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Making the most of Adelaide's water

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Abstract

Adelaide, South Australia, home to over one million people, is the capital of a desert state. Its water must be used carefully for the city to survive and prosper. Over the past decade or so a number of major initiatives have been taken, including the promotion of the integrated management of river catchments, formerly fragmented between different jurisdictions; the storage, cleaning and reuse of stormwater through techniques including the development of artificial wetlands and aquifer recharge; the introduction of dual reticulation systems in new housing areas which provide recycled water for purposes where drinking water is not required; and the reuse of wastewater which is piped to horticultural and viticultural areas for irrigation. These measures have all helped to restrict the city's water consumption, as well as provide a number of other environmental benefits, including, in particular, a reduction in the amount of polluted water discharged into the sea. This paper outlines the initiatives taken, describes the benefits they have produced, highlights the key factors necessary to bring the projects into being and assesses their contribution to making Adelaide a more sustainable city.

Introduction

Adelaide, the capital of a desert state, has water use patterns that are unsustainable. It also faces problems of estuarine and off-shore pollution. Given continual pressure for the expansion of export-based industry to the north and south of the city, these problems will only become worse unless serious measures are put into place the make better use of Adelaide's water.

This paper discusses the nature of the water problems facing the city and outlines what measures are being taken to make the city's water use sustainable. The paper looks at the reuse of sewerage water, the use of storm water through

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aquifer recharge, and the measures taken to prevent pollution of coastal waters and of one of Adelaide's most important recreation spots.

These measures have provided multiple environmental benefits as well as boosting the state's economy. But much more can be done, and in the concluding discussion we note the need for appropriate incentives to see that it is done.

The city of Adelaide and its water use

Adelaide was established in 1936 and has grown to be a city of 1.1 million people. Adelaide's rainfall is 553 mm, though Adelaide Hills, which provide the catchment area for local storage, typically receives 50% more than this amount. About two thirds of this rain falls in the six months from May to October. These are the coolest months and water usage is much higher in the rest of the year, requiring significant water storage.

Despite this storage, Adelaide cannot sustain itself with local rainfall. Adelaide is a low density city and its residents have a penchant for suburban gardens and other features that use water heavily. Annual average water consumption is about 182,000 litres per person (including industry and public uses); 270,000 litres per household for residential use. (SA Water, [1])

Local water needs to be supplemented with water pumped from Australia's largest river, the Murray. In an average year about 40% of Adelaide's water is obtained this way, but the proportion can rise to as high as 90% in drought years. Importantly, the city does not pay to withdraw this water from the river, in contrast with other users, who must buy the rights to draw water on the open market.

But overuse of the river and land clearing along its route over many years has created an environmental crisis to the extent that the Murray Darling Basic Commission predicts that within 20 years the River Murray's water will be too salty to drink. (SA Water, [2])

Furthermore, Adelaide is located on the coast of Gulf St. Vincent, a shallow stretch of water that is important for recreation and commercial fishing. Adelaide's coastal waters are very susceptible to pollution from stormwater or sewerage. The city cannot afford the luxury of simply channelling its sewerage through long pipes into the ocean. The mangrove swamps of the Barker Inlet and Port River Estuary are particularly sensitive, being breeding grounds for fish and crustacean populations on which local commercial and recreation fishing depend. The waters are also home to a variety of local and migratory birds, some of which are endangered.

Responsibilities for managing water

Before turning to the measures taken to deal with these problems, some explanation of the institutional responsibilities for water is necessary.

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Australia is a federal system with three levels of government: national, state (provincial) and local.

Adelaide is the capital of the state of South Australia. With the metropolitan comprising some 17 local government authorities, it falls to the State government to provide most water and to deal with pollution and stormwater problems extending beyond council boundaries. Despite this, stormwater is formally a responsibility of local government, not the state government.

In an effort to overcome boundary problems the state government has formed water catchment management boards. The Adelaide metropolitan area has five of these, one for each of the three catchment systems that cross the Adelaide plains (the Northern Adelaide and Barossa, Torrens and Patawalonga Catchment Water Management Boards) and one for the hilly suburbs to the south and east (the Onkaparinga Water Catchment Management Board). These boards were established in 1995 and comprise local members appointed by the minister of their expertise and/or because of their local government links. They are funded from a levy on properties in the catchment area. Their essential role is to prevent abuse of the natural water resources in the catchment area, through education, infrastructure projects, monitoring and regulating water use.

The three key agencies at state level responsible for water are the Department of Water resources, SA Water and United Water. The former is a state government agency that advises the minister and government as a whole on water policy. SA Water is a public corporation, 75% funded from water rates and charges, which has overall responsibility for implementing state government water policies, including the provision of water to industry and households and for sewerage systems. SA Water contracts the management of its infrastructure assets serving the metropolitan area to United Water, a consortium established by Vivendi Water, Thames Water and Brown and Root to provide water management services in Australia. United Water is half way through a 15 year contract with SA Water to manage the state government's water infrastructure, including its reservoirs, pipes, pumping stations and waste water treatment plants (WWTPs).

Wastewater reuse

The four wastewater treatment plants along Adelaide's coast deal with almost 100,000 ML of water a year. This has traditionally been treated to a point at which it is suitable for marine discharge and then pumped into the sea. This "B" class water is highly suitable for horticultural and other agricultural irrigation. Currently 16% of this water is reused, mainly for irrigation. Although some water reuse has been practised since the 1930s, the proportion has risen dramatically in the past five years and SA Water has a target of 30% of water being reused by 2005. It is hoped that eventually 50% will be reused. (SA Water, [1])

The problem caused by the sensitivity of coastal waters to pollution has created an opportunity in terms of the provision of water. Concern about marine pollution has led to the raising of standards required to be met before the water

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can be discharged into the sea. For example, as a result of these standards, the total amount of suspended solids discharged into the sea halved between 1996/97 and 1999/2000. (SA Water [3]) The suitability of wastewater for reuse has been improving as a result of these standards, to the point that irrigators are now happy with the quality of this water.

Bolivar

Bolivar is Adelaide's major wastewater facility, handling half of the city's wastewater. Before recent efforts to improve the standard of water treatment and to reuse the water, it was major threat to the seagrasses and mangroves in the nearby Barker inlet, and to the fish and birds that rely on them.

At the same time, market gardeners in the Virginia area, 15 kilometres to the north of Bolivar, were becoming subject to increasingly restrictive limits on their water use. The soil on the northern plains has always been good by Australian standards and the warm, sunny weather allows a wide variety of crops. It is at the centre of a State government strategy to treble the value of food produced in the first decade of this century.

The limitation to this expansion has been water. Horticulturalists have traditionally relied on borewater. However the use has not been sustainable and the aquifers have been suffering from depletion and salinity. During the 1990s water was being drawn at twice the recharge rate, resulting in plummeting water tables and increased salinity. The Northern Adelaide Water Catchment Management Board placed controls on the amount of water that could be drawn.

The need to deal with the wastewater problem provided an opportunity for the horticulture industry. A pipeline from Bolivar began delivering water to the Virginia area in 1999. The A$22 million (US$11million) pipeline was paid for through roughly equal contributions of private investment, state and national funds. The pipeline has been built and operated as a BOOT scheme, with the pipeline being transferred to the SA Water in 2018. The irrigators receive the water for about 10 cents a kilolitre, well below the price paid by domestic users.

The scheme to reuse this water by pumping it to the nearby horticultural industry for irrigation represents Australia's most significant reuse of effluent for high quality water purposes. It is expected that reused water will double the horticultural output of the area over ten years, with estimates of the potential value increasing as much as four times in the longer term. (Advertiser, [4]) 23% of Bolivar's wastewater (about 10,000 million litres) is pumped to Virginia at the moment and this proportion be doubled in the future. Expansion beyond this will require aquifer storage of winter water to be drawn in summer. This is being examined.

The Bolivar experience represents the first large-scale use of DAFF (dissolved air flotation and filtration) technology in Australia, and one of the largest in the world. Under this technology, sewerage is maturated for 16 days in detention ponds and treated with coagulating chemicals and high pressure bubbles to cause suspended material to flocculate and float to the surface, where it is skimmed off. The cleaned water is then drained through anthracite and sand

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filters and disinfected with chlorine. (Clayton, [5]) The result is water of such quality that it is permitted to be sprayed onto salad and other crops that can be eaten raw.

The major limitation on the proportion of water that can be reused this way is salinity. Some 4,400 tonnes of salt enters the Bolivar WWTP every year. Indeed, the salt content of some water from the G H Michell wool washing plant (discussed below) is too high even for discharge into the sea. This water is to be separated from the 2 megalitres of low salinity rinsing water produced by the wool washing plant. The rinse water is being cleansed and used for irrigation

Willunga Basin

The Willunga Basin, 25 kilometres south of Adelaide's city centre, is on the fringe of the metropolitan area. It has traditionally been a picturesque almond growing centre and most of the land in the basin is reserved for agriculture.

Unfortunately the area also suffers from a lack of water. Depletion of the local aquifers led to the government imposing licences to restrict the amount of water drawn from underground sources in 1990. These restrictions have become increasingly severe, and have encouraged a shift of land use from almond growing to grape and olive production, which earn a higher return for a given amount of water used.

The Christies Beach WWTP serves about 150,000 and had been pumping 10 billion litres of water a year into the sea; water that had been treated first to prevent pollution to the marine environment. Recent increases in the required treatment standards have led to this water being suitable for irrigation.

At the same time as the government has been capping the amount of groundwater that can be drawn, it has also been encouraging the rapid expansion of South Australia's wine industry as a major export earner. The Willunga Basin includes the McLaren Vale, one of the most important wine producing areas in Australia.

Pressures for expansion led the Willunga Basin Water Users Group (a body consisting mainly of vignerons) to establish a company to pay for the construction of a pipeline from the Christies Beach Waste Water Treatment Plant. The company has built the infrastructure required (included advance telemetry to optimise water use) and charges its customers a price that is fixed at two thirds the cost of mains water.

The trunk pipe is 20 kilometres long, with the first outlet 15 kilometres from Christies Beach. Currently it takes 11% of the water from the plant, but this is expected to rise to 20% in the short-term. The Group's members allocated only 25% of the available water from the scheme to themselves, allowing for plenty of expansion. The current pipe and pumping capacities allow all users to be able to drip feed at the same time, but further drawing on the scheme will require more local storage. (Irrigation Australia, [6])

Despite the fact that less than a fifth of the available water is actually used for irrigation, the government is under constant pressure to allow more ground water to be pumped, despite the depletion of the resource and the increasing salinity

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that results. This is possibly because the bore water appears to be free, though of course this appearance belies the cost of pumping and the capital and maintenance costs of the bore. It is interesting to note that those who have fought to overturn the restrictions on ground water use have been traditional almond growers. None of these have chosen to take the opportunity of purchasing reused water.

Stormwater

In an average year, 180,000 ml of stormwater flows off Adelaide's open space, roofs and roads, into drains and streams and out to Gulf St. Vincent. This amount almost equals total water consumption. The water itself threatens marine ecology, as by the time it reaches the sea it has gathered litter, industrial waste, oil off roads, garden nutrients and chemicals, etc.

Clearly there are two major advantages if this could be prevented: an enormous amount of water could be available for use, and the streams and marine environment would not be polluted. The catchment management boards, as well as state and local government agencies, are undertaking numerous projects to prevent polluted rain water entering the sea. These generally fall under the categories of

- prevention of pollution at source through education and regulation,
- cleansing of stormwater through engineering measures, including the creation of artificial wetlands
- making more efficient use of water through aquifer storage and recovery.

The following details examples of the last two of these. The examples are all taken from the City of Salisbury, a council area occupying a large proportion of the north of Adelaide. The Salisbury examples are followed by an account of measures taken to clean the Patawalonga Lake, a marina and former estuary that drains about half of Adelaide's catchment area.

Salisbury

Noting that the stormwater was pooling in an area of under-utilised land at Para Hills, the Salisbury City Council in the late 'sixties decided to landscape the area and turn it into a recreational asset. This became the City's first wetland, known as The Paddocks. It was soon found that the area attracted a host of bird life and a number of other fauna, thought to no longer exist in the area. But, importantly, it was also found that the slow-moving water allowed most of the heavy metals picked up from the streets to settle as sediment; reed beds planted along the banks very effectively filtered the nutrients; aquatic micro organisms decomposed organic matter and the action of sunlight and oxygen through the shallow water effectively removed many of the biotic pollutants. Within just a few days, it was found that the stormwater had been substantially cleansed.

From these beginnings the idea developed that wetlands might contribute significantly to dealing with problems of water supply, both qualitative and

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quantitative, in Northern Adelaide. In the early 1990s, the additional notion of underground storage of water also came to be seen as a potentially significant component of an overall water management strategy. The seasonal nature of Adelaide's rainfall – hot dry summers and wet winters – means that Salisbury had high irrigation costs in summer but a surplus of water in winter. In collaboration with local universities, the city's engineers explored the potential of storing water in underground aquifers and developed an experimental bore, again at The Paddocks, in 1994. Trials were successful, and demonstrated that aquifer conditions were suitable to store large volumes of water for subsequent reuse. An additional benefit is that the aquifers beneath the City of Salisbury have been heavily depleted through intensive agriculture and other ground water users. Recharge bores, which combine recharge and extraction capacity within the same structure, monitor water quality and shut the injection process down if quality falls below acceptable standards.

In the mid-nineties the City of Salisbury set the ambitious objective of eliminating completely the flow of polluted water into the marine environment of the Barker Inlet. By developing an extensive series of wetlands and implementing aquifer storage and recovery technology, the City of Salisbury is contributing to the ecological rehabilitation of the Barker Inlet while providing cheaper water to local industry and other users.

The City of Salisbury now has some 36 major wetlands, covering in all several square kilometres. In addition, all new residential subdivisions in the last ten years have been required to install wetlands to contain stormwater on site as much as possible, while large industrial developments have been actively encouraged to develop wetlands for the same reason, and in order to contain potential industrial spills on site. Collectively, these initiatives have effectively eliminated flood risk in an otherwise flood-prone area, and have dramatically increased the wildlife habitat and biodiversity within the City. They have substantially reduced the flow of polluted surface water into the fragile Barker Inlet estuary. And, as a somewhat unexpected benefit, they have opened up substantial new opportunities to derive economic benefits from the recycling of stormwater. Two recent projects in particular have demonstrated the enormous potential of this new technology: the Parafield/Michells project; and the Edinburgh Parks project.

The Parafield/Michells project is a major initiative to manage stormwater in the area to the north and east of Parafield Airport, a busy general aviation airport in the middle of the City of Salisbury. G H Michell is Australia's largest wool processing company. The company's processes involve the use of huge quantities of mains water to wash the wool, and similarly large quantities of effluent and sludge waste water are generated. The costs of fresh water and sewerage disposal were high enough to force the company to consider alternative, cheaper locations elsewhere, potentially resulting in the loss of around 700 jobs.

Following a trial developed and monitored on the Michell site, it was demonstrated that the wastewater could be readily treated through natural wetlands, and a concept was developed for a commercial alternative to mains

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water supplies. The concept presented by the City of Salisbury involved diverting stormwater from existing drains to a system of constantly flowing, bird-proofed reed bed ponds on Parafield Airport land, where it would be filtered, cleansed and supplied directly to users, with the surplus water injected into underground aquifers for extraction during dry periods. In the first stage alone, 1.1 thousand million litres of water that was being pumped annually from the River Murray to supply the Michell plant and other users would stay in the river. Instead, these users would rely on the high quality harvested stormwater from the Parafield Airport catchment. The project - now a jointly funded venture between the City of Salisbury and G H Michell & Sons – has resulted captured and cleansed stormwater with a markedly lower salinity than that of mains water and which can be supplied for around half the cost to local industry, irrigators and the community.

The City of Salisbury is the proponent and consortium leader in the Edinburgh Parks project to collect, filter and cleanse stormwater in the catchment around the General Motors Holden car manufacturing plant in the northern suburbs of Adelaide. Holden has been part of the local community for more than four decades. Its plant covers approximately 122 hectares and employs around 4,300 people. The treated stormwater will be supplied to Holden Ltd and to new industries in the nearby Edinburgh Park precinct. This project is even larger than the Parafield project with a design supply capacity of 2,300 million litres per annum. This project will be constructed in stages. The first stage will involve supply to General Motors Holden, Edinburgh Parks, and local irrigators. The second stage will further expand the scheme to supply the Defence Science and Technology Organization (DSTO) and the Edinburgh Airport for the Royal Australian Air Force (RAAF). Detailed design of this scheme is currently in progress and construction of Stage 1 is expected to commence by October 2002.

The Patawalonga

The Patawalonga (or "Pat", as it is locally known) has been the outlet for at least half of Adelaide's stormwater. Before the city's establishment it received a reasonably constant flow of fresh water from the streams that originated in the Adelaide Hills and crossed the southern half of the Adelaide plain.

As the city expanded, two problems began to arise.

1) the amount of fresh water flowing through the estuary declined and became irregular, as local storage and hard surfaces reduced the regular flow. The flow became dramatically more irregular when the main stream feeding the Patawalonga, the Sturt River, was "channelized" as a flood mitigation measure. For most of the time the Pat was a body of still salt water that, because it was not regularly flushed, suffered from anaerobic decay of marine organisms.
2) the storm water that did enter the Patawalonga became increasingly polluted with anything that entered the drains of Adelaide: litter, industrial and household chemicals, oil and so on. It also included treated effluent from the Heathfield WWTP in the Adelaide Hills.

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As one of the ten most polluted stretches of water in Australia, the Pat became a major embarrassment. Once an important recreational area, any activity that brought people into contact with the water was banned. The cleaning of the Pat became a government priority, particularly as the government sought to progress a major real estate development on adjacent land.

The Patawalonga is now a clean, regularly flushed stretch of water in which water sports are once again permitted. A number of measures were necessary to bring this about.

In common with all catchment areas of South Australia, the Patawalonga Catchment has been subject to a number of measures to reduce pollution at source. Regulations to prevent industrial pollution of watercourses have been enacted. The Patawalonga Catchment Management Board undertakes educative and engineering measures. The streams that feed the Pat now have two wetlands, a silt trap, floating trash boom and at least 20 trash racks to cleanse the water before it reaches the sea. The required quality of water emitted from the Heathfield WWTP has been raised and — after some prodding from parliament's Public Works Committee — a project is underway to meet the standards.

While these measures have certainly improved the quality of stormwater, their full potential will not be felt for a number of years, even if all targets are met. Instead, a new outlet has been constructed a kilometre further up the coast, with stormwater ducted through pipes that extend 200 metres off-shore. This will carry stormwater out to sea — stormwater that will be polluted until the upstream prevention measures are fully implemented.

In any case these prevention measures do not address the first problem outlined; that of anaerobic decay. Here the solution has been tidal flushing, using gates on weirs that act as valves. There are now two sea outlets, with weirs at either end. These are electronically controlled to make best use of the tide to flush the lake twice a day.

The weir system also acts as a flood control measure. The pipes at the Barcoo Outlet are not capable of handling the quantities of water that are produced every couple of years or so when Adelaide has a major downpour. In such cases the water levels of the new channel rise above the weirs of the Patawalonga and flows out to sea via the Pat. Such floods rarely last for more than a day or so and the marine environment is soon re-established.

The measures taken to clean the Pat do not of course restore the estuary to its pristine condition. The measures taken are a compromise, with the quantity, regularity and quality of stormwater flowing through the new outlet still not ideal. Indeed, it was argued that when it was it most polluted, the Patawalonga at least acted as a settling pond, removing many of the heavy metals and toxins from the stormwater before it entered the sea. Without the measures taken to reduce pollution throughout the catchment, the diversion to the new outlet would only increase marine pollution.

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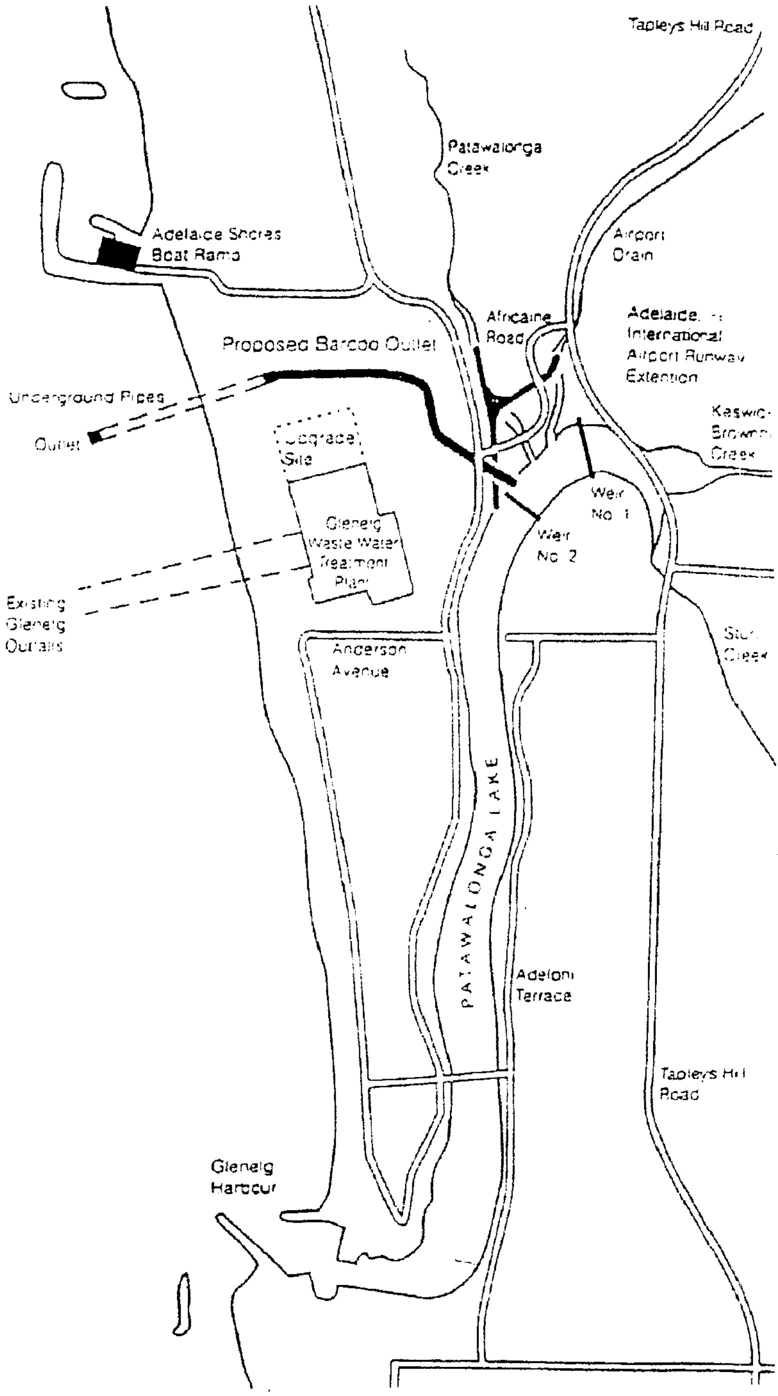

Figure 1: Patawalonga Lake and Barkoo Outlet

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Discussion / Conclusions

The measures outlined in this paper are all admirable examples of what can be done to make better use of water.

The City of Salisbury's experience demonstrates how recycled water derived from wetlands or stored in underground aquifers can be supplied in large volumes at very competitive prices to large water using industries, while the waste effluent from these industries, including effluent laden with detergent, oils and paints, can be effectively and cheaply cleansed for recycling through a natural wetland. Salisbury shows that economic benefits and environmental imperatives can be reconciled and that there are ways of reducing the pressure on the threatened waters of the Murray and the fragile marine ecosystems of the Gulf that can also support local industry and employment.

But Adelaide still has a long way to go before it can wean itself off the River Murray. The further steps needed for sustainability are even more challenging in the context of ageing pipes that leak water and allow saline underground water to enter, increasing population and increasing industrial production. Much more can and should be done.

The educative and engineering measures discussed here will only be taken further if the appropriate financial and regulatory framework is established. As a profit making corporation, SA Water has an interest in maximum consumption, and in its 2001 Annual Report, boasted.

SA Water moved strongly ahead in the 2000-01 financial year with a record profit before tax of $207.7 million, record consumption of water... (SA Water, 2001, p. 8)

The framework in which SA Water operates needs to be changed to reward minimizing use of water.

Fortunately SA Water and its major contractor have risen to the challenge of meeting increasingly onerous pollution standards imposed on it by the government. These standards have led to the development and adoption of technology that is world-leading and a significant source of foreign income. We are confident that dramatic challenges, such as making Adelaide pay the market price for River Murray water, will produce similar opportunities in terms of making more efficient use of our water, so that the 50% target for water reuse will appear modest.

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