appropriately skilled staff, resources and quality management systems to maintain system reliability and effectively manage the process.
  - Implementing effective monitoring and assessment programs.
  - Having transparent public reporting systems on performance.
  - Appropriate management of industrial waste discharges into wastewater systems.
  - Ensuring well resourced regulatory guidance and oversight on the performance of recycled water systems.
  - Ensuring environmental issues associated with the process are well managed.
  - Enhancing national research capacity to identify emerging issues of concern.

Executive summary
continued

- The coastal location of major cities in Australia contrasts with Europe, where cities are generally located inland near large rivers. These large rivers can be used as environmental buffers and recycled water can be conveyed downstream without the need to build extensive pipe networks and pump water considerable distances as would be needed in Australia. This is why calls for Australia to manage its water in a manner similar to London are misplaced (see section 7).
- Although water recycling will reduce the amount of treated effluent being discharged to rivers and oceans, ocean outfalls will still be required. This is because the 'concentrate' generated as a by-product of the treatment process still needs to be disposed of and sufficient storage may not be available to store recycled water in periods of low demand.
- There will be opportunities to recycle stormwater as a source of water for replenishing aquifers (where conditions permit) and for small-scale open space irrigation. Harvesting stormwater on a local scale through rainwater tanks can also provide a valuable source of water in areas of high rainfall. However, the treatment and storage requirements for stormwater limit its potential as a major water source.
- Recycling greywater in domestic premises will contribute in a minor way to water savings due to the limitations of simple greywater diversion systems and the expense and maintenance of greywater treatment systems and the need for significant house re-plumbing.

Recycling in all its forms, needs to be considered as a valuable additional water resource option for our cities. Evaluating options requires a full and transparent process to ensure our community's interests are best served. Using recycled water for non drinking purposes is an option for new growth areas and selected industrial and commercial uses, and will play a worthwhile role in improving our water resource requirements. The use of recycled water to supplement our drinking water supplies, has the potential to make a larger contribution to urban water resource needs but there must be community support before this option is contemplated.

Drought is often viewed as a threat, but it can also be an opportunity to rethink the way water is supplied to our cities.

There is often passionate debate about the merits of various water supply options, but there can be no debate over the fact that there are few more important issues confronting Australia than the sustainable and reliable supply of water to our cities in what is one of the driest and most urbanised countries in the world.

1. Introduction

Recycling in context

Rapidly growing populations, increasingly unreliable rainfall patterns and demands for increased environmental flows are putting pressure on the water supply systems that service Australia's cities. As a result, water restrictions of varying degrees of severity have been introduced in each of Australia's mainland capital cities (except Darwin) in the past five years.

Although Australia has often experienced long and harsh droughts, the current drought is the first to occur at a time when debate on climate change is becoming commonplace.

Early indications suggest that climate change may be permanently changing rainfall patterns. It is possible that the rainfall we rely on to fill our cities' major dams will be generally reduced and increasingly unreliable. The consequence of this is our cities will no longer be able to fulfil the water needs of rapidly growing populations solely from rainfall. To meet these needs, one option that has been identified is the increased use of recycled water.

Recycled water has been used for many decades for industry, irrigated agriculture and urban irrigation such as playing fields and golf courses (ATSE, 2004), but there are now many proposals to, and examples of, supplementing existing drinking water supplies by recycling water to irrigate household gardens and in some cases for in-house uses such as toilet flushing and car washing. These uses are generally well accepted by the community. In a small number of instances there are now proposals to deliberately recycle water back into the environment, via a dam, river or aquifer that will form part of a community drinking water supply. This use is more controversial and less widely used globally.

The opportunity to apply recycled water to a wider range of uses is made possible by advances in treatment technology, particularly membrane technologies including microfiltration and reverse osmosis, where energy inputs and costs have gradually been falling. The enthusiasm to embrace recycled water is based on:

1. Growing concern that traditional sources such as dams will be inadequate to meet the future needs of our cities.
2. Recycled water is rainfall independent and enables cities to diversify their water sources so they are not totally reliant on surface water runoff into dams.
3. Water recycling can reduce ocean and river discharges from wastewater treatment plants.
4. Recycling of any products we consume is strongly supported by the community.

The appropriateness of using recycled water to supplement water supplies varies from city to city. The various approaches adopted will depend on a range of circumstances including access to alternative water sources such as groundwater and through water trading and desalination.

Assessing the options

A systematic and transparent process is required to evaluate all potential water supply options (including water conservation measures, desalination, new dams, water trading as well as recycling) and ensure community confidence in the decision-making process. The decision process chosen for individual communities should recognise these decisions can be complex and different circumstances may deliver different outcomes.

The decision process should address the main concerns to communities in delivering secure urban water supplies. WSAA is working with the University of New South Wales to develop a sustainable decision-making framework for utilities across the country (UNSW and Centre for Water and Waste Technology, 2005).

This framework is designed to assess all available options in a structured and systematic manner. It assesses the financial, environmental and social aspects of a project and includes key public health and system reliability issues. It carries out this process in a transparent and inclusive manner, providing greater confidence that the community is fully involved in arriving at the final decision.

2. Terms

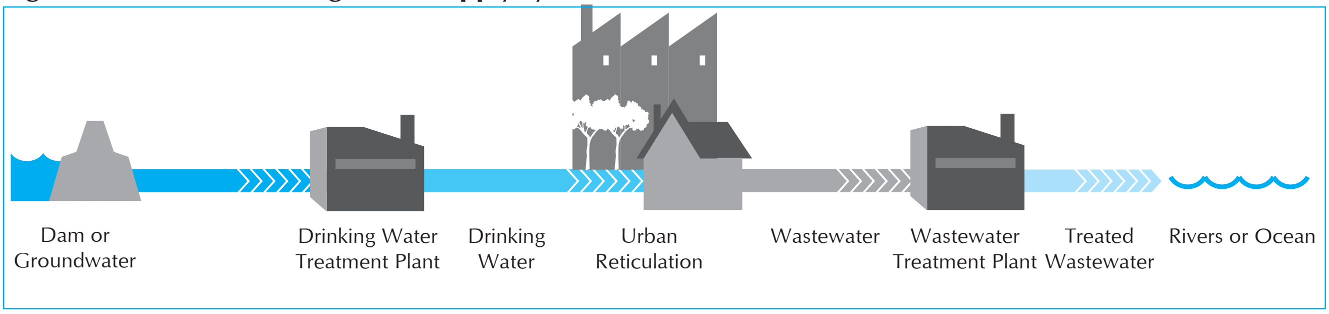
In this paper the following terms are used:

2.1 Treated wastewater

Wastewater discharged into the sewerage system from households and industry that has been treated to a level where it can be safely returned to the natural water cycle.

Our current drinking water and wastewater systems are largely designed as a 'once through system' as shown in Figure 1 below:

Figure 1 - Current drinking water supply systems



2.2 Recycled water

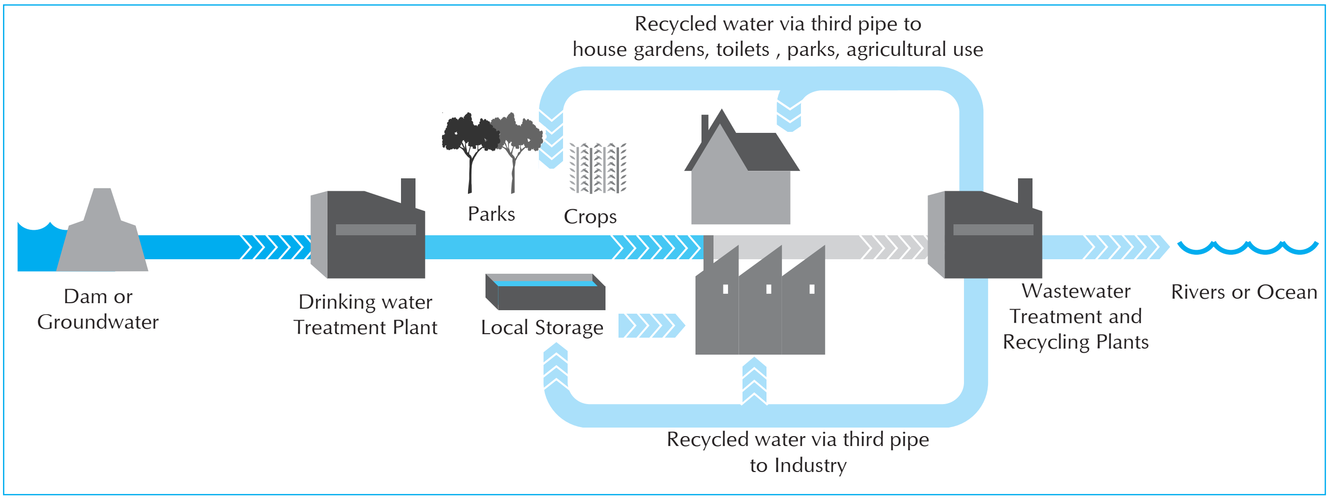
Water taken from the treated wastewater stream and, if necessary, further treated to a quality where it can be reused for beneficial purposes. Recycled water has the potential to be reused many times.

2.3 Non-drinking water recycling

The use of recycled water for purposes other than drinking. Water for non-drinking purposes is conveyed in a separate pipe network. Examples include the use of recycled water for industrial processes, domestic garden watering, urban and agricultural irrigation.

A general schematic of the system is shown in Figure 2.

Figure 2 – Non-drinking water recycling



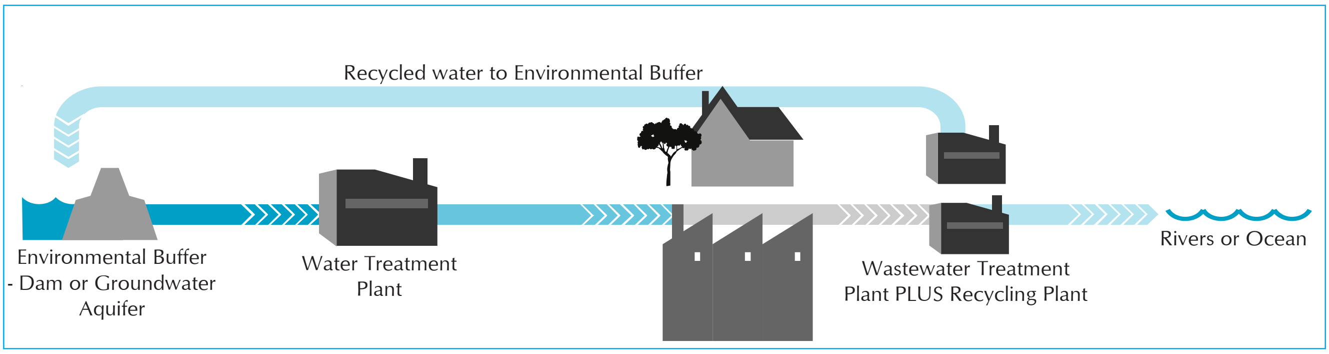
2.4 Indirect drinking water recycling[1]

The use of highly treated recycled water transported and placed in an environmental buffer[2] which provides additional treatment before extraction, further treatment and delivery to the drinking water supply distribution system.

Indirect drinking water recycling may be planned, where the system is deliberately designed to make use of recycled water. More commonly, indirect drinking water recycling is incidental. This is the case in many inland towns and cities in Australia and overseas, where recycled water is discharged to receiving waters such as a river and subsequently used as part of a drinking water supply for a downstream community (see also Figure 9 and Section 7).

The shortened term 'Drinking Water Recycling' will be used in the rest of this paper to describe situations in which recycled water is used for drinking.

Figure 3 – Indirect Drinking Water Recycling

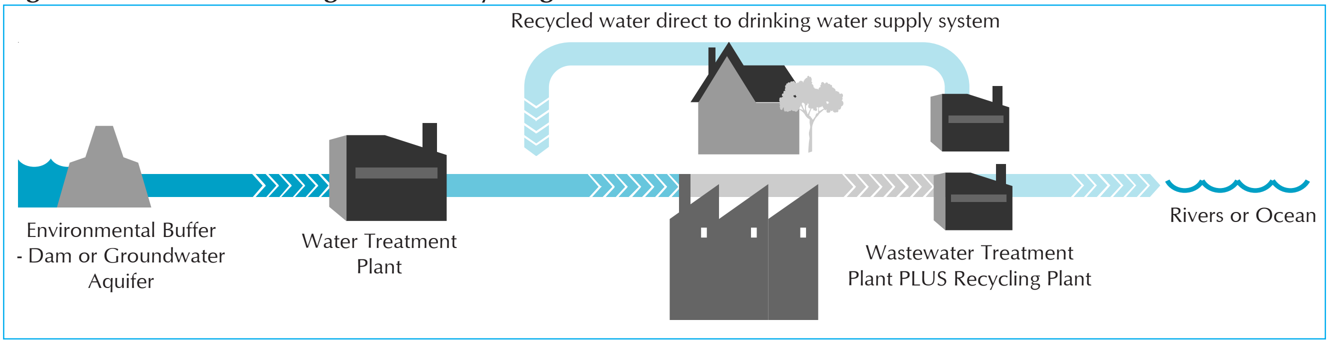


2.5 Direct drinking water recycling

This refers to situations in which recycled water is directly mixed in the drinking water supply system. An environmental buffer is not used. The recycled water may be added at the water treatment plant, a small service reservoir or directly into a drinking water pipelines supplying communities.

The absence of an environmental buffer raises the risk profile significantly. WSAA considers the risks of this form of recycling to be excessively high and does not support it. Direct drinking water recycling is practised only in the city of Windhoek, Namibia. This form of recycling will not be further discussed in this paper but will continue to be assessed by the urban water industry.

Figure 4 – Direct Drinking Water Recycling



[1] A commonly used alternative term is "Indirect Potable Reuse". WSAA has adopted the term Indirect Drinking Water Recycling in common with the forthcoming National Recycling Guidelines.

[2] Such as a dam, river or groundwater aquifer which provides additional treatment and an additional risk management barrier (see section 6.1)

3. Our water and sewerage systems

To develop an understanding of the issues associated with recycled water, it is important to understand the urban water cycle and the design of our water and sewerage systems.

3.1 The importance of sanitation

The tragedies of waterborne typhoid and cholera epidemics of the 19th century heralded great advances in the understanding of public health across the globe. It was realised that to prevent these diseases it was necessary to ensure our drinking water supplies were clean, and that we should minimise contact with our waste products.

To do this effectively in our cities, early engineers adhered to the principles of separating waste from drinking water supplies (Poor Law Commissioners, 1842). Water sources were chosen from the purest supplies possible, often remote from the city. Wastewater treatment plants were also built away from population centres.

Most importantly, separate pipeline systems were built for our water supply and wastewater systems – these are the water supply and sewerage systems that serve cities across the developed world today.

These developments heralded the single biggest advance in public health in the developed world in the 20th century. With good reason, generations of Australians have been educated about the principles of hygiene and understand why we do not mix our drinking water supplies with wastewater.

3.2 Key features of our water and sewerage systems

Generally, the main characteristics of our water and sewerage systems are[3]:

- Dams, which are constructed high in the hills to ensure water entering them is protected from pollution and make the best use of gravity[4] to deliver water to our cities. These dams help purify the water (see section 6.1) and provide storage capacity to ensure adequate water in periods of low rainfall.
- Where necessary, source water is treated further with chemical addition, filtration and disinfection to ensure the water is clean and safe for household and industrial uses.
- Wastewater from our homes and industries flows by gravity (as much as possible) to wastewater treatment facilities where it is treated to an appropriate level stipulated by state environment protection authorities before being returned to a compatible receiving environment (generally rivers or oceans, but in some cases, land).

[3] There are numerous differences in design at a local level for different towns and cities. This is a simplification.

[4] The use of gravity is a recurrent theme in this paper as unlike electricity, water is heavy. Witness the difficulty in carrying 20 litres of water in two buckets. Our urban supply systems currently deliver billions of litres of water every day and pumping against gravity is energy intensive.

4. Water recycling in Australia

4.1 Agricultural recycling

Treated wastewater has been discharged into rivers and creeks for many decades, but this began to change in the 1970s and 1980s. Increasing water extractions from inland waterways for irrigation and a growing awareness of nutrients in the waterways led to concern about the health of these aquatic ecosystems.

This led to efforts by governments to protect the health of our rivers by focusing on water for environmental flows. The water industry commenced upgrades of wastewater treatment systems to remove nutrients or with the encouragement of environmental authorities utilise the nutrients in treated wastewater by recycling water on to land for agricultural irrigation.

State environmental authorities drafted guidelines for land-based recycling around the country, and where the climate, soils and terrain permitted and costs were reasonable, water utilities increasingly adopted water recycling on to land (see ATSE, 2004).

The benefits of this form of recycling are:

- Recycled water can be used to increase agricultural productivity for crops including wine grapes, dairy pasture, horticultural crops and timber production.
- The nutrients phosphorus and nitrogen, which are a problem in rivers and creeks, are an asset to agriculture, increasing the productivity of irrigated crops.
- Recycling in this manner can avoid the need for expensive and energy-intensive upgrades of wastewater treatment plants to remove nutrients.

4.2 Broadening the uses of recycled water

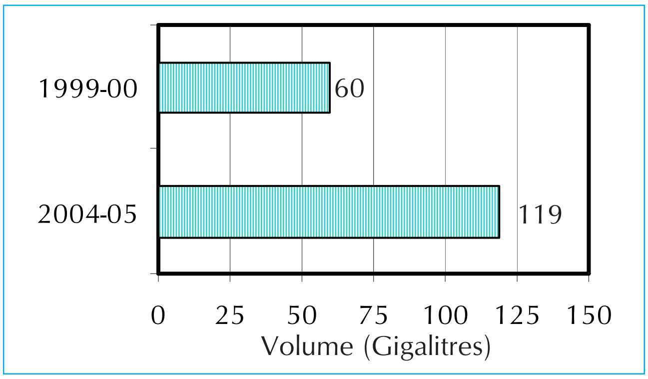
Agricultural recycling is still the dominant form of water recycling in Australia and worldwide, but in Australia recycled water is now used in a wider range of applications. Typical recycled water uses are:

- Irrigating non-food crops (eg cotton, turf, trees).
- Irrigating food crops (fruit trees, vegetables including salad vegetables).
- Irrigating for pasture or fodder production.
- As part of commercial or industrial processes.
- Irrigating municipal public parks and gardens and golf courses.
- Household uses including garden watering and toilet flushing via a third pipe.

In a more limited number of locations overseas, recycled water is also used to supplement drinking water supplies by blending it with surface water storages or direct injection or infiltration to groundwater supplies ***(see section 6).***

Australia's major cities are recycling 119GL of water a year. This equates to just under 8,000 litres of water per person a year (WSAA, 2005). By contrast, European countries recycle just over 3,000 litres per person a year (IWA, 2006), some 2.5 times less than Australia.

Figure 5 Growth in the use of recycled water in Australian cities



(Source: WSAA*facts*)

4. Water recycling in Australia
continued

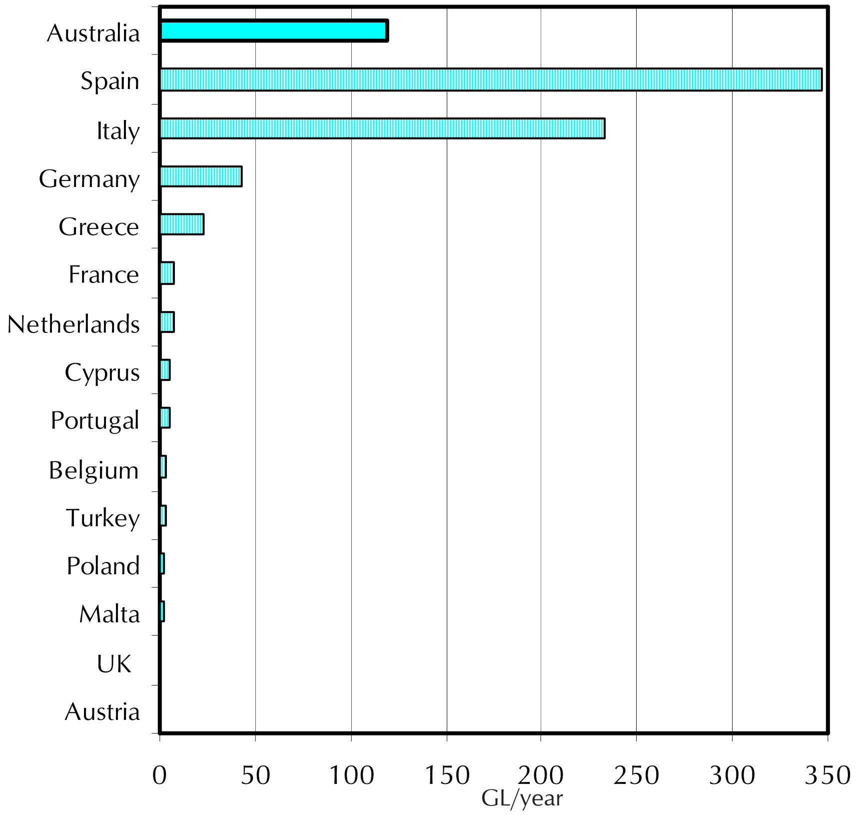
A recent review by the International Water Association (Durham B. and Angelakis A.N, 2006) on the present and future recycling capacity showed the level of recycling in the European Union. Figure 6 compares these levels with recycling from WSAA member utilities in Australia.

Note: This comparison excludes instances where drinking water is extracted from a river containing treated wastewater from upstream cities. Overseas this incidental (or unplanned) practice is not considered to be recycling. See Section 7 for more information.

Figure 6 shows that in Europe, the countries recycling the most water are the water-stressed Spain and Italy. Most of these projects use recycled water for irrigated agriculture. The level of recycling in Australia is high compared with European countries, and is higher still on a per capita basis.

Very recently, the emergence of climate change has resulted in countries in other parts of Europe taking a renewed interest in recycled water projects. In the decades to come, the level of recycled water use is expected to rise significantly in Europe.

Figure 6 European and Australian recycled water use



NOTE
Recycling rates for these EU countries are unavailable but are expected to be very low

Bulgaria
Crete
Czech Republic
Denmark
Estonia
Finland
Hungary
Ireland
Latvia
Lithuania
Luxembourg
Norway
Romania
Slovak Republic
Slovenia
Sweden
Switzerland

Source: Durham B and Angelakis A. N. 2006. Australian information WSAA*facts* 2005

4.3 Issues associated with agricultural recycling in Australia

Despite agricultural recycling currently being the largest use of recycled water, there are issues associated with its further expansion from major urban centres where potential volumes are greatest.

- Large areas of irrigation land are required. Examples of this form of recycling are the major wastewater treatment and land based recycling facilities north of Shepparton and Mooroopna[5] (40,000 people) in Victoria, which currently recycle 70 percent of the 12GL of wastewater received. These facilities have storages and irrigation areas as large as both these cities.
- To maximise the volumes of water recycled, millions of litres of water must be stored when the crops do not need the water, such as during winter. This requires significant land areas.
- Agricultural recycling often requires significant infrastructure to ensure reliable delivery of water. The costs to deliver this recycled water from our major urban centres on the coast will almost certainly outweigh the economic benefits derived from increasing agricultural output.

Because the use of recycled water for agriculture does not increase the available water for our major cities, more recently attention has focused on increasing the opportunities for recycled water to supplement supplies for urban areas.

The impact of this trend on agricultural output is likely to be minimal because urban water utilities in Australia generate only 1,500GL of treated wastewater (WSAA, 2005). This is a fraction of the 16,660GL (ABS, 2004) of water extracted from the environment which is currently used for irrigated agriculture. Even if all the treated wastewater from our major cities could be recycled for agriculture, it would represent only an 8 percent increase in available water for agriculture.

The issues associated with the greater use of recycled water in our cities are explored below.

4.4 Why water recycling is increasing in our cities

A convergence of inter-related factors are resulting in strong community support for recycled water to supplement drinking water supplies in our cities. These factors are:

- Australia's major population centres have had 10 years of well below average rainfall, which has resulted in dramatic reductions in inflows to dams that supply Australia's major cities. This drought has coincided with increasing evidence that the effects of climate change are influencing our water supplies (Australian Greenhouse Office, 2003). The response to this climatic uncertainty by the urban water industry has been to supplement existing dams by developing a portfolio of rainfall-independent water sources, including recycled water, desalination and in some cases groundwater (WSAA, 2005b).
- The population of our cities is growing rapidly. Australia's mainland capital cities and the lower Hunter and Gold Coast regions are expecting to grow by 35 percent or about five million people by 2030 (ABS, 2005). Population increases of this magnitude require the urban water industry to identify options to develop new sources of water and to conserve water to ensure the reliability and sustainability of our urban water supplies.
- Many proponents of recycled water are attracted to it because it results in less treated wastewater being discharged to receiving waters such as rivers and oceans.

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[5] See Google Earth (Shepparton, Australia or 36 19S 145 22E)

4. Water recycling in Australia
continued

It is a common misunderstanding that if we were able to achieve 100 percent recycling, there would be no need for outfalls to our rivers and oceans. However, discharges will still be required. This is because:

- In dry months recycled water used for irrigation may eliminate discharge to oceans and rivers but in wetter months when irrigation is not required, discharges to ocean and rivers will occur unless there is significant storage capacity available[6]. This would be problematic in densely populated urban areas.
- During storm events, flows into the sewerage system increase significantly. Given the difficulty of developing economically feasible storage areas, it is likely that outfalls will still be required so that these peak flows can be released to receiving waters.
- Recycled water that is treated using reverse osmosis technology produces a liquid waste by-product called a 'concentrate' which is 15 percent to 20 percent of the flow. This contains impurities removed from recycled water. Within the limitations of today's technology, assimilating the concentrate in an environmentally acceptable manner will require properly designed outfall discharges[7] (see also section 6.9). The volumes of liquid discharged to receiving waters will be reduced significantly, although the load of impurities will not.

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[6] As explained earlier, constructing storages of the size needed to store recycled water for use in summer in urban centres is not likely to be feasible economically or environmentally. For example, for Melbourne to store recycled water for the cooler seven months of the year when irrigation is not required would require a storage almost half the size of Sydney Harbour.

[7] Alternatives are constructing evaporation pans which will require large volumes of land and potentially have significant environmental issues or to use thermal evaporation which will require large amounts of energy.

5. Why non-drinking uses are limited in cities

The capital cities in urban Australia currently use 1,660GL of water per year (WSAA; 2005).

Non household consumption (industry, commercial, local government) represents less than 30% of total water consumed in urban Australia (ABS; 2004). Unless recycled water can be returned to the drinking water supply, non-drinking uses for recycled water in our cities will be limited and much less than the 30% of water used for non household purposes.

The reason for this is that new pipe networks are required to deliver recycled water from wastewater treatment plants to areas where the water can be used. Pipe networks are very expensive and extensive networks would be required to deliver recycled water in meaningful quantities across the vast areas that our cities occupy.

For instance, Sydney has almost 20,700 kilometres of water pipelines and to contemplate duplication of even a fraction of this system to enable recycled water to be used by households would represent an enormous cost to the community. It would require re-plumbing every home and result in significant social dislocation and disruption. Many billions of dollars would be required to retrofit major cities.

This means that the more economic uses of recycled water for non-drinking purposes will be limited to irrigation of urban open space, commercial and industrial uses. Recycled water can also be used in new residential developments in growth corridors and major infill redevelopments for purposes such as toilet flushing and garden watering.

Often the areas where recycled water can be used are remote from the coast (particularly urban growth corridors), which means that recycled water has to be pumped long distances in dedicated pipe systems – which has energy and greenhouse gas implications. Water is heavy, with one cubic metre weighing one tonne. Transporting water over long distances is costly due to the high cost of constructing and operating pumps and pipe networks (see also section 7).

Many commercial and industrial businesses use relatively small amounts of water and it is uneconomic to supply recycled water to them (notwithstanding the attractiveness of onsite recycling opportunities, of which many projects are proceeding – see Appendix 1). However, recycled water can often be economically supplied to high water-using industries, and to commercial and industrial precincts near wastewater treatment plants. It may also be economic to supply recycled water to large scale industries such as power stations, oil refineries and steel manufacturing plants (see Appendix 1). Water mining[8] may also become more cost effective for a greater number of applications as the technology develops and matures.

Putting aside the costs of supply, some high water using industries will face significant difficulties using recycled water. The food and beverage processing industry, for example, must meet international standards and have rigorous quality systems in place. For mainstream supply to these industries, recycled water quality would need to match drinking water quality. For export, international acceptance would be also be necessary as this is not current practice overseas.

The implications of the above points are that the use of recycled water for non-drinking water purposes will be at the margins in our large coastal cities in the short to medium term.

There may be opportunities to use recycled water for very large scale industries such as power generators. If this can be achieved economically, significant quantities of freshwater could become available for urban consumption.

There are many examples in our cities of recycled water projects, some of which are described in Appendix 1 and such projects are contributing to our overall efforts in conserving drinking water supplies.

[8] Water mining (also called sewer mining in some states) is a technique to extract wastewater from the sewerage system within a city, treat it locally using a small wastewater treatment plant and then use the recycled water for irrigation in a local park or garden. An example includes the Rocks Riverside Water Mining Plant in Brisbane.

6. Recycling for supplementing drinking water

One way of greatly increasing the opportunity for large scale recycled water use without the costs of retrofitting properties and duplicating delivery networks is to add recycled water indirectly to the drinking water supply system.

Advances in treatment technologies of the past two decades which are now able to bring recycled water to drinking water quality, combined with concern about climate change and environmental issues, has led to renewed interest in using recycled water to supplement drinking water supplies.

While the number of projects using recycled water for drinking[9] is still very small, it is growing due to water shortages in other areas of the world. It is likely that if the current period of low rainfall continues in Australia, some urban and regional centres will need to seriously evaluate this option much sooner than is generally appreciated.

WSAA's view is that supplementing our drinking water supplies with recycled water is a viable option that needs to be considered along with all other alternatives, but caution must be exercised if we are to proceed along this path. Because of the nature of the source water, there must be an effective multi-barrier approach to ensure that drinking water is continuously safe for our communities.

If recycled water were to be used to supplement drinking water in some towns and cities across Australia, there are several key community and technical issues to be addressed.

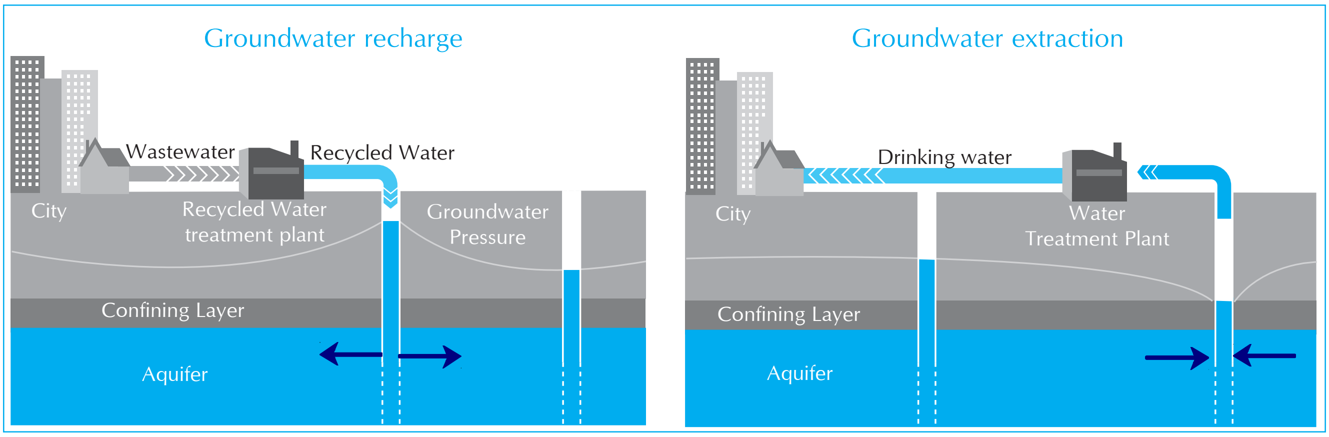
6.1 Environmental buffers – using natural treatment

Indirect drinking water recycling requires highly treated recycled water to be added to an environmental buffer before further treatment in the drinking water treatment plant.

An environmental buffer may consist of a stretch of river, a water supply reservoir or a soil-aquifer system (see Figure 7) to which recycled water is added. The amount of recycled water may vary from less than 1 percent to 70 percent during more extreme dry summer conditions (Durham B and Angelakis A.N.. 2006). In California, recycled water is pumped into groundwater aquifers where it is stored before being later extracted as a source of water.

The need for an environmental buffer is an important component of risk management. Natural systems have long been known to purify water (National Research Council, 1998). The efficiency of removing disease-causing microbes in natural soil-aquifers led to the development of modern filtration plants.

Figure 7 – Example environmental buffer - aquifer storage and recovery



[9] WSAA fully recognises that there are many cases overseas (and in Australia) where a city draws its water downstream of the treated wastewater discharges of upstream cities. This is addressed more fully in the section – Why doesn't Australia follow the London Example?

6. Recycling for supplementary drinking water
continued

Rivers and reservoirs are subject to natural ultraviolet light, which has a strong disinfection action. Natural biological communities also exist in these systems, which are capable of biodegrading a multitude of chemicals and inactivating many microorganisms, including those that may cause disease. In most cases these systems also act to dilute the recycled water with the other natural water present, which further minimises the risks of contamination.

Moreover, these systems often provide a natural delay before recycled water enters the drinking water supply system. This delay, often called detention time, can often be many years. This substantial time lag before water is used for drinking allows any potential failures in the treatment process to be detected and remedied.

The use of environmental buffers represents current world's best practice. The presence of an environmental buffer is supported by most communities which have made the decision to supplement their supplies with recycled water, and is likely to be critical to the acceptance of future drinking water recycling in Australia.

6.2 Building community trust

For the community to support recycled water for drinking, there needs to be effective communication and information transfer between the community, key stakeholders and the scheme proponent (usually a water utility). This process is complex and time consuming, and experience in the United States indicates that understanding and acceptance may take some years (WateReuse Foundation, 2004). This may be able to be accelerated if trust has already been established between the proponent and the community.

To gain this trust, a series of best practice activities has been developed by the WateReuse Foundation (WateReuse Foundation, 2004). WSAA supports these best practice activities. Experience shows that compromising these activities on specific projects is likely to result in community resistance to such schemes. The WateReuse Foundation has also developed four checklists for utilities contemplating the use of recycled water to supplement drinking water supplies (WateReuse Foundation, 2006). By interpreting these checklists in an Australian context, they provide a roadmap for water utilities to address community and stakeholder concerns relating to recycled water. The checklists are reproduced in Appendix 3.

Building trust with the community requires the proponent to lead a dialogue with key community groups that fully explains the concepts of reliable water supplies, and given water scarcity, the need to examine all options for saving water and the potential need to invest in new water supplies. All options available should be considered including supplementing drinking supplies with recycled water.

The process needs to be open and honest with the utility having an open mind to all options. Given that complex issues are likely to need assessment, a formal process to thoroughly evaluate each option will be necessary. An example of such a process is described in the document, *Methodology for Evaluating the Sustainability of Urban Water Supplies* (UNSW, 2005).

6. Recycling for supplementary drinking water
continued

Generally a key issue raised by the community is that water quality depends on the physical source of the water. Again, this needs to be discussed openly with the community so that there is an understanding that modern technologies can reliably remove contaminants of concern.

It is important to understand that the aim is to find the correct solution, whether or not this involves using recycled water to supplement drinking water supplies.

6.3 Modern treatment technologies

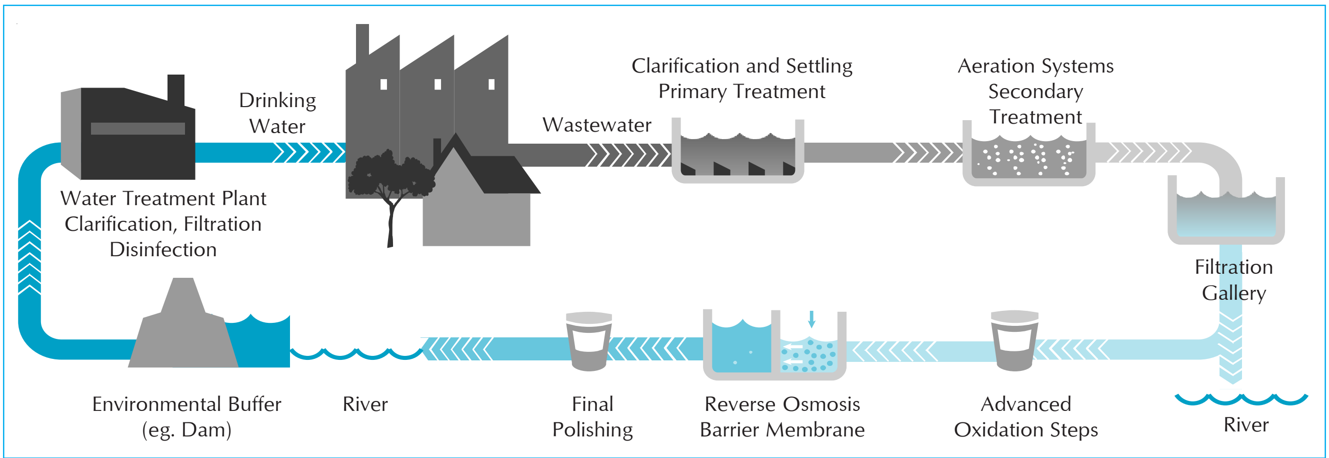
Water and wastewater treatment technologies have advanced significantly in the past decade. By implementing the best practices outlined in this section, the community can be assured that contaminants that may cause human harm and may be present in treated wastewater can be effectively and reliably removed (WateReuse Foundation, 2006b).

These modern technologies are typically based on the use of membrane filtration, reverse osmosis and advanced oxidation systems and processes, which are added to existing wastewater treatment plants. Reliability engineering techniques should be used to manage risk so that failure modes and their frequency are identified and sufficient redundancy is in place to ensure the continued integrity of the treatment system.

Each class of contaminant in the waste stream needs to be considered separately and treatment processes designed specifically to remove potentially harmful compounds. Each treatment process step should be evaluated to establish its performance against broad categories of contaminants (WateReuse Foundation, 2006b).

Disease-causing pathogens (harmful viruses, bacteria and protozoa) are of principal concern. Untreated wastewater contains high numbers of these pathogens, but for many years wastewater and water treatment processes have been designed to eliminate these risks.

Figure 8 – Example of extensive multi-barrier treatment processes to ensure the safety of recycled water supplementing a drinking water supply.



Membrane filtration, reverse osmosis and advanced oxidation provide additional barriers against these organisms.

With the addition of membrane filtration, reverse osmosis and advanced oxidation processes, this provides many times the treatment capacity necessary to remove these pathogens. Similarly, treated wastewater contains a variety of chemicals, of which only a few are potentially harmful in the long term to human health. Reverse osmosis systems and advanced oxidation processes have the capacity not only to provide redundancy in systems for removing pathogens but to effectively remove any remaining potentially harmful chemicals.

Environmental buffers provide further protection, as discussed previously.

This concept of multiple barriers is fundamental to ensuring the continued reliability of treatment systems for drinking water recycling. Failure of one process component must not compromise the safety of the supply to the community. This effective risk management process is detailed in the current *Australian Drinking Water Guidelines* (NHMRC-NRMMC, 2004) and the *Draft Australian Recycled Water Guidelines* (NRMMC-EPHC, 2005). Further guidance on this issue will be provided in the second stage of the Australian recycled water guidelines which will specifically address supplementing drinking water supplies with recycled water which are due out in draft form in late 2006.

6.4 Building institutional capacity

The technologies necessary to produce high quality recycled water for drinking have been established for some decades in other industries. However, the use and detailed understanding of the performance of these technologies in removing contaminants of concern in drinking water is relatively new to water utilities.

When recycled water is added to the drinking water supply, technical knowledge is required to ensure that all systems are operating to specification. Specialist technicians need to continuously monitor process performance and understand the ramifications of new research on contaminants on treatment process systems. The utility also needs specialist communications staff who are able to discuss these technologies in a manner the community can readily appreciate.

Management systems need to be based on the draft Australian Recycled Water Guidelines Risk Framework (NRMMC-EPHC, 2005). Formal externally accredited quality management systems such as HACCP (Hazard and Critical Control Path Analysis) and ISO 9001, or quality systems based on the Australian Guidelines, are likely to be required.

The utility will need real time monitoring systems, high level process engineering skills and the support of microbiologists, chemists and environmental scientists. Management commitment and support is also crucial to provide the necessary resources.

Many of these skills and capacity are already in place within the large utilities in Australia, but the institutional frameworks for managing water vary widely across Australia. In some cases these skills and capacity are not present and will need to be developed before considering water recycling to supplement drinking water.

6. Recycling for supplementary drinking water
continued

6.5 Recycled water quality

The quality of recycled water can match that of drinking water through the use of modern treatment technologies and an environmental buffer combined with a multi-barrier approach to managing risk.

The water quality if used to supplement drinking water supplies must meet national drinking water quality guidelines and any specific guidance identified by health agencies during the project evaluation (NRC, 1998).

The current Australian Drinking Water Quality Guidelines (NHMRC-NRMMC, 2004) assume water supplies are sourced from the best available supply, such as a clean river or groundwater. Because the source water for recycled water may contain contaminants not expected to be present in significant quantities in rivers or creeks, the Federal Government is developing national recycling guidelines targeting indirect drinking water recycling. These guidelines will apply in addition to the national drinking water guidelines.

6.6 Industrial waste management

Industry connected to the sewerage system currently discharges wastewater under licence from the responsible local water utility. This industrial or "trade waste" is monitored and controlled to ensure the wastewater treatment system is capable of degrading or removing contaminants before the treated wastewater is discharged into the environment.

Nonetheless, for utilities that are implementing drinking water recycling, industrial waste management presents a risk to the quality of treated wastewater, and stringent industrial pre-treatment and pollutant source control programs need to be in place. There is a need to work closely with all industries discharging to sewer to ensure industrial wastes are compatible with the recycling plants.

This also applies to waste from residential sources. While this presents less risk, there can be no short cuts in ensuring the safety of drinking water.

Proponents of drinking water recycling projects need to document and monitor all major chemical wastewater inputs from household, commercial, industrial and agricultural sources and have risk mitigation measures in place (National Research Council, 1998).

6.7 Monitoring and assessment

Thorough assessment programs that include contaminant monitoring and health and safety testing are critical to any drinking water recycling scheme. Such monitoring and assessment must include a thorough evaluation of potential microbial, chemical and radiological contaminants that may enter the sewerage system (National Research Council, 1998) using proficient and reliable sampling and analytical service providers.

Although not a regulatory requirement, it is likely that future best practice will dictate the need for monitoring such as continuous toxicological and chemical monitoring, as well as the normal process monitoring systems linked to SCADA[10] and telemetry networks. SCADA sensors need to be calibrated regularly.

[10] SCADA is a technical acronym for Supervisory Control and Data Acquisition System. It generally refers to a system that monitors and controls a complete site using sensors transmitting information to operational staff monitoring the site. See SCADA in Wikipedia (www.wikipedia.com)

6.8 Environmental considerations

In order to treat wastewater to high quality recycled water, a by-product, generally called a 'concentrate' (made up of concentrated salt, membrane de-scaling chemicals, nutrients, pathogens and other matter) is produced. Depending on the nature of the recycled water treatment process and the quality of the recycled water, the risks from these by-product contaminants will vary. This needs to be assessed, generally through a public environmental review process.

Disposal of this concentrate, often to an aquatic environment via an ocean outfall, is a key management issue.

Further treatment of the concentrate may be necessary to ensure that all the requirements set by environmental regulatory authorities are met. This may include studies on the toxicity of the concentrate, impact on aquatic communities and the structure of these communities and possibly bioaccumulation assessment. Process monitoring of this part of the system is also likely to be required.

Utilities also need to consider other environmental issues including energy requirements and greenhouse gas emissions associated with the treatment process and pumping the water from the recycling plant (at the bottom of catchments) to the surface water storage or groundwater system (See section 7 discussion on energy issues).

6.9 Regulatory guidance and public reporting

Most guidelines developed to date for recycled water have focused on agricultural uses. In 2005, the Federal Government released *Draft Guidelines for Recycled Water* (NRMMC-EPHC, 2005), which incorporate applications such as close personal contact use in urban developments, but not drinking recycled water. The next stage of these guidelines, which are being developed at the present time, will include detailed requirements for drinking water recycling.

Nonetheless, the existing draft guidelines provide information on risk management systems and system design parameters. The risk management system adopted is common with the *Australian Drinking Water Guidelines* and is likely to be adopted for the guidelines for supplementing drinking water with recycled water. This risk management approach provides a good framework for implementing drinking water recycling. As previously indicated further guidance will be forthcoming in late 2006.

Monitoring of the utility managing the system is essential. This is the role of the regulator, in this case the state public health regulator (IWA, 2004).

These state-based regulatory agencies need to be well resourced and skilled to effectively oversee the management systems in place in the utilities constructing and operating drinking water recycling schemes. Guidelines developed by these agencies should be based on the national guidelines to enable a consistent application of treatment technologies and implementation of supporting management systems.

The regulatory oversight also needs to assess the performance of the utility managing these systems, and require public reporting of information related to the performance of systems underpinning drinking water recycling. The monitoring results, system process performance and industrial waste management requirements should also be open to health regulatory authorities and public scrutiny.

6. Recycling for supplementary drinking water
continued

6.10 National research capacity

Because the source water for drinking water recycling is wastewater, there is always some risk that a yet to be identified chemical or microbial agent may penetrate the multiple barriers in place. While the risks to human health are extremely low, communities expect that water utilities are at the forefront of knowledge in these areas.

Research is proceeding to verify the ability of traditional wastewater treatment plants to remove low levels of compounds such as endocrine disruptors[11] and pharmaceuticals, which are of concern particularly in relation to environmental impacts.

For drinking water recycling, the addition of advanced treatment systems (such as reverse osmosis membranes and advanced oxidation) to these treatment plants significantly increases the capability of these systems to remove a vast range of additional chemicals and all microbial agents. This produces very high quality recycled water. However, with the advanced and very sensitive analytical detection techniques available today, some chemicals are known to penetrate these membranes and treatment systems at extremely low concentrations.

These chemicals are currently understood not to be harmful to people (or the environment) in the quantities present, but it will always be necessary to understand what chemicals and microbial agents our treatment systems can remove, and the risks to people from drinking. In many respects, this is no different to improving our understanding of current drinking water treatment systems sourced from rivers and reservoirs.

To achieve this, Australia needs to build on its already strong research capacity to ensure that future findings about contaminants in water supplies are factored into our management of recycling.

WSAA members already support the Cooperative Research Centre for Water Quality and Treatment (CRCWQ&T) and the Global Water Research Coalition (GWRC) whose members coordinate global urban water research, including contemporary information on drinking water recycling. The GWRC comprises major water research groups from the United States, United Kingdom, France, Germany, South Africa, the Netherlands, Switzerland and Singapore.

WSAA envisages that the successor organisation to Australia's Cooperative Research Centre for Water Quality and Treatment (which includes CSIRO, Monash Medical Centre and many others) will play a vital role in working with the GWRC and Australian utilities in cutting-edge scientific understanding of water recycling, including drinking water recycling.

[11] An endocrine disruptor is a natural or synthetic chemical that when taken up by an organism mimics, modifies or blocks the actions of hormones and disrupts normal physiological processes.

7. Why doesn't Australia follow London's example?

It is popular in Australia to cite cities such as London, which extract water from the Thames River that contains treated wastewater discharged by upstream cities, as being at the forefront of water recycling. The implication is that Australia is lagging behind international standards in water recycling.

However, the Americans and Europeans view Australia as a leader in the use of recycled water. How can this apparent contradiction be reconciled? In North America and Europe, pumping water out of rivers for the drinking water supply is not regarded as recycling.

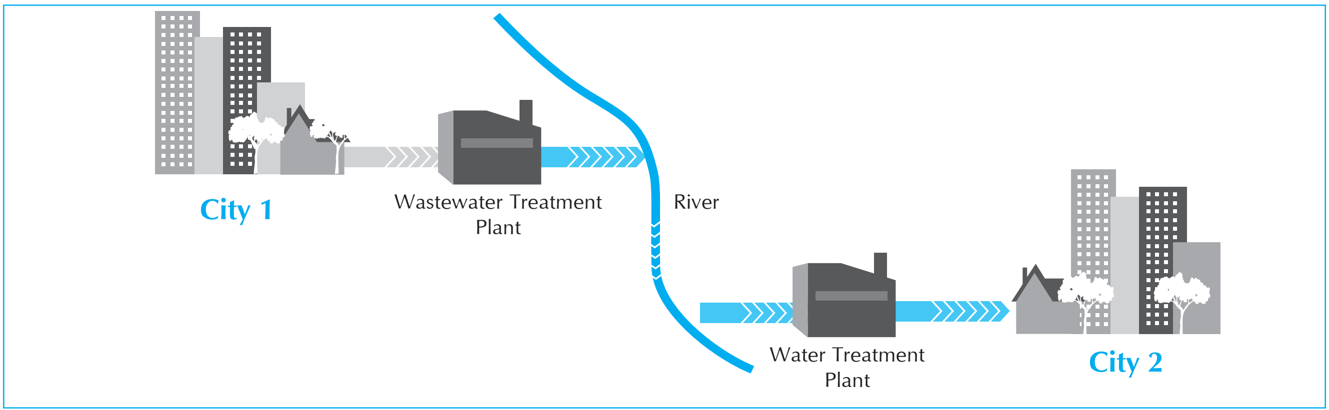
As shown from Figure 6, the United Kingdom actually reports very little recycling.

The approach used in some European cities is to return treated wastewater into rivers and then extract a proportion of the river water downstream and treat it for drinking purposes. This practice has not developed as a deliberate attempt to recycle water, but rather as a consequence of 19th century initiatives to improve sanitary conditions in large cities through the construction of sewers to convey human waste to the nearest convenient river or creek. Advanced water and wastewater treatment has followed in response to the widespread water pollution that resulted from the discharge of large quantities of waste to these rivers and creeks. This is similar to practices in inland Australia, albeit with much smaller populations.

There are several reasons why the approaches adopted in Europe and parts of the US are difficult to emulate in most of Australia's capital cities.

1. Australia's major cities, except Canberra and a small number of other inland cities, are located on the coast. Many of the large European cities are inland. Inland cities can use rivers as environmental buffers and gravity to convey treated wastewater downstream; they do not need to build infrastructure and consume energy in pumping water. In contrast, Australia's sewerage systems generally use gravity, with wastewater treatment plants at the lowest point in the catchments, which is on the coast. But reservoirs and dams are often many kilometres from the treatment plants where recycled water is produced and, in the case of our capital cities, they are invariably at a higher altitude, which requires long and expensive pipelines and significant energy for pumping.
2. Europe and the US have large and grand rivers compared with those in Australia. These rivers generally have significant year-round flows and provide a much greater buffer than the smaller, more variable flow in many Australia rivers. Often in the US, large lakes, the magnitude of which we could only dream about in Australia, are used as environmental buffers.

Figure 9 – Treated water discharges to rivers and subsequent mixed water abstracted for drinking water



7. Why doesn't Australia follow London's example?
continued

3. In parts of Europe, water is not extracted from rivers, but pumped from below the river bed. In Germany, for example, extraction wells along the banks of the Rhine enable water to be pumped from 20 to 30 metres below the riverbed. This process is referred to as bank filtration. The riverbeds consist of thick layers of sand and gravel, which act as natural biological water filters, allowing good quality water to be extracted for further treatment even though the quality of the water in the Rhine is often questionable.

For Australian capital cities except Perth and Adelaide, which have accessible groundwater aquifers, the only option available for an environmental buffer is to pump recycled water back to the reservoirs and dams that supply our cities. Depending on the size of the reservoir (and where the water is returned to it in relation to the dam outlet), it could be possible to provide sufficient detention time for the recycled water.

For example, in Sydney, the distance from the coastal treatment plants to an environmental buffer such as Warragamba Dam is about 70 kilometres with a pump lift of 120 metres. Energy requirements for this option are about 2.8 kw-hr per kilolitre of recycled water treated and transported[12]. Greenhouse gas emissions are similarly high at 2.3 kilograms of carbon dioxide per kilolitre of water[13]. These figures can be compared to the higher energy costs of a desalination plant and associated infrastructure, which would require energy of 4.5 kw-hr per kilolitre of seawater treated and transported.

However, in a capital cost comparison between desalination and supplementing Sydney's drinking water supply with 500 ML per day of recycled water, desalination is cheaper at $2.5 billion compared with $3.8 billion for the recycled water option. Annual operational costs are also cheaper for desalination at $165 million compared with $175 million for recycling water (Sydney Water, 2006).

Conventional water supply systems from dams using gravity consume significantly less energy than the above options, plus about 0.2 kw-hr energy needed for operating water treatment plants.

These figures emphasise the need to assess each option fully on its merits using a process such as the sustainability assessment methodology outlined previously (UNSW and Centre for Water and Waste Technology, 2005).

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[12] Source: Sydney Water *personal communication*.

[13] Using the Australian Greenhouse Office 2005 NSW emissions factor of 0.835 kg CO_2 per kw-hr power consumed.

8. Recycling stormwater

Treated wastewater is not the only source of water available to recycle. Stormwater can also supplement drinking water for our cities.

Following rainfall in our cities, the community observes significant volumes of water 'going to waste' down gutters and out to sea.

Historically, stormwater management was driven by the need to provide flood protection. In more recent times, it has been recognised that urban stormwater can, if not managed effectively, damage our rivers and oceans following heavy rain. Stormwater management was seen as a different discipline to managing drinking water and wastewater.

There has been a change in mindset recently due to the development of a discipline called Water Sensitive Urban Development (WSUD). The principles[14] that underpin WSUD are:

1. Minimise impact on existing natural features and ecological processes.
2. Minimise impact on natural hydrologic behaviour of catchments – for example, maintain water balance within development areas relative to pre-development conditions.
3. Protect water quality of surface, ground and marine waters relative to pre-development conditions.
4. Minimise water demand, especially on the reticulated water supply system.
5. Improve the quality of and minimise polluted water discharges to the natural environment.
6. Encourage collection treatment and/or reuse of runoff, including roof water and other urban stormwater.
7. Reuse of treated wastewater and minimising wastewater generation.
8. Increasing social amenity in urban areas through multi-purpose greenspace, landscaping and integrating water into the landscape to enhance visual, social, cultural, economic and ecological values.
9. Add value while minimising development costs – minimise the drainage infrastructure cost of the development over the length of its expected operational life.
10. Account for the nexus between water use and wider social and resource issues.

The principles of WSUD can generally be applied only in new suburbs or major redevelopments where the infrastructure can be installed during the development stage. Even then, there are major barriers to the implementation of WSUD. The National Water Initiative recognises the importance of WSUD in ensuring that the growth corridors around our cities are developed in a manner that will improve the sustainability of our water resources. There are several actions[15] in the National Water Initiative associated with the promotion of WSUD and investigating what barriers may be in place preventing its broader acceptance.

Recycling, of course, can be part of this new paradigm for urban development which addresses the water cycle in an integrated manner.

The most public example of the effectiveness of WSUD is the development that took place for the Sydney Olympic Games. Extensive attention was paid to every aspect of the water cycle in this area, including management of stormwater in wetlands. Further use is made of this stormwater by combining it with recycled water for delivery to residents via a "purple" third pipe system for garden watering and toilet flushing. Drinking water supply savings are estimated at 40 percent.

The development at Rouse Hill in north-west Sydney, Pimpama Coomera in the Gold Coast, Mawson Lakes in Adelaide (see Appendix 1) and at the Lynbrook estate (CRC Catchment Hydrology, 2002) in Victoria are other examples of WSUD.

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[14] As identified by the National Water Commission.

[15] National Water Initiative - See Section 92
- i) develop national health and environmental guidelines for WSUD
- ii) develop national guidelines for evaluating options for WSUD
- iii) evaluate existing 'icon' developments to identify knowledge gaps
- iv) review institutional and regulatory models for achieving integrated urban water cycle management and planning

8. Recycling stormwater
continued

8.1 Benefits of stormwater recycling

Although recycling stormwater is rainfall dependent, small-scale capture and reuse options are becoming increasingly popular. Stormwater harvesting has many of the benefits of wastewater recycling, including conserving drinking water and reducing the demand on our water supply and reducing the chemical and energy requirements for treating and transporting water to individual properties.

By capturing stormwater we can reduce the impact of runoff into our waterways and minimise the need for augmenting stormwater infrastructure. Stormwater options can be particularly attractive on a property scale or where large storage areas exist.

Rainwater tanks are an obvious way of collecting and using this water and they are becoming increasingly popular in some cities, particularly where rainfall patterns do not result in long dry summer periods.

Rainwater tanks can provide a valuable water source for flushing toilets, in washing machines, watering gardens and washing cars.

On a larger scale it is generally considered that the only cost-effective way of storing stormwater in existing urban areas is to place it in aquifers, which are limited in most Australian capital cities.

However, some opportunities for aquifer injection are emerging. Perth is well placed to use stormwater to recharge underground aquifers and it is estimated that 200GL already naturally percolates through the sandy soils on which the city resides into the groundwater below Perth each year. The Botany Aquifer in Sydney has recently been identified as a potential storage area for stormwater (Turnbull, 2006). This aquifer is near the coast where rainfall is more frequent, so it already recharges quickly. The recharge rate could be increased by diverting stormwater flows so that they percolate into the aquifer. With increased recharge rates the aquifer could supply up to 4GL of water a year.

Adelaide also has opportunities for using aquifers to store stormwater. Small-scale storage in wetlands or water bodies incorporated into open spaces in our cities have the potential to supply water for local irrigation, but these opportunities will provide only small amounts of water.

Like all water supply options, rainwater tanks and other stormwater options should be considered as part of a consistent decision-making framework.

8.2 Issues with stormwater recycling

Like so many other aspects of water resource management, there are many complex issues associated with capturing stormwater to supplement water supplies for our cities.

Factors that limit the extent to which stormwater recycling can significantly assist the supply/demand balance in our cities are:

- **Diffuse sources**

  Unlike treated wastewater that is generated at a small number of wastewater treatment plants serving our cities, stormwater is generated from diffuse sources. There are many hundreds of drains that flow into urban waterways and the ocean and capturing water from these geographically dispersed sources presents many difficulties. For instance, in Melbourne there are 300 drains, managed by Melbourne Water and councils, that discharge into Port Phillip Bay (Melbourne Water, personal communication).

- **Poor and variable quality**

  Stormwater is often of poor quality because it contains chemicals and oil from roads and other pollutants flushed out of the catchment in runoff. Stormwater would require treatment before it could be used to supplement drinking water supplies. Higher quality stormwater comes off roofs and can be captured by domestic rainwater tanks.

- **Low level of reliability**

  Stormwater flows are dependent on rainfall, which is becoming increasingly unreliable. Stormwater as a source of water does not diversify the portfolio of water sources available to a city due to this dependence on rainfall.

- **Storage**

  It is difficult in established urban areas to find sufficiently large areas to store captured stormwater until it is needed. It is generally considered that the only cost-effective way of storing stormwater in existing urban areas is to place it in aquifers, which are limited in most Australian capital cities. In established areas of our cities, there is generally no open space available to store meaningful quantities of stormwater. It would be possible to create underground storages such a constructing large underground tanks, but these would be very expensive.

- **Space for treatment**

  In addition to land needed to store the water, land would be needed on which to build plants to treat the stormwater. It would be difficult to find places in established urban areas for a stormwater treatment plant.

- **Protecting environmental flows**

  Stormwater is the only source of environmental flows to many urban rivers and creeks. Although excessive runoff and peak flows can damage urban waterways, it is also true that denying stormwater flows to these rivers and creeks would have significant environmental impacts. When assessing environmental impacts on rivers and creeks, it is important to consider the frequency of stormwater flows into these waterways and not just total volumes, which might be heavily influenced by intense rainfall events.

Unless aquifer storage is available, the use of stormwater in established areas is likely to be limited to small localised projects where it can be stored in wetlands and lakes in open space corridors for irrigation of adjacent parkland and sports fields. These types of projects should be pursued wherever possible because they reduce demand from drinking water supplies. They can also reduce the quantity of pollutants and nutrients entering waterways, and create attractive landscape features which are often habitat for wildlife. Although important for reducing the damage caused by stormwater on receiving waters, they will only ever make a small contribution to enhancing water supplies for our cities.

Where aquifer storage is available, the opportunities to use stormwater for a variety of purposes are much greater. Aquifers represent a cost-effective means of storing stormwater in an established urban environment so it can be extracted for later use.

9. Household greywater recycling

The use of recycled water from large-scale wastewater treatment plants has been discussed previously in this paper. However, with increasingly harsh restrictions on outdoor water use (including total bans on outdoor use in some instances), the possibility of recycling greywater on a household scale is increasingly promoted as an option to save water.

Simple greywater diversions are being installed by many households. These diversions generally involve the connection of a diverter pipe to the clothes washer discharge pipe or shower for application to gardens.

Greywater recycling requires careful selection of detergents to avoid excessive salt and to have due regard for health risks (most health agencies recommend covering untreated greywater irrigation lines).

The practice also generally relies on a favourable household block slope and some re-plumbing to take advantage of gravity feed from the clothes washer or shower. Problems can occur with pipe blockages (from lint and hair) and greywater must be diverted to sewer when garden water is not required, for example during wet conditions. If diversion does not occur and grey water runs off household properties, both public health and environmental problems will become significant in urbanised areas. This relates directly to the reason we separated our water and wastewater systems in the first place (see section 3.1).

Many residences do not have such favourable household block circumstances, nor the time or inclination to manage such a system, and consequently the opportunity to divert greywater safely in this manner is likely to be limited.

For wider takeup of household greywater reuse systems, it would be necessary to overcome the above difficulties. This would generally require a storage and treatment system, filtration, pumps and an irrigation network layout. More advanced systems would include biological treatment processes. Ability to divert the greywater to sewer during the wetter parts of the year is also necessary.

These more engineered systems are significantly more expensive and require maintenance. Given the costs and maintenance requirements, they are most likely to be taken up only by enthusiasts in the community. Information from the Victorian Department of Sustainability (DSE, 2005) shows that for Victoria, of the 110,000 rebates given for a variety of household water-saving measures, only 312 greywater recycling rebates were given. Estimated savings from these greywater systems were 8.5ML per year from a total water saving of 956ML per year. By comparison, estimated water savings from AAAA clothes washing machine rebates were 226 ML per year.

For these reasons, household greywater recycling is unlikely to be able to supplement our water supplies on a large scale for the foreseeable future.

10. The way forward

There is no doubt that the use of recycled water for a wide variety of purposes will become an increasingly attractive option for Australian cities as our climate becomes more variable, drought persists for longer periods and population growth continues. Australia is already viewed as a leader in the use of recycled water and pressures imposed by drought and climate change are likely to ensure this position of leadership is consolidated.

Recycling as a concept has a high level of support in the community (witness the success of kerbside recycling programs). The challenge is to engender the same level of confidence in water recycling that exists for other forms of recycling.

It can be argued that all water on the planet is recycled through the water cycle – evaporation, rainfall and runoff. All that recycling schemes do is shorten the loop so that rather than having to wait for wastewater to evaporate once it is released into the environment and return to us in the form of rain (an increasingly high risk scenario with our rainfall patterns becoming more fickle), we are now able to purify our wastewater with new technology and enable it to be used again without going through the natural water cycle.

This position paper has been developed to help the community understand the opportunities for using recycled water but also to increase awareness of its constraints. There is a high level of support for recycled water for non-drinking purposes; the same cannot be said for proposals that involve blending it back in with our water supplies for drinking purposes.

This paper emphasises that without community support for using recycled water to supplement our drinking water supplies, the use of recycled water, particularly in coastal cities, will always be limited. And in that context, recycling must compete with other major options such as desalination and water trading.

Every player in the water industry has an important role if recycling is to play an increasingly important role in meeting our urban water needs. Governments must show leadership and establish appropriate regulatory regimes and guidelines to set the standards. Regulators must police these standards and guidelines with great vigour. The water utilities must build the same level of community confidence in recycling as they have done for drinking water from traditional sources.

Drought is often viewed as a threat, but it can also be an opportunity to rethink the way water is supplied to our cities.

There is often passionate debate about the merits of various water supply options, but there can be no debate over the fact that there are few more important issues confronting Australia than the sustainable and reliable supply of water to our cities in what is one of the driest and most urbanised countries in the world.

Appendix 1

Existing recycled water projects in our cities

The following is a selection of significant recycled water projects completed or being developed across Australia.

Rouse Hill residential recycling scheme – Sydney

Australia's largest residential recycling scheme is Rouse Hill in Sydney's north-west. Begun in 2001, it now has some 16,000 homes using 1.7GL/year of recycled water for toilet flushing, watering gardens, washing cars and other outdoor purposes.

The scheme, which has reduced drinking water demand by 35 percent within this area, supplies recycled water via a third "purple" pipe system to ensure the drinking water supply and the recycled supply are separated.

Recycled water in this system is treated to a very high standard, with all microbial contaminants and the vast majority of chemical contaminants removed. The recycled water is not designed for drinking, but accidental drinking for a short time will not cause harm.

Wollongong industrial recycled water plant – Wollongong

In September 2006, Sydney Water commissioned Australia's largest industrial recycled water facility which will supply approximately 7GL/year of high quality recycled water to the nearby BlueScope Steel Port Kembla steel works.

The treatment process adds membrane filtration and reverse osmosis technology to the Wollongong wastewater treatment plant to deliver recycled water for purposes such as around-the-clock steel making, cooling and dust suppression. The scheme's viability is due to the proximity of the recycled water plant and the high demand from this particular industry.

The scheme will reduce the demand on drinking water from the Avon Dam by up to 20 percent and reduce ocean discharges of treated wastewater by 40 percent. The scheme will also reduce BlueScope Steel's demand for water by 50 percent.

Virginia recycling market produce scheme – Adelaide

Operating since 1999, the Virginia Recycling Scheme north of Adelaide transfers 15GL/year of recycled water to more than 200 market gardeners for production of vegetables and other produce.

The scheme is a co-operative undertaking of the Virginia Irrigation Association (representing market gardeners and other irrigators), SA Water and Water Reticulation Systems Virginia (a private sector subsidiary of Tyco International).

The implementation of the scheme required a $30 million upgrade to SA Water's Bolivar wastewater treatment plant to produce recycled water suitable for irrigating food crops. With financial assistance from SA Water and the Federal Government, an additional $22 million recycled water distribution network was constructed.

Use of reclaimed water is expected to increase as the horticultural industry continues to expand production, as groundwater substitution takes place, and as growers establish on-site infrastructure and refine irrigation methods.

It is expected that 50 percent to 70 percent of the treated wastewater from the Bolivar plant could be used for irrigation on the northern Adelaide Plains.

Mawson Lakes – Adelaide

When fully developed in 2010, Mawson Lakes – a new suburb in Adelaide's north – will be home to about 10,000 people. A major feature of the Mawson Lakes development is an innovative $16 million water recycling system which complements the normal mains water supply.

Eventually, recycled water will be delivered to about 4000 homes in the area and save about 800 megalitres of mains water being drawn from the Murray River each year.

Appendix 1 Existing water recycling projects in our cities *continued*

The system distributes a mixture of highly treated recycled water from the Bolivar wastewater treatment plant and stormwater harvested in Salisbury that is cleaned and treated through a series of engineered wetlands.

Residents are now using recycled water for toilet flushing, garden watering and car washing. The recycled water is also being used for irrigation of public parks and reserves. Recycled water is delivered via clearly distinguishable purple pipes, mains, meters and taps. The project is benefiting the environment by helping to reduce stormwater and wastewater pollutants going to the local marine environment.

Luggage Point industrial recycling scheme – Brisbane

Brisbane City Council, in a commercial agreement with the nearby BP refinery, supplies the refinery with ultra high quality recycled water for processing uses, including for cooling towers and boilers.

Additional treatment is required at the Luggage Point wastewater treatment plant to demineralise the recycled water using microfiltration and reverse osmosis membranes. This water recycling project is Brisbane's largest, with about 3.6GL/year recycled to supply the refinery; saving a similar amount from the Brisbane drinking water supply system.

Kwinana industrial recycling scheme – Perth

The Kwinana industrial recycling scheme developed by the Water Corporation is Western Australia's largest recycling system, capable of delivering about 6GL/year to industries in the Kwinana industrial area, south of Perth. The second stage, which is being considered, will deliver an additional 3.7GL/year to industry.

This scheme takes treated wastewater from the Woodman Point wastewater treatment plant and further treats it using microfiltration and reverse osmosis membranes. This produces high quality recycled water with low salinity that can be used in various industrial processes.

The use of this recycled water replaces drinking water formerly used by these industries in their processes.

Gnangara Mound groundwater replenishment – Perth

The West Australian Water Corporation is planning a major trial of injecting microfiltered reverse osmosis and ultraviolet-treated recycled water into the Leederville Aquifer at Beenyup wastewater treatment plant, north of Perth. This will lead to a corresponding increase in groundwater extractions for drinking water supply. The objective of this trial is to successfully demonstrate recycled water aquifer recharge in Perth to allow full scale implementation of the scheme by 2015.

The scheme could supply up to 30GL/year of recycled water to supplement drinking water aquifers for Perth's future if it is accepted by regulators and the community. This would be an example of drinking water recycling.

Pimpama Coomera Waterfuture Project and other recycling – Gold Coast

The Pimpama Coomera region on the Gold Coast is one of South East Queensland's fastest growth areas. By 2050 the region is expected to house 150,000 people.

Commenced in 2003, the Pimpama Coomera Waterfuture Project incorporates a full water cycle approach, making use of water sensitive urban development in streetscapes, recycled water via third pipes to houses for garden watering and toilet flushing, rainwater tanks and water-efficient fixtures in housing developments.

The scheme is expected to reduce demand on drinking water supply systems to these households by 80 per cent as well as improve the quality of urban runoff.

Many other recycling projects have also been implemented on the Gold Coast, ranging from irrigation of golf courses, plant nurseries, municipal parks and gardens, commercial, industrial and agricultural recycling. Total recycled water used for these activities is now more than 5.3GL/year.

Appendix 1
continued

Recycling projects in and around Melbourne

Melbourne currently recycles 46GL/year of water, which is projected to rise to 72GL/year by 2010. A significant proportion (36GL/year) of this occurs at the two major wastewater treatment plants at Carrum and Werribee.

The remaining 10GL/year of recycled water is made up of numerous smaller projects managed by the Melbourne water companies including dual pipe networks for residential properties, agricultural recycling, municipal parks and gardens, golf courses, schools and industrial recycling. Some 2GL/year is projected to be saved via the use of dual pipe networks in the growth fringes of Craigieburn and Werribee. Agricultural and industrial recycling is also projected to expand significantly.

The innovative cleaner production and recycling program for industry operated by City West Water in the industrial heartland of Melbourne has also delivered major benefits. These industrial customers include chemical producers, breweries, laundries, food and beverage manufacturers, metal manufacturers and finishers and others. Projects have focused on works in individual companies to increase internal recycling of process waters, as well as works to reduce overall use of water and other waste products (cleaner production).

The program has been very successful, with collective water savings due to recycling and cleaner production of more than 1.5GL/year.

In the area served by Western Water on the outskirts of Melbourne, the recycling rate has reached 88 percent. This area is growing rapidly, and 'third pipe' recycled water systems access agricultural, municipal and residential areas (eg new Eynesbury development). Some 6.6GL/year is recycled from seven treatment plants.

Appendix 2

Recycled water projects overseas[16]

In arid countries or where there are other key drivers such as dense population with high water demand or major environmental discharge constraints, water recycling projects have provided a valuable additional source of water.

These include the Middle East, Spain, Italy, Greece and Germany in Europe, South Africa, Japan (due to dense populations) and parts of the US including California, Arizona and Florida.

The examples below are a selection of water recycling projects from overseas.

Californian projects

Due to high population growth and an arid environment, California has long been involved in recycling. The California Department of Water Resources reports that 650GL/year was recycled in 2003 (ATSE, 2004). This is broken into the following uses:

Agricultural recycling	297GL/year
Landscape irrigation	137GL/year
Industrial recycling	34GL/year
Groundwater recharge	60GL/year
Seawater barriers	32GL/year
Recreational impoundments	41GL/year
Wildlife habitat	25GL/year
Other	21GL/year

A project[17] of note in California is the Orange County Water Factory 21. Orange County Water District (OCWD) supports a population of 2.5 million. Three-quarters of the water supply is sourced from groundwater aquifers with the other 25 percent from northern California or the Colorado River.

[16] The projects identified below are those recognised by their respective countries as recycling or reuse projects. As is the case in Australia, there are also many cases of recycling occurring where a city draws its water downstream of the treated wastewater discharges of from upstream cities. This is addressed more fully in section 7– Why doesn't Australia follow the London Example?

[17] Extensive details on the project are available at www.ocwd.com/_html/wf21.htm

Appendix 2 Recycled water projects overseas
continued

Increased pumping during the 1950s and 1960s in northern Orange County resulted in the ingress of seawater into the freshwater aquifers. In order to protect the groundwater basin, OCWD constructed an advanced water recycling facility in the early 1970s called Water Factory 21 (WF21).

Since 1976, WF21 has injected about 60ML per day of high quality recycled water that has been treated by conventional clarification and filtration followed by partial demineralisation with reverse osmosis and polishing with activated carbon. The final recycled water is blended with deep well water sourced from aquifers and injected back into the groundwater basin via 26 injection wells located within five kilometres of the plant.

After 25 years of successful operation, OCWD decided to expand the amount of recycled water that is added to the aquifer from the original 2 percent up to 15 percent by building a Groundwater Replenishment System (www.gwrsystem.com). This plant will replace the original WF21 and produce up to 370 ML per day of recycled water using microfiltration, reverse osmosis and advanced oxidation (the same processes proposed for the Toowoomba Water Futures project). This first phase of the project will produce 270ML/day and will be on line late in 2007.

Singapore NEWater

In 1998, the Singapore Government adopted a "Four Taps" policy to diversify water sources and secure long-term water supplies for Singapore.

The four taps are:

- Malaysian sourced surface water
- Singapore sourced surface water
- Desalinated seawater
- Recycled water.

Recycled water is sourced from the city's wastewater treatment plants and further treated using membrane filtration, reverse osmosis and disinfection with ultraviolet light. The final product is known as NEWater.

The predominant use of NEWater is to substitute water supplies to the industrial areas of Singapore. Currently three NEWater plants supply about 92 ML/day (33GL/year). By 2010 Singapore expects non-drinking use of NEWater to replace 15 percent of Singapore's water demand. In addition, NEWater is providing about 1 percent of drinking water supplies. This is projected to rise to 2.5 percent by 2011 (Singapore Public Utilities Board website, accessed September 2006).

The Singapore Public Utilities Board says that NEWater is safe to drink, with extensive testing on the final product.

The project is supported by an extensive community education program, which includes every school child visiting the NEWater Education Centre. Bottles of NEWater are made available to visitors.

Israel

Water recycling in Israel has had a long history because its water resources are extremely limited. The country has embarked on a rapid expansion of recycling and desalination facilities to secure sustainable water supplies for the future.

The growth in these alternative water supplies is shown in the table (Tal, 2006):

Israel's alternative water supplies (GL/year)

	2000	2005	2010
Desalination	0	120	365
Recycling	280	340	510
Total	**280**	**460**	**875**
% of Water Supply	18%	30%	56%

As at 2005, some 72 percent of treated wastewater is reused in the country (Cohen, 2006).

In the Dan region, 95 GL/year of secondary treated wastewater from 1.5 million people in Tel Aviv is stored in aquifers for future agricultural recycling. Some 32GL/year of treated wastewater from Haifa is stored for subsequent recycling by agriculture (ATSE, 2004).

All recycled water is used for agricultural and horticultural irrigation with no recycled water utilised for drinking purposes in Israel.

Appendix 3

Advice checklists for utilities considering supplementing drinking water supplies with recycled water[18]

(WateReuse Foundation; 2006)

Checklist 1: Investing in Water Reliability

Step 1: Stick with Water Reliability and Water Quality

Define the Process of "Planning for Reliability" - Defining the issues that go into water reliability planning provides an important context for any dialogue about investing in new supply. Discuss a drought planning standard, the critical value of water storage, and the value of drought proof water supplies like recycled water.

Define "Water Reliability" - Define what you mean by water reliability by having meaningful reliability standard or reliability goals. State your drought planning scenario and the level of service you plan to provide during that scenario. Articulate natural disaster reliability scenarios and level of service, if applicable.

Describe and Emphasise the Value of Water Storage Assets - Groundwater basins and reservoirs are extremely valuable assets. Communicate the critical value of storage assets and the fact that Water Supply Replenishment maximises their value by keeping water levels at optimum.

Address Water Quality Concerns - Use the insights from the Water Quality Confidence checklist and tools to ensure that you are perceived as the trusted source of quality. Water Supply Replenishment creates a high quality water supply that typically improves the quality of the overall supply.

Step 2: Treat Your Community Like Investors

Improve The Situation - Whether water quality or drought resistance, people are more inclined to invest in improvement. Make sure your proposed investment demonstrates improvement in both water reliability and water quality.

Define the Local Problem - Often utilities focus on the proposed project before the problem is clearly defined or accepted by the audience. Make sure that you define the needs of the community within the context of water reliability planning. Focusing on the problem establishes the fundamental motivations and answers why the utility is reaching out to the community in the first place.

Communicate the Benefits of Water Supply Replenishment - Use the "planning for reliability" context to demonstrate that Water Supply Replenishment is a compelling option. It improves water quality, increases drought resistance without having to build new reservoirs, does not require separate delivery or storage infrastructure, and leverages past investments made in transporting or treating water.

Express Costs in Meaningful Terms - Show the costs of alternatives in terms of relative impact on rates or fees. Costs expressed in dollars are not meaningful.

Step 3: Develop Credibility and Build Trust

Make Sure You State Your Corporate Values - Express the key values that drive the behaviour and decisions of the utility. These should be *commitments* related to ensuring a reliable water supply and preservation/management of key assets. For groundwater this might be a commitment to balancing withdrawals and replenishment.

[18] The WateReuse Foundation uses the term "Water Supply Replenishment" to mean supplementing drinking water supplies with recycled water. In this appendix there are a number of other American terms that are used. These need to be applied in an Australian context.

Appendix 3 Advice checklists
continued

Present the Options for Solving the Problem - People want to see that you have not adopted a specific solution without seriously considering alternatives. Show them that you have considered all the options. Always share your logic.

Make a Recommendation - You *should* recommend a solution, but lead a dialogue about the alternatives. Make sure that the rational for recommending Water Supply Replenishment is clear and that you are listening to people's concerns.

Use Your Values to Manage the "No Growth" Argument - It is not the role of water utilities to make growth planning decisions. Emphasise that your job and commitments are focused on delivering water reliability. Part of this commitment involves taking into account projected growth. Not planning for growth would be malpractice. Do not be shy about your *commitment* to planning for reliability.

Checklist 2: Creating Water Quality Confidence

Step 1: Establish Your Water Quality Values

Commit to Water Quality Improvement - People are not inclined to support investment in projects that degrade quality of life or that maintain the status quo. Make it a core value to improve water quality as your knowledge grows.

Commit to Increasing Knowledge - People know that science is not perfect and that things change. They will accept that growth and the expanding use of chemicals impacts source water quality. Telling them there is nothing to worry about won't fly and is not generally true. Investing in more knowledge is cheap compared to managing conflict and lawsuits.

Manage Emerging Contaminants - Articulate actions or plans that address emerging or new contaminants.

Connect Actions with Motivations - When describing treatment technologies or methods, always include the motivation for employing the method or process. Remind them that the motivations originate from meeting your commitments.

Step 2: Be the Trusted Source of Information

Communicate How and Why You Test - Communicate in simple and meaningful terms how much you test the water quality and why. Make sure that your audience knows that you are asking the tough questions and looking for answers.

Share Your Emergency Response Plans - Share your plan for responding to water quality problems. Be proactive in your response to the problem and communications. Working through problems with your community can create more trust than having no problems at all!

Articulate Water Quality Risks - Define the issues and risks that need to be addressed in simple and meaningful terms. Describe the different types of contaminants, where they come from, and why they are a problem. People who are paying attention won't buy that there are no risks.

Describe General Treatment Capabilities - First, let people know that we can make the water as pure as we want to. Describe in simple and meaningful terms the operations of separation, destruction, and disinfection. Being simple, yet meaningful will increase trust. Technical information without meaning erodes trust. For example, relate treatment processes to familiar things - such as kidney dialysis or bottled water treatment.

Step 3: Be the Trusted Source of Quality

Put Source Control in the Proper Context - Managing and improving the quality of source waters should be described as one of many things that the utility does to create high quality water. Putting source control in the context of the entire process of water quality management keeps people from believing that the physical source determines final water quality.

Use Multi-Step Purification Processes - Once people understand that the source water is unacceptable for drinking, they will want to see a process that puts some distance between the source and the final water product. Communicate how multiple and diverse steps address a broad spectrum of contaminants, create system redundancy, create safety factors, and establish

Appendix 3 Advice checklists
continued

long-term sustainable solutions. Categorise these steps as separation, disinfection, or destruction.

Employ Natural Treatment Processes When Possible - Design in or highlight natural treatment processes. Studies and experience show that natural processes increase people's confidence.

Use Track Record to Create Confidence - Scientific data alone is usually ineffective when trying to create confidence. Science and data are not fool proof. Share track record information about your utility and the industry. It helps to have specific examples where you have taken a stand and advocated for improved water quality.

Checklist 3: Turning Conflict and Opposition into Assets

Step 1: Lead a Meaningful Community Dialogue

Carefully Select Utility Spokespeople - Spokespeople should be employees of the utility, be committed to the need for investment, and have a genuine desire to have a meaningful dialogue with the community. They must be clear-spoken, not condescending, and have the authority to speak for the utility.

Provide Information for Participation and Sound Decisions - Meaningful public participation requires timely and full access to information about proposals, problems, impacts, and alternatives. Those with the resources must produce this information and share it. Make sure that there are widely announced opportunities for comment on all documents, and that people receive the documents well in advance of meetings.

Address the Process Needs of All Participants - People understand issues, communicate, and make decisions in many different ways depending on gender, class, race, culture, religion, and education. The dialogue must include participants in the process design and address issues that may not be important to all parties.

Enable Members of the Public to Speak For Themselves - The public must articulate for itself and in its own ways what their concerns and interests are.

Step 2: Embrace Differing Points of View and Listen

Gather Diverse Opinions - Actively seek out and understand different perspectives, concerns, suggestions, local expectations and needs, and different priorities.

Public Participation Should Have an Impact on Decisions - The public's engagement should have an impact, or else they will believe that they are window dressing for decisions that are already made. Such 'non-effectual' participation de-legitimises the process, sours relations, makes future interactions more difficult and robs the utility of important information and creative ideas.

Assess the Community with Respect to Conflict - All communities have a history of conflict, which can act as a catalyst for conflict on new issues, especially if they are controversial. Assessing past conflict involves understanding what happened and who was involved. Those involved should be high on the utility's relationship development list.

Find Opposing Points of View Early - Finding opponents after major capital has been committed is a problem. Design communication efforts such that they find people with differing points of view. Highlight decision points early in the process to encourage opponents to identify themselves and engage.

Step 3: Develop Relationships with Opponents

Pursue Individual Relationships - The number of opponents, or those who lead groups of opponents, is usually not a large number of people. As a result, utilities can and should pursue individual relationships.

Understand the Motivations and Needs of Opponents In order to foster a relationship, you have to listen. Seriously try to understand the motivations of opponents. Sometimes people just want to be heard. Listening also allows you to improve your messages and uncover flaws with your current proposal.

Make Sure Opponents Understand Your Constraints In developing relationships, both parties must come to understand the other's situation. Make sure that opponents understand the constraints that the utility is working under or assuming. This helps them better understand your motivations. Working together, you may be able to remove constraints or secure more investment.

Avoid Labelling Opponents as Irrational - Marginalising those who disagree without ever pursuing a relationship with them is the easy way out, unproductive, and risky. Pursuing a relationship allows you to better assess risks, and can turn a liability into a relationship asset.

Checklist 4: Ensuring a Good Policy Decision

Step 1: Understand and Support Policy Makers

Develop a Positive Attitude About Policy Makers - Assume policy makers are ethical and want to protect the interests of their constituents. Be willing to understand their motivations and concerns. Don't judge their actions and decisions as "politics" without careful consideration and attempting to understand their motivations.

Develop a Foundation of Written Support - "Cover" and help policy makers be confident by developing a strong foundation of *written support*. Asking for written support encourages a deeper, stronger relationship.

Develop Political Champions - Development champions within governing bodies, especially if multiple governing bodies have jurisdiction or influence on outcomes.

Keep the Relationships Going - Maintain a database of key audiences/relationships and periodically send them information updates. Keep it simple and relevant to motivations, value, and investment.

Step 2: Build Strong Relationships

Define Priority Relationships - You can't reach everyone. Prioritise people that policy makers listen to, represent a larger group, have been involved in past conflicts, or are likely to energise conflict.

Identify Early Supporters - Early in the outreach process, identify and seek out "early adopters" who are willing to give written support without having to see a long list of supporters.

Create Water Quality Confidence - Create water quality confidence by becoming the trusted source of quality. Emphasise your water quality ethics and actions.

Turn Conflict and Opposition into Assets - Seek out and embrace conflict and opposition as a path to stronger relationships, more committed supporters, and better outcomes. Create events *designed* to find opponents early. Finding opponents after significant capital has been committed to a specific project can be very expensive.

Step 3: Communicate with Purpose and Diligence

Adopt a Collaborative Communication Style - Don't waste your audience's time by not listening and learning. Seek to understand people's motivations and ask "why" a lot. Your audience has valid inputs.

Lead a Meaningful Dialogue - Lead a meaningful dialogue about water supply reliability, the need for new water supply, and the options for creating new supply. Make sure your communications emphasise the problem and your commitment to solving the problem, not a pet project.

Pay Attention to the Media - Reach out and develop ongoing relationships with the media. Don't just show up when you need something from them. Help them by being a good source of information and stories.

Understand Public Sentiments - Document feedback and collect information from your audiences during all meetings. Compile and use this information to improve your message and help policy makers be more confident.

Glossary

Aquifer
A layer of porous rock and soil that stores water and allows it to drip through. Aquifers provide natural underground storages of water.

Dam / Reservoir
Technically, the dam is the wall that holds the water in and the reservoir is the water. Commonly, though, the words are interchanged.

Desalination
The removal of salt and other impurities from water sources, especially seawater.

Drinking water
Water that is treated to meet the *Australian Drinking Water Quality Guidelines 2004*, and is safe for supply directly to households, commercial premises and industry for drinking and other purposes. These guidelines address contaminants that may be present in source waters, typically rivers or groundwaters.

Environmental buffer
An environmental buffer may consist of a stretch of river, a water supply reservoir or a soil-aquifer system to which recycled water is added. The need for an environmental buffer is an important component of risk management.

Gigalitre (GL)
One thousand million litres (1,000,000,000 litres). Sydney Harbour is just over 500GL in capacity.

Greenhouse gases
Generally relates to the enhanced greenhouse effect where man-made emissions of gasses such as carbon dioxide and methane collect in the lower atmosphere and reflect solar radiation back to earth.

Greywater
Wastewater from household laundries, bathrooms and kitchens that varies in quality from relatively clean to containing significant contamination including harmful microorganisms.

Groundwater
Water collecting below ground level in an aquifer or water table.

Megalitre (ML)
One million litres. (1,000,000 litres). A swimming pool of dimensions 50 metres x 20 metres x 1 metre deep contains one ML of water. Typically Australian households use 0.3ML of drinking water per year.

Microfiltration
Water which is pumped into pipes constructed of filter membranes with tiny pores too small to allow suspended solids and some pathogens to pass through. The process is now commonly used for both water and wastewater treatment.

Microorganisms
A living being that is too small for the naked eye to see. Microorganisms include bacteria, algae or fungi that live in soil, air or water. They can be useful or harmful (pathogenic).

Nutrients
Substances such as nitrogen and phosphorus which promote the growth of plants and algae. Excessive nutrients in waterways contribute to algal blooms and degrade our waterways.

Ocean outfall / River outfall
A site where liquid, usually treated wastewater from a wastewater treatment plant, is discharged through a pipe into the ocean or river

Permanent water saving rules
Rules (such as a ban on hosing paved areas) designed to save water at all times regardless of storage levels. Rules also assist the promotion of a water conservation ethic in the community.

Receiving waters
Water (such as in rivers or oceans) into which treated wastewater is discharged.

Reverse osmosis
This treatment process forces water at very high pressure through very fine membranes that remove the majority of chemicals including salts. Reverse osmosis removes microorganisms, organic chemicals, and inorganic chemicals, and is capable of producing very pure water.

Glossary
continued

Stormwater

Rainfall that runs off roofs and roads and other surfaces and flows into gutters, rivers, creeks, bays and oceans. This water can carry a wide range of contaminants. Some are obvious such as plastic bags or oil from roads. Others are not so obvious, such as nutrients and heavy metals.

Wastewater

Any water which has been used at least once and cannot be used again without being treated. Treated wastewater can often be used for recycling purposes depending on the level of treatment undetaken.

Water conservation

An approach to reducing the overall demand for water. It is also called demand management. Water conservation measures include educating people about how to save water, promoting the use of household and industrial appliances that use water more economically, such as dual-flush toilets, and pricing water to a level that provides people with a signal of its true value.

Water recycling

Water recycling is the multiple use of water, usually sourced from sewerage systems, that is treated to a standard appropriate for its intended use.

Water restrictions

Compulsory limitations on the time and use of water introduced by governments or water authorities to conserve drinking water during periods of drought.

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