Local Government Association of South Australia State Government of South Australia

Metropolitan Adelaide Stormwater Management Study

Part B

Stormwater Harvesting and Use Final Report

KBR

LOCAL GOVERNMENT ASSOCIATION AND STATE GOVERNMENT OF SOUTH AUSTRALIA

Metropolitan Adelaide Stormwater Management Study

Part B – Stormwater Harvesting and Use

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INTRODUCTION

In 2003, the Local Government Association of South Australia prepared the 'Stormwater Management Strategy' dated 27 June 2003, and presented it to the State Government (Minister for Local Government).

The Strategy, targeted specifically at metropolitan Adelaide, was prepared to 'provide a constructive means to address the significant challenges and opportunities in relation to stormwater management in metropolitan Adelaide'. Endorsed unanimously by all metropolitan council Mayors and Chief Executive Officers, the strategy proposed a partnership approach to stormwater management with equal responsibility for funding between councils and the State Government.

'Step 1' of the proposed strategy – an independent study to clearly define 'The What' subsequently resulted in the preparation of the terms of reference brief for the 'Metropolitan Adelaide Stormwater Management Study' (MASMS). The MASMS is being undertaken in three distinct, although inter related parts:

- Part A—Audit of Existing Information
  - Component 1: Assessment of the current position
  - Component 2: Recommended actions/way forward
- Part B—Stormwater Harvesting and Use
- Part C—Apportionment of Council Costs.

This report constitutes the outcome of Part B: Stormwater Harvesting and Use.

Stormwater harvesting and use is one part of the sustainable management of the urban water cycle embraced within water sensitive urban design (WSUD) which includes holistic management of urban rainwater, stormwater, groundwater and wastewater. This report focuses on the emerging technology and community interest in harvesting and use of stormwater, recognising it as a resource rather than a disposal problem.

CONTEXT

Use of urban stormwater as a supplementary water resource for Adelaide was first investigated by Miles in the early 1950s based around enhancing brackish aquifers by stormwater recharge to provide a fresh groundwater reserve for use in times of water shortage.

A major attraction of the use of injection wells (bores) and aquifer storage in an urban context is that only a small surface footprint is required for the wellhead works to achieve a very large storage which can underlie the urban development it serves.

Since the 1950s the concept has been advanced resulting in the quantification of the stormwater resource, an understanding of the accessible metropolitan aquifer systems, and the implementation of trial aquifer storage and recovery (ASR) installations leading to the development of significant non potable stormwater harvesting and ASR installations of 0.5 to 1.0 gigalitres per annum (GL/a) capacity.

The metropolitan stormwater runoff to the Gulf is generally recognised as currently being between 160 and 250 GL/a, which compares to the 200 GL/a current mains water use by the metropolis. This tantalising fit of unused resource (which expands with urban growth) and demand has excited visionaries, researchers and practitioners over the years. The concept has received impetuous of late due to the realisation that the Murray River, a major source of Adelaide's water supply, has been significantly compromised in quantity and quality through overuse by irrigators and associated saline drainage impacts.

Apart from quantifying the stormwater resource, almost all of the development work undertaken to date has focussed on the availability and capacity of ASR as a means of providing small footprint storage in the wetter winter months for use in the high demand summer months. There has generally been a lack of focus on efficient capture and cleansing for injection, storage and use.

The pioneering harvesting projects undertaken by the City of Salisbury, the development of the WaterCress hydrologic modelling tool by Creswell and Clark, and an understanding of wetland cleansing dynamics by Lawrence and the CRC for Catchment Hydrology, has allowed techniques to be established for the sizing of capture and wetland cleansing works.

A prime objective of this report is to review and evaluate the current knowledge of the processes and spatial requirements for stormwater capture, cleansing and storage works; pre-conditions required for viable harvesting and use; and to highlight what lessons have been learnt from existing schemes. In addition, opportunities for and constraints to stormwater harvesting throughout the developed and undeveloped parts of metropolitan area have been examined.

CONCLUSIONS

It can be concluded from the work undertaken that stormwater harvesting schemes exhibit a definite economy of scale in both the capital cost and production cost areas. Supply levels of 100 ML/a or more trend to a unit capital cost of below $5,000/ML/a, and a unit production cost including loan repayments of below $1.00/kL, which is competitive in relation to the current mains water tariff of $1.03/kL.

Spatial requirements for capture, cleansing and aquifer storage or surface storage demonstrate that scheme providing 100 ML/a with ASR requires 1.2 to 2 ha (approximately 20 to 30 house lots) for the harvesting works. This rises to 12 ha (approximately 150 house lots) for a 1000 ML/a ASR scheme similar to that on Parafield Airport. If surface storages have to be used for seasonal balancing, the area required for the works is five to six times larger.

It can be seen that whilst the availability of ASR can greatly reduce works area requirements, the land take is still significant, particularly from a developer's perspective even for greenfield sites. For urban regeneration and infill projects where the square metre value of land is usually much higher, the loss of return to the developer from allocation of the harvesting works areas is a significant disincentive to this level of WSUD proceeding. The compensating factor is that around 70% of the combined household and open space water requirements of the development may be economically provided from this local resource as a second pipe non potable supply, should the incentives to do so exist.

In the nineteen Council interviews conducted the most common impediments to adopting stormwater harvesting schemes noted were the lack of available land for capture and/or cleansing works and lack of identification of potential users, particularly industrial users.

Problems are experienced from time to time with clogging of ASR wells during injection from particles in the injected water, biological growths and chemical reaction products. Various methods are used to control and rectify these occurrences.

During injection, pressure builds up in the aquifer producing what is termed mounding. This has to be controlled to a safe level to prevent fracturing of the confining strata above the aquifer. Similarly, under extraction, the wells suffer drawdowns. These effects can influence other wells up to a 5 to 10 km radius, depending on the nature of the aquifer.

A code of practice for ASR has recently been released by the EPA and this is considered a satisfactory document.

Household rainwater tanks have an important place in stormwater harvesting. The normal 2 to 20 kL sizes used solely for garden watering are inefficient due to the tanks filling in the rainy period from April to October but the water being required mainly in the peak watering period of December through February when some 130 kL is used on average.

Usage can be increased by plumbing the tank into the house to supply toilets, the hot water service, laundry and kitchen (including under sink filter and UV disinfection), with mains water backup. Modelled results indicate that about 24 to 70 kL of the total of 260 to 280 kL average annual household use can be supplied using this arrangement. The cost of the water harvested in this way is estimated at $8.00/kL including servicing loan repayments.

Approximately 90–95% of the mean annual runoff volume from urban catchments occurs at flows less than the 3 month ARI event, and this is the focus for harvesting. It is to be noted that this focus is at the opposite end of the stormflow spectrum to flood mitigation. This is the fundamental reason why economic harvesting provides little benefit to flood control.

Development work undertaken by City of Salisbury, KBR and others shows that some 70% of the catchment yield can be economically harvested if the following is provided:

- an on-stream capture basin equal to the volume of a 1 year ARI storm;
- a holding storage of the same capacity and a 24 hour capacity transfer pump;
- transfer of the stored water through a cleansing facility such as a reedbed, screen or filter at a rate of about one tenth the holding storage capacity volume per day.

Stormwater harvesting and use schemes attached to existing wetlands, or smaller schemes using wetland surcharging, can be designed aesthetically with amenability to public access.

Harvesting for urban non potable use involves achieving high final water qualities. On-stream capture works provide substantial quality improvements to flows which are not able to be captured. The harvesting works consistently remove some 90% of all contaminants and at least 70% of nutrients. With disinfection, the water is satisfactory for the irrigation of crops eaten raw, such as salad vegetables, using the SA reclaimed water (treated effluent) guidelines, as there are no guidelines for harvested stormwater quality.

It is concluded that the following principles should be taken into account by councils when considering locations for the implementation of stormwater harvesting schemes:

- Urban catchments with less than 200 ha total or with less than 70 ha impermeable area are generally not economic for commercial harvesting in comparison to SA Water potable water tariff.
- Commercial ASR is unlikely to be feasible if the T1 or T2 aquifer system does not exist, and costly, large footprint, surface storage is required for seasonal balancing.
- Use of flood retardation basins for harvesting storage reduces the ARI protection rating of the works and is generally not feasible unless capture and holding storages are added to the facility, potentially doubling the required works area.
- Unless the irrigation areas or industrial users are within several kilometres of the harvesting site, the cost of water transfer can render schemes uneconomic.
- Broadacre areas zoned for development can be designed to accommodate economical WSUD and stormwater harvesting and distribution to residences in a dual pipe system, whereas retrofitting is generally uneconomic except to large users.
- Catchment pollution surveillance is an essential part of sustainable stormwater harvesting.
- It is necessary to obtain the approval of SA Water to the maximum pressure allowed in any non potable water distribution system within the SA Water supply area.
- Salinities of harvested and ASR stored water are generally low in comparison to reclaimed sewage effluent and native aquifer water.
- Water quality monitoring costs can be substantial (typically 4 to 8c/kL) and need to be taken into account in cost assessments.

The SA planning and environmental health Acts are silent on requirements for stormwater harvesting and use. This puts uncertainty into the approval process, and the minds of proponents, developers, and consultants, and is considered to be the major impediment to works proceeding. Amendments to the Planning Strategy for Metropolitan Adelaide to introduce WSUD principles are currently underway and will help this situation.

In South Australia, allocations of, and entitlements to, water from natural sources, including allocation of water for the environment are set out in the Water Resources Act 1997 (WRA).

The WRA does not confer ownership of the water upon any person but sets out the rights to take water in a number of degrees. Councils (and other bodies) in the metropolitan Adelaide study area owning or having drainage easement rights over drainage reserves, have the right to harvest the stormwater from works in those reserves without requiring a licence.

Dyson (2004) has analysed the legal position and recommends resolution of policy issues on ownership and allocation. In addition, the paper has recommended legislation be prepared in relation to certainty, adequacy and quality of supply of stormwater and other related matters.

Large broadacre areas in Playford and Salisbury, the Adelaide City Parklands and the Adelaide Airport stand out as excellent prospects for stormwater harvesting and use projects. Adelaide Airport could be a major harvesting site supplying internal demands and those of adjacent open space by using areas for the works which would be otherwise undevelopable due to airport operational constraints. This is the basis of the Parafield Airport facility.

Building on work by Clark (2003) it is shown that subject to site availability, 240 economical dual well, 0.5 GL/a ASR schemes distributed over Adelaide could harvest in the order of 120 GL/a of stormwater for non potable use at a capital cost of some $700 million including land but excluding reticulation works. The water would have a production cost of about $0.85/kL. This proposal is notional but appears to have merit when compared to many of the schemes listed in the Water Proofing Adelaide Discussion Paper. Direct potable supply using transfer between wells as the final treatment process is under investigation and this could eliminate the requirement for dual reticulation.

It is considered that the practicable limit to stormwater harvesting in the Adelaide metropolitan area is around 25 GL/a, which is considerably less than the above figure but more than the qualified 10 GL/a included in the Water Proofing Adelaide discussion paper.

Licensing of ASR facilities is on an annual basis and this is a critical area requiring some form of legislation or variation to existing procedures to give owners of the facilities some certainty that their investment will be able to continue for its planned life. The possibility of one party being licensed to extract ASR water injected by another party without agreement has been raised as a legal technicality. In relation to this matter it is hard to imagine that the licensing agency would allow the issue of a license in this regard. This is a matter that should be rectified at the same time as the licence term.

There is a need for an agreement in perpetuity to give the harvesting council or other body exclusive rights to an agreed proportion of the water from the catchment. It is considered that the statutory arrangements for the sharing of responsibilities for flood mitigation works could provide a basis for facilitation of agreements between Councils in this regard.

If the amendments to the Planning Strategy for Metropolitan Adelaide are implemented, the initiative for implementation of stormwater harvesting schemes will not be haphazard as it is at present. Developers will have to think recycling at the outset and this will involve the private sector in devising, designing, and constructing the schemes. It is assumed that Councils and SA Water will own the schemes with some being implemented through a BOOT (build, own, operate and transfer) arrangement eventually being handed back to the Council or SA Water at the end of the contract period.

Planning, design and operation of water supply schemes is not currently the core business of councils in SA and this is a possible barrier to the implementation of beneficial non potable water supply schemes within their municipalities. Whilst the benefits can be significant, the ownership and operation of such schemes involves a level of risk. Councils could manage the risk by engaging locally represented companies such as United Water and United Utilities to operate and maintain the facilities under long term outsourcing contracts. This could be extended to build-own-operate (and transfer) contracts as outlined in the Study Part A Report. SA Water, and companies such as United Water and United Utilities, have the skills to assess the hydrologic requirements and risks in producing contracted outcomes taking into account the vagaries of climate, the economy and consumers. It would be feasible to implement and operate harvesting works on an output based contract basis of a long term such as 20 years.

RECOMMENDATIONS

It is recommended that:

- Potential stormwater harvesting sites are identified where main drainage routes pass through open space in locations favourable to development of ASR.
- Proposals are initiated to establish South Australian and national guidelines for the use of stormwater for non potable purposes.
- The Minister be requested implement the proposed amendments to the Planning Strategy for Metropolitan Adelaide under the Development Act 1993, as approved by Cabinet, to provide for the inclusion of water sensitive urban design in development proposals.

- Legislative amendments are initiated to provide for the licensing of ASR wells to be extended for a period of at least ten years with rights for renewal to allow owners of facilities to obtain security of their works.

- Legislative amendments are initiated providing for the protection of agreements for the use by councils of the runoff from catchments fully or partially within another municipality for stormwater harvesting.

- Councils use long term output based contracts for the implementation and operation of stormwater harvesting schemes, to obtain the necessary level of expertise and management of risk.

Glossary of Terms

Aquifer—a rock or sediment in a geological formation, group of formations or part of a formation which is capable of being permeated permanently or intermittently and can therefore hold and transmit water.

Aquifer Storage and Recovery (ASR)—the process of recharging water into an aquifer for the purpose of storage and subsequent withdrawals.

Average Recurrence Interval (ARI)—the expected or average interval between events of a rainfall intensity of a given magnitude being exceeded.

Broadacres—a relatively large tract of developable land within an urban planning boundary.

'Brownfield' development – a broadacre site being redeveloped from a previous use.

Detention—the temporary storage of stormwater caused by a reduction in outflow capacity of a holding device (e.g. tank, basin) which results in a reduction in discharge.

Detention basin—a basin with a restricted outlet which releases water at a lesser rate than the inflow.

Determinand—a chemical, radiological, biological or physical constituent in, or characteristic of, water in relation to water quality.

Drawdown—the pressure reduction in an aquifer below its standing water level under extraction pumping.

Filtration—the process of removing solids from a flow of water by passage through a bed of sand, mesh screen or a closely planted reed bed.

'Greenfield' development—a broadacre development (i.e. housing, industrial, commercial) which occurs on land previously being open space.

Groundwater—water contained within the hydrological cycle below ground.

Hydrogeological—the characteristics of the behaviour of water in rocks.

Hydrologic analysis—the study of water and its constituents as they move through the natural process that constitute the hydrological cycle (i.e. rainfall, runoff, evaporation, infiltration).

Mounding—the pressure build-up in an aquifer above its standing water level under injection or recharge.

Native groundwater—the groundwater in an aquifer prior to stormwater or other water being injected.

Plume—used to describe the shape of the body of water injected into an aquifer, the injectant plume being a different quality to the groundwater previously in that part of the aquifer.

Pollutant—any substance introduced into the environment that adversely affects the usefulness of a resource, e.g. contaminants (heavy metals, hydrocarbons, organic matter, litter etc) contained within stormwater flows.

Quaternary aquifers—shallow aquifers across metropolitan Adelaide at generally 10 to 60 m depth.

Rainfall intensity—the rate at which rain falls, typically measured in mm/hour which varies throughout a storm.

Rainwater tank—a tank used to retain runoff directed off a surface (i.e. roof area) and used for irrigation, drinking, washing etc. The tank overflows only when the available storage is exceeded.

Reedbed—a wetland containing reeds used to improve the quality of the water flowing through by filtering out particles and absorbing nutrients.

Retention—the permanent storage of stormwater due to a holding device (e.g. tank, basin). It can also be representative of soil infiltration or percolation which prevents stormwater from discharging into the 'minor' and 'major' drainage system. Water remains in the hydrological cycle but continues in a different process.

Standing water level—the level water stands in a well under static conditions, i.e. no extraction or injection. This represents the pressure in the aquifer intersected by the well.

Tertiary aquifers—deep aquifers across metropolitan Adelaide at generally 100 m or more depth.

'Turkey nest'—used to describe the construction of a dam (usually circular) where the earth for the embankment is excavated from within the dam. This gives the most economical construction.

Well—a bore.

Wetland—permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions.

1 Introduction

1.1 SCOPE

In 2003, the Local Government Association of South Australia (LGA) prepared the 'Stormwater Management Strategy' dated 27 June 2003, and presented it to the State Government (Minister for Local Government).

The Strategy, targeted specifically at metropolitan Adelaide, was prepared to 'provide a constructive means to address the significant challenges and opportunities in relation to stormwater management in metropolitan Adelaide'. Endorsed unanimously by all metropolitan council Mayors and Chief Executive Officers, the strategy proposed a partnership approach to stormwater management with equal responsibility for funding between the councils and State Government.

'Step 1' of the proposed strategy, an independent study to clearly define 'The What', subsequently resulted in the preparation of the terms of reference brief for the 'Metropolitan Adelaide Stormwater Management Study' (MASMS) dated 6 October 2003. The MASMS is being undertaken in three distinct, although inter related parts:

- Part A—Audit of Existing Information
  - Component 1: Assessment of the current position
  - Component 2: Recommended actions/way forward
- Part B— Stormwater Harvesting and Use
- Part C—Apportionment of Council Costs.

This report presents the outcome of Part B: Stormwater Harvesting and Use.

The scope of this report includes a review of the costs and benefits of existing stormwater harvesting and use systems and other relevant components of water sensitive urban design projects in metropolitan Adelaide. Because the number of operating harvesting and use facilities in South Australia is quite small, some planned projects were included, and interstate enquiries were made in an endeavour to provide additional data for analysis.

Further, an evaluation of pre-conditions for viable harvesting and use, identification of opportunities and impediments to optimising harvesting and use and recommendations of measures to overcome impediments have been documented.

The above aspects are discussed in the following sections of this report with detailed material being included in the Appendices.

1.2 CONCEPTS AND DEFINITIONS

Stormwater harvesting and use is one part of the sustainable management of the urban water cycle embraced within water sensitive urban design.

'**Water sensitive urban design**' (**WSUD**) is defined as the integration of urban planning and development with the management, protection and conservation of water within a consideration of the water cycle as a whole (WSUD 2003).

WSUD uses structural and non-structural techniques to achieve the holistic management of:

- urban stormwater (flood, quality and harvesting and use)
- reticulated and rainwater tank potable water
- reticulated non potable water
- sewerage
- groundwater
- vegetation-soil-water interactions
- water harvesting and use (sewage and stormwater, and industrial recycling) and
- environmental flows (to streams and to groundwater).

It is noted that AASTE (2004), Section 2.3, in summarising WSUD indicates that it has its origins in stormwater management with extension into rainwater tanks and stormwater harvesting and use, grey water reuse and on-site wastewater treatment and disposal. The section states that WSUD should extend into off-site wastewater treatment and reuse. It is to be noted that the scope included in the WSUD 2004 national conference to be held in Adelaide includes all the aspects listed above involving the whole urban water cycle.

'**Stormwater harvesting and use**' is applied to the capture of rainwater from roofs and stormflow at any other point in the drainage system as it travels to the sea or other receiving water, followed by cleansing and use.

'**Capture basin**' refers to storage provided on or adjacent to a storm watercourse for the purpose of temporarily trapping water which arrives during a storm event. The objective is to transfer the contents of the capture basin to an off-stream holding storage as quickly as practicable so that the capture storage is standing empty for the next storm event. The capture basin becomes the primary settlement facility in that it collects gross debris from the stormflow.

'Holding storage' refers to the storage receiving water from the capture basin so that it is held for filtering through a wetland or a mechanical filtering device at a much slower rate than the transfer rate from the capture basin. Typically the holding storage would take one day to fill in a 3 month to 1 year ARI event and ten days to empty through the filtration process. It will be apparent that in a sustained wet period the holding storage backs up the process and water is unable to be transferred from the capture basin. The holding storage is the secondary settling facility and removes the finer silts and clays well into the colloidal fraction.

'Reedbed' or **'filtering wetland'** refers to a closely planted relatively shallow wetland through which the water from the holding storage is passed for the purpose of filtering the water prior to use and transfer to seasonal balancing storage.

'Seasonal balancing storage' refers to the provision of tanks and dams, and the use of aquifers to store surface runoff for later use.

The capture basin – holding storage – reedbed – use/seasonal balancing storage use process concept is an innovation developed by the City of Salisbury, KBR, Richard Clark & Associates and Barrie Ormsby Landscape Architect. It is the principal stormwater harvesting and use process discussed and demonstrated in this report.

'Surcharging wetlands' refers to the raising of the water level in a wetland to provide capture and/or holding storage as an alternative to separate process components. It is useful for small schemes and retrofitting harvesting to an existing wetland.

'Detention' refers to the function of storage facilities in stormwater networks which reduce the peaks of stormflow events by releasing outflows at lesser rates than inflows. The technical term for this is flood routing.

'Retention' refers to the capture of stormflow so that it does not continue in the stormwater drainage network. After capture it may be used for irrigation (agriculture, open space and household lawns and gardens), domestic purposes (drinking, bathroom, toilet, hot water service and laundry), industrial purposes, groundwater replenishment (infiltration or aquifer injection) or environmental flows.

'Average recurrence interval' **(ARI)** is defined in ANZECC (2000) as the average time between events of a given value. In this report for example, a 5 year ARI stormflow for a location is the peak flow rate for a storm event occurring not more than once in 5 years on average. In rainfall runoff modelling it is the stormflow calculated from a selected ARI rainfall event.

'Interest and redemption' **(I&R)** refers to the equivalent cost of capital based on a 15 year loan of the Credit Foncier type typically used for the financing of works by local government instrumentalities. Based on payments at six monthly intervals at an interest rate of 5.75% pa, the annual payments are about 10% of the amount borrowed. The capital cost of establishment of schemes includes all on-costs such as planning, engineering design and construction management, and legal agreements. It is not always clear from the literature whether or not these on-costs have been included in reports of schemes.

'Operation and maintenance' (O&M) refers to the total cost of operating schemes including providing sufficient repairs and maintenance (including periodic major overhaul) of depreciable assets to keep them in good working order to the end of their normal working life when replacement or refurbishment is subject to refinancing the capital cost involved. As well as attention to the physical assets, O&M includes water quality monitoring and reporting, licence renewals, condition monitoring and reporting, and services to consumers. In some cases it is unlikely that these latter costs are reported in the literature.

1.3 REPORT FOCUS

Stormwater harvesting and use is one part of the sustainable management of the urban water cycle embraced within water sensitive urban design (WSUD) which involves holistic management of urban rainwater, stormwater, groundwater and wastewater. This report focuses on the emerging technology and community interest in harvesting and use of stormwater, recognising it as a resource rather than a disposal problem.

This report focuses on the harvesting of urban stormwater for use by communities and industry. This focus does not include that component of WSUD which uses retention for the purposes of infiltrating stormwater into the ground as a means of reducing flows to the drainage network (e.g. soakage trenches and grassed swales). This aspect of stormwater management is discussed in the Study Part A report. In the context of the report, this practice is categorised as providing environmental flows, even though in some cases it increases soil moisture and reduces irrigation requirements. For more information on this technique refer to Section 1.3 of UWRC (2004).

Use of urban stormwater as a supplementary water resource for Adelaide was first investigated by Miles in the early 1950s based around enhancing brackish aquifers by stormwater recharge to provide a fresh groundwater reserve for use in times of water shortages in Adelaide's catchment storages and the Murray River (Pavelic 1992 and Miles 1952).

A major attraction of the use of injection wells (bores) and aquifer storage in an urban context is that only a small surface footprint is required for the wellhead works to achieve a very large storage which can underlie the urban development it serves. Typically, only the area of a house lot is required for the wellhead works to provide many megalitres (ML) of storage, compared to many house lot areas for an equivalent surface storage.

The concept has been advanced since the 1950s through significant work by numerous individuals and organisations, a number of which are referenced in this report. This work has resulted in the quantification of the stormwater resource, a relatively comprehensive understanding of the accessible aquifer systems underlying the metropolis, and the implementation of trial stormwater and reclaimed wastewater aquifer storage and recovery (ASR) installations leading to the development of significant non potable stormwater harvesting and ASR installations of 0.5 to 1.0 gigalitres per annum (GL/a) capacity with at least one planned for expansion to 3.0 GL/a.

The amount of metropolitan stormwater runoff to the Gulf is generally recognised as currently between 160 and 250 GL/a, which compares to the 200 GL/a current mains water use by the metropolis as provided in the Water Proofing Adelaide data (SA Government 2004).

This tantalising fit of unused resource (which expands with urban growth) and demand has excited visionaries, researchers and practitioners over the years. The concept has received impetuous of late due to the realisation that the River Murray, the flexible resource Adelaide relies on to supplement its local catchments in times of drought, has been significantly compromised in quantity and quality through overuse due to poor irrigation practices and the associated saline drainage impacts.

Apart from quantifying the stormwater resource, almost all of the development work undertaken to date has focussed on the availability and capacity of ASR as a means of providing small footprint storage in the wetter winter months for use in the high irrigation demand summer months. There has been a lack of focus on how to economically and efficiently capture the highly variable and intermittent stormflows and to cleanse them to a quality for injection, storage and use.

The pioneering work on wetland performance and larger scale projects undertaken by the City of Salisbury, the development of the WaterCress hydrologic modelling tool by Creswell and Clark, and an understanding of wetland cleansing dynamics by Lawrence and the CRC for Catchment Hydrology, has allowed techniques to be established for the sizing of capture and wetland cleansing works.

A prime objective of this report is to use the above knowledge to outline the processes and spatial requirements for typical stormwater capture, cleansing and storage works in the context of Adelaide. It is hoped that the information provided will be of value to developers, planners, engineers and natural resource managers involved in urban development projects.

A further objective of the report is to examine the opportunities for and constraints to stormwater harvesting throughout the developed and undeveloped parts of metropolitan area.

2 Harvesting scheme performance and land requirements

2.1 SIZE CATEGORIES

To enable differentiation, schemes considered in this report have been arranged according to magnitude of harvesting and use from individual building size projects, through neighbourhood and district to large schemes.

Indicative urban catchments/supply capacities associated with each of these are outlined below. Indicative open space irrigation area capacities are provided to assist in an appreciation of the relative performances of the scheme sizes in an urban context. Industrial harvesting and use is generally not as seasonal as irrigation and leads to lower balancing storage requirements.

It is to be noted that the sizes of harvesting components, dams and works areas given in the scheme categories listed below are indicative only. Site specific factors result in considerable variations in the final designs compared to preliminary assessments. Variations in the order of at least +/- 20% can be accepted.

2.1.1 Individual lot

Individual lot size is typically 0.05 to 0.1 ha for housing and larger for institutional, commercial and industrial, with the catchment confined to the one lot, or contiguous lots forming the one development. The primary focus is capture of roof runoff with addition of parking areas and other impermeable surfaces where economically feasible. The supply capacity can be up to 1 ML/a, typically sufficient to irrigate 1000 to 2000 sq m (0.1 to 0.2 ha).

For schemes of this size, seasonal balancing storage is typically provided by above or below ground tanks, dams, or shallow ASR if suitable hydrogeological features exist (e.g. some 30 m deep in the Adelaide plains Quaternary aquifers). At the higher end, tank sizes may become substantial, e.g. possibly of the order of 500 kL (100,000 gallons) for irrigation supply resulting in the trend to ASR with increasing size if it is available. Quality management for tanks and ASR is much easier than for dams. ASR has a space requirement of the same order as tanks, however, dams require more space. For a more detailed discussion on rainwater tanks, ASR and dams – refer Sections 2.2, 2.3 and 2.4 respectively.

2.1.2 Neighbourhood

Generally defined as a group of lots, with the possibility of some external catchment. The catchment could be up to 10 ha and the supply capacity in the range of 1 to possibly 10 ML/a, capable of irrigating 0.2 to 1.6 ha (the area of Adelaide Oval).

Seasonal balancing storage would typically be ASR, 60 to 100 m deep in the Quaternary or upper T1 aquifer on the Adelaide plains, or to site specific depths in fractured rock aquifers. Dams would have the attendant spatial impact and quality issues discussed for individual lot schemes. There are also public safety and aesthetic issues associated with dams due to their level variation over the capture and use seasons.

Typically for the 10 ML/a facility, the following works and space would be required:

- diversion weir and 0.5 ML on-stream basin or wetland surcharge on a main drainage line;
- a 0.5 ML holding storage filled by a pump from the on-stream basin;
- a 200 sq m reedbed feeding the ASR well by gravity;
- a supply pump delivering from the reedbed to the distribution system (and the ASR well if gravity feed is insufficient);
- an ASR well equipped with an extraction pump;
- an area of 0.6 ha for the above works (i.e. about 10 house lots);
- if a dam 3.5 m average depth were used instead of ASR, an additional area of some 1.0 ha (i.e. about 15 house lots) would be required.

2.1.3 District

Designated as a group of lots with a total internal and external catchment up to 200 ha and a supply capacity from 10 to 200 ML/a, capable of irrigating 1.6 to 30 ha. For comparison an 18 hole golf course generally uses 120 to 150 ML/a.

Seasonal balancing storage would typically be ASR, 100 to 150 m deep in the T1 and T2 aquifers on the Adelaide plains, or to site specific depths in fractured rock aquifers. Dams may be feasible at the lower end involving issues discussed above, but would almost certainly be out of the question at the larger end due to spatial impact.

Typically for the 200 ML/a end of the range, the following works and space would be required:

- diversion weir and 6.3 ML on-stream basin or wetland surcharge on a main drainage line;
- a 6.3 ML holding storage filled by a pump from the on-stream basin;

- a 2500 sq m reedbed;
- a supply pump delivering from the reedbed to the ASR and distribution system;
- an ASR well equipped with an extraction pump;
- an area of 2.1 ha for the above works (i.e. about 30 house lots);
- if a dam 3.5 m average depth were used instead of ASR an additional area of some 11 ha (i.e. about 150 house lots) would be required.

2.1.4 Large

Catchments greater than 200 ha and/or supply capacities in excess of 200 ML/a have been included in this category.

Seasonal balancing storage would typically be ASR, 100 to 150 m deep in the T1 and T2 aquifers on the Adelaide plains, or to site specific depths in fractured rock aquifers. Dams would almost certainly be out of the question at the larger end due to spatial impact.

To indicate the scope of works for a large scheme, the details of the 1,100 ML/a Parafield Stormwater Harvesting Facility are provided below:

- diversion weir and 49 ML on-stream basin;
- a 48 ML holding storage filled by a pump from the on-stream basin;
- a 20,800 sq m (2.1 ha) reedbed;
- a supply pump delivering from the reedbed to the ASR and distribution system;
- two T2 ASR wells equipped with extraction pumps;
- an area of 13 ha for the above works (i.e. about 180 house lots);
- if a dam 3.5 m average depth were used instead of ASR, an additional area of some 42 ha (i.e. about 590 house lots) would be required.

2.1.5 Spatial requirements for harvesting

The spatial requirements from the above range of harvested annual volumes have been graphed as shown in Figure 2.1. It should be noted that the areas are indicative only and will vary from site to site depending on topography, runoff and stormwater course characteristics, feasible basin depths and demand patterns.

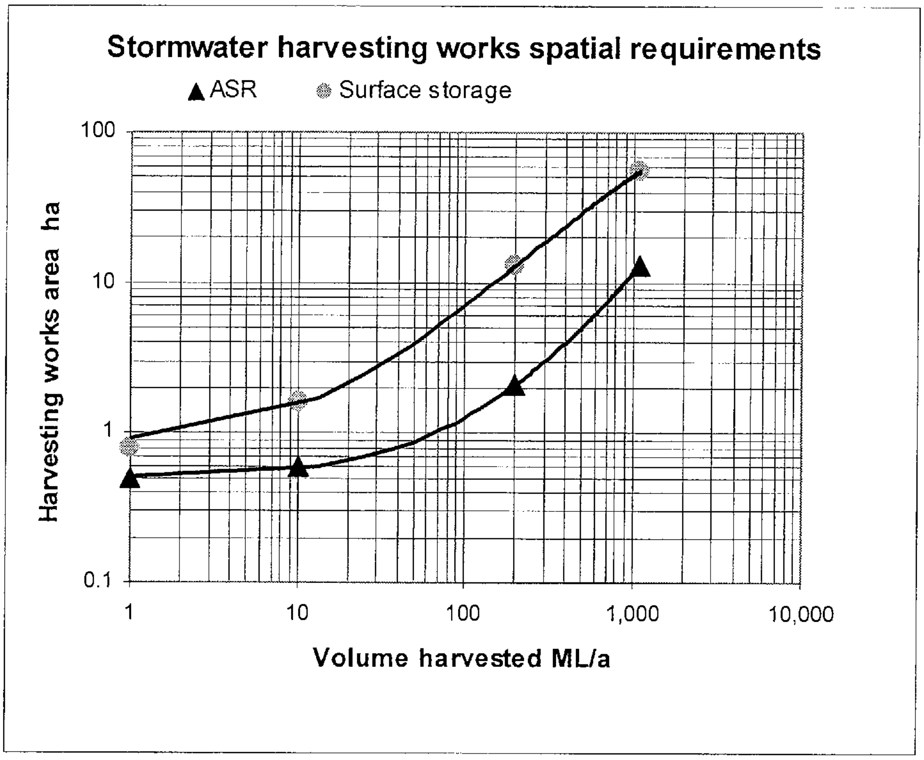

Figure 2 .1 Spatial requirements for stormwater harvesting works

Effect of demand patterns

In relation to the effect of demand patterns, industrial demands which use water through the winter result in reductions in the sizes of works compared to irrigation projects. Capture and holding works remain the same, but for a given annual volume, the peak supply rate is reduced which reduces the reedbed or filtration, ASR or surface storage, and distribution works sizes. Also, any supplies which can be provided direct during winter do not suffer aquifer storage losses of notionally 20%, or seasonal balancing storage evaporation loss, which can be of the same order.

Surcharging of wetlands to provide working storage

The surcharging of wetlands to provide capture and holding storage volume can lead to savings in area requirements, especially for schemes below about 500 ML/a. However, for the larger schemes, capture and holding storage volumes tend to dominate the spatial requirements because surcharge depth requirements exceed manageable values. For example it may be feasible to surcharge a wetland by 0.5 to 1.0 m if incoming drains have a reasonable grade or there is an inlet drop. However, this depth range is only one third to one seventh of the capture and holding storage depths used for ascertaining the above area requirements. As a consequence, surcharged water surface areas are required to be in the order of three to seven times larger than the above indicative areas for the same throughput. This is exacerbated by greatly increased evaporation losses.

The practice of surcharging wetlands needs to be carefully considered in relation to detriment to aquatic plant habitat and reduction in flood mitigation capacity of the facility. The holding storage of an efficient harvesting facility can remain substantially full for some two months through the winter. For example, the Parafield facility is expected to average 97 harvestable storms a year and the experience of one season has confirmed the long period of holding storage depths of 2 to 3 m. Fortunately, it is off-stream so does not compromise the flood mitigation capacity of the Parafield Drain.

2.2 RAINWATER TANKS

At the individual household level, effective rainwater tanks are typically 2 to 5 kL (500 to 1000 gallons) with the larger sizes of 10 to 20 kL being only marginally superior in performance. Rainwater tanks of these sizes solely for garden watering are inefficient due to the tanks filling in the rainy period from April to October but the water being required mainly in the peak watering period of December through February (UWRC 2001).

Average household water use in Adelaide is 256 kL of which about half (say 130 kL) is used on the garden and other outdoor uses (SA Government 2000, vol. 2, Sec. 1.3.3). Hence, even a large 20 kL rainwater tank, if only used for outdoor uses, would supply less than 10% of the overall household requirement. A 5 kL tank for outdoor uses would provide possibly only about 3% of the overall household requirement.

Assuming Adelaide's average rainfall of 450 mm, and 20% losses (Clark 2004), the annual yield for a 160 sq m connected roof area would be 58 kL. Taking the 20 kL tank scenario, the 20 kL per annum provided for garden watering represents a harvesting efficiency of 34% of the potentially capturable yield. A 5 kL tank would have a much lower efficiency. The practical objective for the larger schemes is 70% harvesting efficiency to achieve economy. Hence, a rainwater tank for household outdoor use only has a low level of harvesting efficiency.

For a three person house with a roof area of 160 sq m feeding a 5 kL tank, plumbing the rainwater tank to the hot water service and toilets is calculated to increase the annual supply to 61 kL which represents 24% of the overall household requirement. Provision of a 20 kL tank would increase this to 69 kL, being 27% of the overall requirement (based on UWRC 2001). Note that the usage volumes for these two cases exceed the harvestable volume, so a larger connected roof area would be required. The significant point is that this arrangement has a harvesting efficiency of 100% of potentially capturable yield compared to the practical objective of 70%. However, it is considered that systems from roofs can only be relied on to capture up to 80% of runoff due to gutter blockages, etc (Clark 2004).

Coombes and Kuczera (2003) undertook detailed modelling of rainwater tank performance in Adelaide, Brisbane, Melbourne and Western Sydney based on the tank having a pressure pumpset connected to the household plumbing for supply to toilets, laundry, hot water and outdoor uses. Tank sizes were from 1 to 10 kL and occupants numbering from 1 to 5+ persons. The water savings for a 10 kL tank were 24.7 kL/a irrespective of the number of occupants. For a 3 kL tank this reduced to about 22.8 kL. It is to be noted that these values are about half to a third of the values in UWRC (2001) discussed above.

About 40% of Adelaide homes have rainwater tanks. Australian Bureau of Statistics (ABS) in 1988 indicated that 5% of the tanks were used for garden water, 7% for bath/shower use, 9% for washing clothes and 38% for drinking water (total 59% - uses for remainder not stated) (UWRC 2001). If it is optimistically assumed that the bath/shower and clothes washing (16% total) implies connection to the hot water service, a large cultural paradigm shift would be required to raise the way rainwater tanks are used to achieve an effective level of stormwater harvesting. Implementation of the benefit involves owners installing a pump and additional plumbing into the house as well as a mains water make-up connection with back flow prevention to the tank, and this is likely to be a barrier due to cost and maintenance.

The recent mandating of rainwater tanks for new dwellings by the SA Government from July 2006, associated with the increased awareness of the potential for water shortages will progressively increase the proportion of tanks and the technology available for plumbing them for in-house use.

Assuming an average density of 14 houses/ha with an average connected roof area of 160 sq m/house and 20% loss, it can be shown that with 100% harvesting efficiency, 18% of the total precipitation is captured. This is about two thirds of the total catchment runoff coefficient normally used in the assessment of schemes. As a consequence, it is necessary when assessing catchment water availability for harvesting to take into account the proportion of houses with rainwater tanks and the extent of connection of the house plumbing fixtures.

The above discussion is about harvesting roof runoff in rainwater tanks. A discussion of the role rainwater tanks can play in flood mitigation is contained in the Study Part A Report.

2.3 AQUIFER STORAGE AND RECOVERY (ASR)

Soundly based trials which have become operating schemes have shown that ASR for the seasonal balancing of stormwater harvesting and use schemes is feasible.

As discussed in Section 1.3 considerable investigation has been undertaken on the use of sedimentary and fractured rock aquifers for storage and recovery of stormwater and, to a limited extent, treated sewage effluent.

There are three major groups of aquifers occurring below the metropolitan area. The first are the shallow Quaternary aquifers comprising sand, gravel, silt and clay of varying depth often to around 60 m and of variable performance for ASR. These are followed by the deeper Tertiary sedimentary limestone and sand aquifers from about 100 m depth separated by impermeable clay layers, well defined in the north but less in the south. The first two of these are the T1 and T2 aquifers used for high production ASR. These are followed by the T3 and T4 aquifers, which are too deep for general use. The third aquifer group is fractured bedrock which occurs under the deeper sedimentary aquifers and has some potential for ASR particularly from the eastern suburbs close to the foothills. (PIRSA 1992).

Native groundwater salinity in the shallow Quaternary aquifers is quite variable to 3000 mg/L and the Tertiary T1 and T2 1000 to 2000 mg/L. Stormwater salinity is generally in the order of 100 to 300 mg/L. Depending on the hydrodynamic characteristics of the aquifer, salinity is generally not a barrier to ASR as the injected water displaces the native groundwater thus enabling the stored water to be withdrawn until the native groundwater begins to re-enter the well.

Injection rates for the Quaternary aquifer are typically 0.5 to1.0 ML/d and for the Tertiary aquifers typically 2 to 4 ML/d. Extraction rates are about 50% higher.

Problems are experienced from time to time with clogging of the wells during injection from particles in the injected water or breaking off the aquifer material, biological growths and chemical reaction products. Various methods are used to control and rectify these occurrences.

Under injection, the pressure tends to build up in the aquifer producing what is termed mounding. This has to be controlled to a safe level to prevent fracturing of the confining strata above the aquifer. The mounding head can be quite high, e.g. at Parafield the limit is 90 m head above the ground surface level. The wellfield has a standing water level 4 m below the ground surface.

Similarly, under extraction the wells suffer drawdowns. For Parafield the expected drawdown with the wellfield developed to 3,000 ML/a capacity is 130 m below ground level.

These dynamic effects spread out from the wellfield, tapering off to no effect at distances of typically 5 to 10 km for the T1 and T2 aquifers in the Adelaide plains. This means that, in the design of the wellfield, operating wells within this radius have to be taken into account as the drawdown and mounding effects may cause well levels to reduce pump delivery rates, fall below pumps, or to rise to a level where the pumps are over discharging.

Hydrogeological modelling is undertaken to determine the above effects. Approval of the operational arrangements for the wellfield and associated hydrodynamic effects is required by the Water Resources section of Department of Water Land and Biodiversity Conservation (DWLBC) when licence applications are made.

An increasing cost factor with ASR facilities is the expense of the water quality monitoring stipulated in the licence conditions. Some 47 chemical, physical and biological determinands are to be analysed, counting group determinand tests (such as pesticides) as a single test. The extent of tests from this suite varies with time and amount of water injected but currently averages in the order of 4.4 cents/kL of water produced. Details of the additional cost in the commissioning year and the subsequent yearly costs are shown in Table 3.4.

Table 2.1 ASR water quality testing costs (approximate)

	Annual volume extracted ML			
	50	100	500	1,000
Commissioning year	$8,400	$10,500	$28,000	$50,000
Annual thereafter	$2,200	$4,400	$22,000	$44,000
Cost after commissioning c/kL	4.4	4.4	4.4	4.4

In addition to the water quality testing charges above there are the associated costs of sampling, delivery of the samples to the laboratory, and assessment and reporting of the results for compliance. An indicative cost of this would be in the order of 4.4 c/kL at 50 ML/a trending to 0.5 c/kL at 1000 ML/a injection.

It is suspected that most of the operation costs of the schemes provided do not include testing, sampling and reporting costs of the above order.

In addition to the above, continuous on-line monitoring of turbidity, electrical conductivity (EC), pH and other determinands is required for environmental and operational monitoring purposes. This provides a large body of data which needs to be managed.

The above laboratory testing does not include reticulated water quality monitoring which can also be quite onerous, if required.

2.4 DAMS AND BASINS

It can be seen from Section 2.1 that substantial dam and basin volumes are required to provide seasonal balancing storage for irrigation based demands where ASR is not used. Where industrial demands are more evenly distributed over the year, the volumes are reduced.

Evaporation losses are significant in Adelaide, with standard pan evaporimeter recordings averaging typically 1.95 m of evaporation. Evaporation from water bodies such as dams and lakes is less than from evaporimeters, typically by a factor of 0.8. Taking into account the average rainfall in the study area of 0.45 to 0.55 m, the net evaporation from dams is about 1.1 m. The effect is that depending on demand patterns, about 15 to 30% of harvested water can be lost through evaporation in seasonal balancing storage dams of some 3.0 m working depth.

The dam site area assessments in Section 2.1 are based on relatively level terrain such as occurs on the Adelaide plains and 'turkey nest' construction which minimises excavation. Harvesting sites in undulating areas in the approaches to the hillsface could have valley sites providing a greater average water depth and smaller overall area. Such dams can directly harvest water from their own catchments to supplement the urban runoff. The requirement for spillways often means that costs of these dams are similar to the turkey nest type.

It is necessary to line the dams and basins used in harvesting, or to ensure that the natural material without engineered compaction has a very low permeability, which is rarely the case. Compacted clay lining 200 to 300 mm thick is often used. Sites without readily available clay deposits require sheet lining with plastic, synthetic rubber or bentonite impregnated geotextile.

Yabbies can penetrate clay lining and will burrow many metres down to the watertable to survive under empty dam conditions, believing that the empty dam or basin signifies a drought. Yabbie holes are potential seepage routes if permeable strata are penetrated. Robust plastic or synthetic rubber sheet lining prevents this problem, but makes removal of silt and debris more difficult. This can be overcome by applying a protective layer of soil or clay over the sheet liner, which adds to the expense.

Making turkey nest dams deeper reduces the site area but introduces geotechnical issues if the base of the dam intersects the watertable. To achieve balanced earthworks for 3 to 4 m deep dams up to 50 ML capacity on level sites, the base has to be excavated 1 to 2 m below the natural surface to provide enough material for the banks. This depth will often intersect the watertable, requiring special geotechnical design to prevent the lining (both clay and sheet) being displaced by the uplift of the watertable under low and empty dam situations. Balanced earthworks turkey nest dams have reducing excavation depths with increasing capacity (given a fixed operating water depth), so that for a 100 ML dam the excavation depth is 0.7 m and for 1000 ML is in the order of only 0.3 m.

Algal and aquatic weed growths may occur in seasonal balancing storages, resulting in filtration being required to achieve a satisfactory harvesting and use water quality. It is probable that re-passing the water through the reedbed prior to use would achieve the necessary level of treatment, but it is not known if this method has been tried.

3 Costs and benefits

Details of operating stormwater harvesting and use schemes in South Australia and interstate have been collected and the results are summarised in Appendix A. Appendix B includes the full details of each of the schemes listed in Appendix A.

A key objective in the data collection was to obtain as much of the physical attributes and cost details as needed to gain an indication of the potential viability of particular approaches, and in particular, if economies of scale exist.

3.1 SIGNIFICANCE OF SA WORKS

It has become apparent that the work undertaken in the Adelaide metropolitan area is more extensive, and has been operating longer, than facilities in other states. The fact that stormwater harvesting has proved a success in Adelaide, which has a relatively low rainfall of around 450 mm a year, means that it should be viable in the other capitals which enjoy higher rainfalls, except perhaps Perth which has extensive areas of highly permeable ground.

3.2 SCHEME DESCRIPTIONS

3.2.1 Large schemes

The largest stormwater harvesting facility in Australia is the Parafield Airport Scheme (SA metro) with a Stage 1 supply capacity of 1,100 ML/a from an industrial and residential catchment of 1,650 ha. The project was developed as a partnership between the City of Salisbury, Michell Australia (wool processors) and the Parafield Airport, on which the harvesting facility is built under a long-term supply contract.

This scheme has only been operating for a year and as such, the costs have not been fully established. The site has the advantage of the availability of an aquifer for storage of the stormwater in the wetter months of May to October (the harvesting season), allowing recovery for use in the balance of the year. Michell Australia has contracted for half of the Stage 1 supply and arrangements are in hand for the other half to be supplied to the Mawson Lakes development as the stormwater component of its non potable dual pipe reticulation.

Mawson Lakes recycled water reticulation using stormwater and reclaimed wastewater is not yet operating. The original plan was to harvest some 500 to 600 ML/a of stormwater from the development site and its upstream catchment. However, the wetlands to be used as part of the cleansing process are too saline for irrigation harvesting and use. The Parafield connection is being made for this reason.

The second largest scheme is the Morphettville Racecourse Facility (SA metro) at 200 to 250 ML/a supply using ASR with capacity up to at least 400 ML/a, but no sites are available to take the additional water. It harvests water from a 465 ha residential catchment.

The third largest scheme is the Pooraka Triangle Facility (SA metro) at 200 ML/a supply using ASR with potential for 400 ML/a if additional users are found. This facility diverts water from Dry Creek with a catchment of over 3,000 ha to an off-stream capture basin. The water is used for Council reserves.

Sydney Olympic Park (Newington) which obtains 200 ML/a of its total 900 ML/a non potable supply from stormwater, with the balance from reclaimed sewage effluent potentially has the next ranking. However, the imperative for Newington is environmental protection rather than purely harvesting urban stormwater as a water resource. Newington stormwater is collected in an environmentally sensitive quarry site called 'The Brick Pit' which induces a high salinity level and requires reverse osmosis (RO) treatment to render it safe for discharge to the general environment. The cost of the high level of treatment required skews the economics and the scheme cannot be used as a guide to normal practice.

3.2.2 District schemes

The fourth largest scheme is Northfield – Regent Gardens (SA metro) which supplies 40 ML/a from a catchment of 77 ha using ASR.

The fifth largest scheme is Andrews Farm (SA metro) which supplies 35 to 40 ML/a for watering Council reserves using ASR.

Other district and neighbourhood schemes are The Paddocks and Kaurna Park, but final data are not yet available.

3.2.3 Neighbourhood schemes

There appears to be no district or large schemes interstate and the first scheme of any size appears to be Kogarah, New South Wales, which provides 70% of the supply to 193 residential apartments and 4,500 sq m of commercial area. This is likely to provide about 20 ML/a supply but details have not been obtainable. Underground tanks are used for storage.

Other schemes in this range include Tea Tree Gully Golf Club (25–50 ML/a), Pine Lakes ASR (15–20 ML/a) and New Brompton Estate (amount not known), all in the Adelaide metropolitan area, and Fig Tree Place (approx. 4 ML/a) in Newcastle.

3.2.4 Individual lot schemes

Three examples of this type of scheme are in Adelaide namely, Parfitt Square, St Elizabeth Church and Plympton Anglican Church. All are in continuous operation except that Parfitt Square ASR is not being operated for extraction of the water, with injection only occurring at present. Two interstate examples are the Intelligent Home which is a research project in Brisbane, and a house or building in Elwood, Victoria monitored by the Port Phillip Council.

3.3 COSTS AND ECONOMY OF SIZE

Analysis of the costing data obtained for seven harvesting facilities spanning the capacity range discussed in Section 2.1 is presented below.

Household rainwater tanks not listed in Appendix A and are discussed below in relation to costs.

3.3.1 House rainwater tanks

There is a considerable body of data on household tanks as indicated in Section 2.2. Annual supply capacities, and in some instances, capital and operation costs of household tank supplies are discussed in Allen and Pezzaniti (2001), Lang. et al (2002), Landcom (2003), Coombes and Kuczera (2003 & 2003A), and UWRC (2004). Coombes and Kuczera (2003A) is particularly good in relation to the supply capacity of household tanks and comparisons between the capital cities.

In Section 2.2, it is shown that provision of a 5 to 20 kL tank with a pressure pumpset plumbed into the hot water service and toilets in Adelaide is estimated to provide 60 to 70 kL of water saving per annum for 160 sq m of roof connected. The recent decision by the SA Government to mandate rainwater tanks will encourage this type of service to houses.

The Environmental Health Branch of the Department of Human Services recently advised that it was most likely that the policy guidelines being developed for tanks would require bacterial filters and disinfection units (such as UV) for tank supplies connected to the kitchen area (Cunliffe 2004). These units are likely to cost some $500. Extension of the tank supply to the kitchen would increase the amount of water able to be harvested. Assuming that this is done, the approximate costs of a rainwater tank system are estimated as in Table 3.1 below.

Previous estimates of rainwater tanks have not costed the additional time that the owner/occupier has to spend maintaining the system to sustain the capture and quality. In general, power costs are negligible.

It is considered that the costs provided in Table 3.1 would apply to new dwellings and even then are possibly optimistic. Costs of retrofitting systems to existing dwellings are likely to be 50 to 100% higher.

Table 3.1 House rainwater tank costs

Item	Capital cost $	O&M $		I&R $	Overall $
Tank and plumbing*	2,000	2%	40	200	240
Pump, filter & power	1,000	7%	70	100	170
Cleaning leaf traps, filter		0.5hr x 6 times x $50	150		
	$3,000		$260	$300	$560
Cost $/kL based on 70kL/a			$3.71	$4.29	$8.00

Note. * Includes a backflow prevention device on the SA Water potable supply meter.

3.3.2 District scale schemes

Cost details of functioning district scale schemes is limited. To provide another data set, a scheme which was investigated but is unlikely to proceed is outlined as follows.

A detailed costing was recently undertaken by KBR for a proposed surcharged wetland and ASR facility to supply 170 ML/a from a 200 ha residential catchment at a capital cost of $964,000. The total O&M cost was about $0.50/kL and the I&R cost about $0.50/kL, making a total of $1.00/kL.

The supply capacity versus unit capital and unit production cost data for this scheme is included in the following material.

3.3.3 Capital costs

Capital costs of the range of schemes from individual lot to large size have been related to annual volume of supply to provide unit capital cost in $000/ML/a.

It has been found impossible to obtain completely accurate costs for all projects as the information is not readily available. It is possible that with the cooperation of all the parties involved, full details may be obtainable but the study period timing and allocated budget were insufficient to allow this. These difficulties have been encountered by other investigators, refer Hatt *et al* (2004).

Land costs are not included in the capital costs as far as could be ascertained. In any event these costs are quite variable ranging from drainage reserve to prime housing land values, with each site having its own characteristics and therefore likely to skew the comparisons.

The Parafield site is leased, so the land value does not come into the capital costs, but is reflected in the annual costs. Also, such arrangements may be accommodated by a reduction in water supply tariff rather than a lease rental.

As land costs are site specific, it is considered that the provision of both spatial requirement and capital cost data related to harvesting scheme size, as presented in this report, enables the reader to consider the land cost separately from the works cost for a site under investigation.

In many cases, it is unlikely that the cost of legal agreements between the parties relating to funding, land lease, supply contracts and operational aspects is included. In the case of major partnerships like the Parafield scheme, these costs can be substantial. It is suggested that estimates of these costs be added to any capital cost assessments completed using the indicative unit costs provided in this report.

The unit capital cost data ($000/ML/a) over the scheme size range considered has been derived from the schemes listed in Table 3.2. The data are graphed in Figure 3.1.

Table 3.2 Unit capital costs of stormwater harvesting
(location Adelaide unless stated otherwise)

Scheme	Harvested volume (ML/a)	Unit capital cost ($'000/ML/a)
House rainwater tank	0.07	43
Figtree Place (Newcastle)	4	28
Northfield–Regent Gardens	40	5.5
District scheme	170	5.7
Grange Golf Course (concept only)	320	6.4
Morphettville Racecourse	500	4.5
Parafield Airport	1,100	4.1

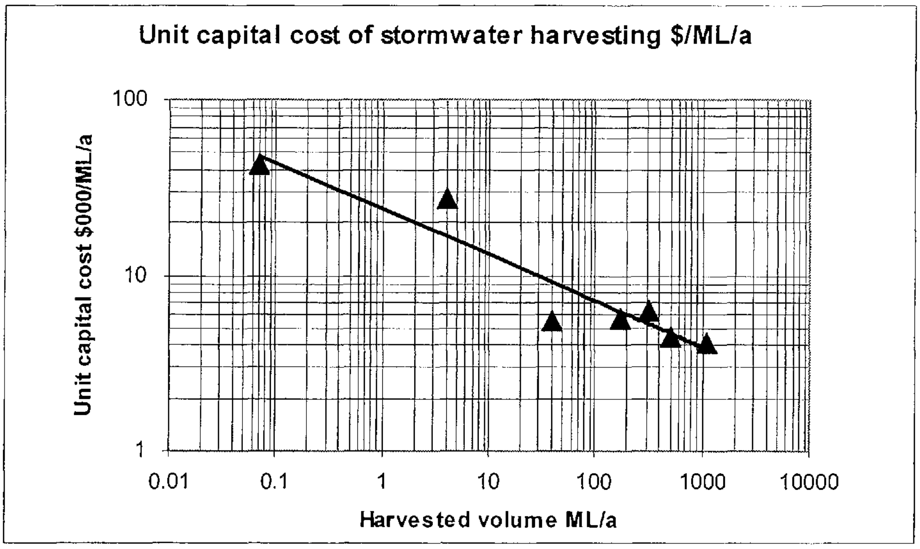

Figure 3.1
Unit capital cost of stormwater harvesting

3.3.4 Unit production costs of stormwater harvesting

The production cost data ($/kL) over the scheme size range considered has been derived from the schemes listed in Table 3.3. The data are graphed in Figure 3.2.

Table 3.3 Unit production costs of stormwater harvesting
(location Adelaide unless stated otherwise)

Scheme	Harvested volume (ML/a)	O&M ($/kL)	Loan repayment ($/kL)	Total cost ($/kL)
House rainwater tank	0.07	3.71	4.29	8.00
Figtree Place (Newcastle)	3	2.00	2.95	4.95
Northfield	40	0.54	0.55	1.09
District scheme	170	0.50	0.50	1.00
Grange Golf Course (concept)	320	0.20	0.64	0.84
Morphettville Racecourse	500	0.15	0.45	0.60
Parafield Airport	1,100	0.27	0.41	0.68

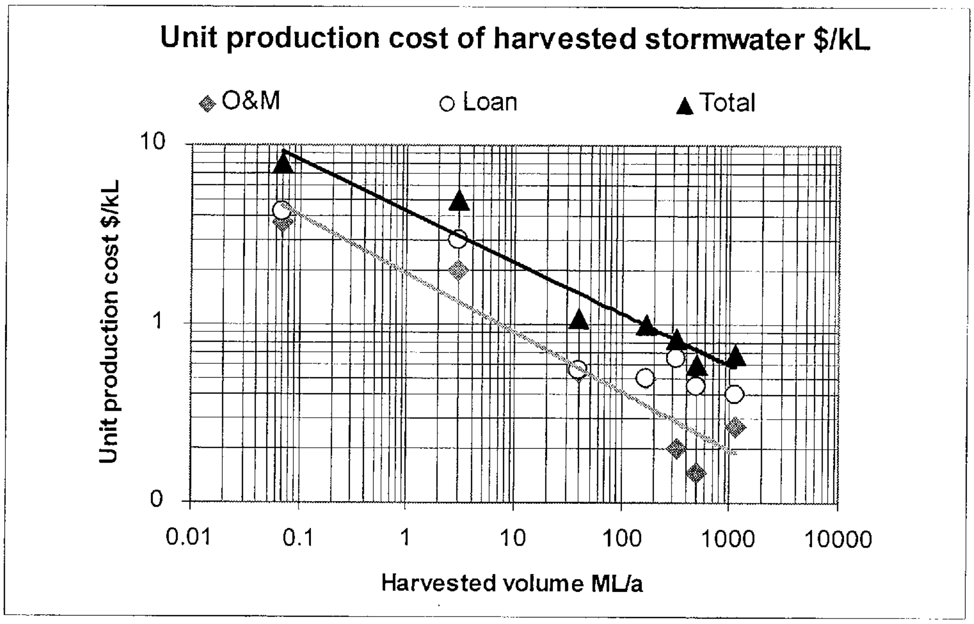

Figure 3.2
Unit production cost of harvested stormwater

The upper line on the graph is the trendline for the total costs and the lower line for the O&M costs. There is a wide scatter of the data due to project variability, so care must be taken in the use of the data. However, the trends are obvious.

It is considered that, in general, the annual costs used for the above data are probably inaccurate. For instance, it is unlikely that the current costs of ASR monitoring are fully accounted for as discussed in Section 2.3. Also, generally the schemes have not been operating sufficiently long enough to establish accurate cost history. As a consequence, the above figures must be used with caution. They represent the indicative unit production cost of a range of scheme sizes and in view of the large variation in unit cost with size, it is considered that larger schemes definitely provide significant economy of scale.

Note that the $0.50 to $1.50/kL cost of harvesting stormwater given in Waterproofing Adelaide Discussion paper (p 48) generally covers the 30 to 2,000 ML/a harvesting schemes on the above graph. This is the district to large size in the range provided above and would be an appropriate size for an agency such as SA Water, a council or private entity to manage with economy.

3.3.5 Conclusion

From a financial perspective, it can be concluded from the above costing data that stormwater harvesting schemes exhibit a definite economy of scale in both the capital cost and O&M areas. Supply levels of 100 ML/a or more trend to a unit capital cost of about $5,000/ML/a and appear increasingly competitive in relation to the current mains water tariff of $1.03/kL given in the Waterproofing Adelaide Discussion paper.

Other issues of scheme management come into play when considering scheme size. Generally, the more reliance on individual householders, the more variable the outcome in relation to quality and performance. Schemes of a district size and above can be managed by an agency such as a council, water authority or private entity to consistently meet performance objectives.

On the other hand, small schemes can achieve a greater sense of ownership by local residents. This intangible quality needs to be taken into account when considering the viability of schemes and the general approach to the policy of considering stormwater a valuable resource. Ideally, optimal stormwater management should include a range of scheme sizes in the one general locality to allow residents to attain a holistic linking of their local actions to a responsible participation in management of the whole water cycle.

3.4 REVIEW OF COST–BENEFIT ASSESSMENT FOR HARVESTING AND USE SCHEMES

There seems to be no well developed method for objectively and consistently assessing the costs and benefits of water recycling schemes (Hatt *et al*, 2004). There are additional benefits and disadvantages due to environmental and social (non-monetary) issues, which add a degree of complexity to the traditional cost/benefit approach and are often not included in the assessment.

The lack in development of a structured cost assessment procedure may be a result of the lack of specific formal guidelines relating to stormwater harvesting and use.

In order to make an assessment of the cost effectiveness of a recycling scheme, it is necessary to determine the actual costs (true costs) involved with supply and disposal—that is:

- does it include infrastructure and treatment costs;
- what is the increase/decrease to land value as a result of supplying a recycled water source, enhanced public amenity of open spaces and watercourses and possible increased aesthetic values (Water Proofing Adelaide);
- should stormwater flood mitigation and water quality components, e.g. detention basins, dams, wetlands etc, that would normally be required to reduce downstream discharge and achieve quality improvement from a new development, be included in the cost when assessing an integrated harvesting and use scheme (Pitman 2004).

The costs associated with developing a harvesting and use scheme can be separated into the following broad categories:

- capital costs
- operating and maintenance (O&M) costs
- user price (where recycled water is supplied by an agency or water authority).

Costs that are often omitted in the water supply cost are:

- land developer capital costs
- inadequate expenditure on asset replacement
- ongoing environmental levies and expenses.

For the smaller schemes included in the costing data above, it is unclear whether or not all costs are included. However, for the larger schemes, it is considered that all such costs are included to a realistic level.

When the costs of smaller schemes are looked at and compared with the cost of reticulated mains water supply rates, the majority will never appear economical. However, if the assessment is extended to include the range of other 'benefits' resulting from recycling, the schemes become more economically attractive (McAlister 1999; Water Proofing Adelaide). Some of these benefits include:

- reductions in point source pollutant loads, e.g. sediment and reductions in peak stormwater flows to downstream receiving bodies leading to downsizing of stormwater infrastructure required;
- possible savings resulting from less pollution entering receiving waters and the need for rubbish removal;
- financial benefits resulting from increased amenity and aesthetics of land used for capture, holding and treatment of stormwater for harvesting and use purposes, possibly increasing property value.

Perhaps a more suitable comparison could be made between the cost of developing an alternative source of water to the cost of implementing stormwater harvesting and use (McAlister 1999).

Hatt *et al* (2004) conclude that due to inadequate development in methodology to objectively assess the costs and benefits of water harvesting and use schemes, their implementation will be held back.

3.5 PERCENTAGE OF STORMWATER HARVESTED

The Australian Guidelines for Stormwater Management (ANZECC 2000) in Section 3.3.1 gives the key to effective stormwater harvesting when it states

'Commonly in urban areas, approximately 90–95% of the mean annual runoff volume from urban catchments occurs at flows less than the 3 month average recurrence interval event (approximately 25–50% of the 1 year flow in temperate areas). These frequent events are the target of most stormwater quality controls.'

Harvesting and use of stormwater is yet to be included in the guidelines, but it is evident from the above that the same philosophy applies to harvesting as applies to quality controls, i.e. harvesting works capacities should be directed at the 3 month ARI end of flow spectrum. In KBR's experience to date with the design of schemes, hydrologic modelling shows that this is the clue to economic designs.

The CRC for Catchment Hydrology has indicated that putting a pump on a wetland which has little operating surcharge volume will only achieve a capture of around 20% of the catchment flow. Hydrologic modelling undertaken by Richard Clark & Associates using the WaterCress program and associated costing for a number of schemes in the district to large size has indicated the following rules for designing a harvesting facility on a given watercourse or stormwater drain.

Some 70% of the catchment yield can be economically harvested if:

- an on-stream capture basin (i.e. a basin freely receiving all storm flows) of a capacity approximately equal to the volume of a 1 year ARI storm is provided;
- a holding storage of the same capacity is provided including a gravity pipe or a pump station capable of transferring the full volume of the on-stream basin to the holding storage in 24 hours;
- the stored water is processed through a cleansing facility such as a reedbed, screen or filter at a rate of about one tenth the holding storage capacity volume per day.

The arrangement is shown in diagram form in Figure 3.3.

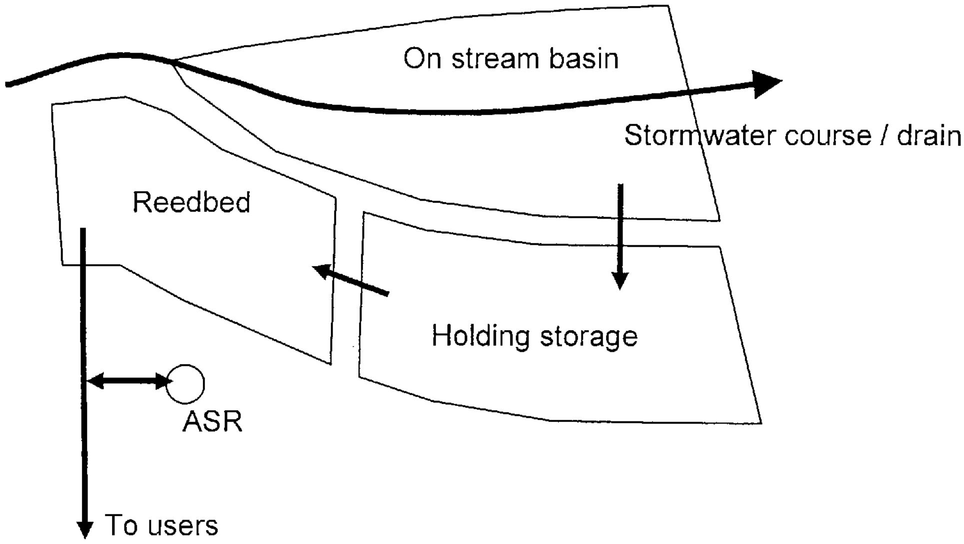

Figure 3.3
Stormwater harvesting works arrangement

When using ASR it is prudent to assume at the design stage that there will be a loss of about 20% of the injected water to the aquifer. This water is assumed to be either lost down gradient (i.e. the general direction of groundwater flow away from the wellfield), or in the injectant plume boundary mixing zone if the native groundwater is of unacceptable salinity or quality for the use applying.

Hydrogeologic assessment of the aquifer is generally required, involving the construction of test wells, in order to verify the feasibility of ASR.

In designing a scheme, water loss to the aquifer can be minimised by delivering as much water as possible direct to users without injecting and extracting it.

3.6 WATER QUALITY IMPROVEMENTS ACHIEVED

In general, with the settlement process provided by the capture and storage basins and the use of closely planted wetlands for filtering of residual suspended colloidal matter, a very high quality water can be obtained which meets the EPA licence requirements for injection to aquifers as well as the general stormwater quality requirements. Over the winter harvesting season with the facility operating at its design limit, the minimum detention through the facility is about 10 days. This allows time for very effective settlement and filtering of suspended matter to which is attached most of the toxic pollutants such as metals. The result is that in the order of 90% of the pollutants and 70% of the nutrients are removed.

For the Parafield facility to date, inflow suspended solids have averaged 38 mg/L and final cleansed water 4.4 mg/L, inflow turbidity 23 NTU and final cleansed water 2.2 NTU. For nutrients total nitrogen has been reduced from 1.46 to 0.38 mg/L and total phosphorous 0.139 to 0.024 mg/L.

It is to be noted that nutrient levels in raw stormwater are, in general, an order of magnitude below those of tertiary treated sewage effluent. As a consequence, the nutrient levels in cleansed stormwater (as above) are two orders of magnitude below tertiary sewage effluent.

There are no guidelines for stormwater quality for general community use. In general, the SA Reclaimed Water (Treated Effluent) guidelines are used. The qualities of water being achieved with disinfection are equivalent to Class A reclaimed water which is accepted for the irrigation of crops eaten raw. Without disinfection, the cleansed stormwater would be equivalent to Class B, which can be used for public open space irrigation with restrictions.

3.7 REDUCTIONS IN STORMWATER FLOWS

The frequent low stormwater flows (i.e. those less than 3 month ARI) in the wetter months constitute over 90% of annual flows (ANZECC 2000) and this is the pointer to economical design of harvesting schemes. This focus on small flows sets harvesting at the opposite end of the storm flow spectrum to flood mitigation. As a consequence, the schemes discussed may have some influence on flood flow management at the 1 to 2 year ARI level but virtually no influence for 5 year and higher ARI events. The relationship between harvesting and flood mitigation is discussed in the Study Part A Report.

As a consequence of the focus on diverting and capturing low flows, the further up the catchment the works are located the more emphasis has to be given to maintenance of environmental flows during low flow periods. The on-stream basin produces a significant improvement in water quality by detention and sedimentation even if no flows are captured. This means that environmental releases will be of a markedly improved quality. If a very high quality environmental release is required, it can be made following the final reedbed or filter.

Because of the focus on low flows, it can be seen that harvesting will not reduce the peaks of flood flows significantly. Modelling has shown that any attempt to design the works to capture and process larger flows than say 6 month to 1 year ARIs results in loss of economy with little harvesting gain.

3.8 VALUE AND AMENITY OF IMPROVEMENTS

For the smaller schemes where surcharging of wetlands is used as the capture and holding storage, there is scope for public access and to design the facility to have natural aesthetics.

For larger schemes, the capture basins have characteristics similar to flood detention basins in that the objective is to have them empty as much as possible, ready to capture the next event. As a result, they are not suited for public access. The in-stream basin tends to collect unsightly debris and involves dangers to the public. The holding storage has similar aspects but not to the same degree. In both basins, the water level can rise quickly and the banks can be slippery, which offers a dangerous situation to the public. It is considered that there is a requirement to exclude public access to the capture basins on public safety grounds.

It is only the reedbed which has attributes that may be attractive to access by the public for viewing, as is the usual case for ponds with aquatic planting. The water level in the reedbed could range from 0.3 to 1.0 m. The reedbed can be aesthetically designed with an organic shape rather than rectangular, etc. Interpretative signage can assist public appreciation of the facility.

It can be seen therefore that the works for larger schemes do not provide a direct public amenity in themselves. However, the harvested water can be used for the improvement of parklands and in the provision of water bodies and irrigation water for parks, which can add value to properties in their vicinity. In fact, this aspect of stormwater harvesting is being recognised by developers and has resulted in the developer funding harvesting works.

It is interesting to note that the use of reclaimed sewage effluent does not have this extent of attraction because of its residual nutrient levels and associated algal and aquatic weed production tendencies, precluding its use in water bodies. On the other hand, treated effluent is generally ideal for landscaping enhancement via irrigation.

Where ASR is available, the land take for the works is relatively small and it can be shown that if the harvested stormwater is used for water bodies and enhanced landscaping, the increased value of the benefiting land compensates for the loss of land used for the harvesting works.

Where ASR is not available, a cost/benefit assessment can be done to determine the extent of land which can be used for seasonal balancing storage. Even if the area required is not able to provide the full storage requirement, the reduction in the use of mains water and the water body amenity provided, can result in harvesting being economically viable in spite of annual mains water supplementation being required.

The writer has been involved with a number of projects where the increased value of allotments fronting constructed water bodies has attracted a premium of some 20–30%. The effect on allotments values in those not fronting but within easy walking distance can also be significant.

4 Preconditions for viable harvesting and use

In some respects, as harvesting and use of stormwater is in its infancy, it is not possible to give a comprehensive statement on the preconditions for viable harvesting and use. The following discussion is provided therefore at the risk of taking positions which may well prove to be incorrect, even in the short-term, as the technology progresses.

The following limitation principles should be taken into account when considering locations for the implementation of stormwater harvesting schemes:

- Urban catchments with less than 200 ha total or with less than 70 ha impermeable area are generally not economic for harvesting in comparison to SA Water potable water tariff (but may provide social benefits which outweigh the cost disadvantages as discussed previously).
- ASR is unlikely to be feasible if the T1 or T2 aquifer system does not exist, and costly, large footprint, surface storage is required for seasonal balancing. For example in general each 3 ha of irrigation served would require around 1 ha of storage space.
- Locating a diversion pump on a wetland not having a large seasonal storage capacity (e.g. surcharge provision) tends to be uneconomical. Typically, unless the seasonal storage surcharge depth is more than a metre, the yield will be unreliable.
- Use of flood retardation basins for harvesting storage reduces the ARI protection rating of the works and is generally not feasible unless capture and holding storages are added to the facility, typically doubling the works area (KBR is currently involved in development of techniques for conjoint use of existing and proposed works for both detention and capture and cleansing, and some solutions are emerging).
- Unless the irrigation areas or industrial users are within several kilometres of the harvesting site, the cost of water transfer can render schemes uneconomic.
- Greenfields areas zoned for development can be designed to accommodate economical stormwater harvesting and distribution to residences in a dual pipe system, whereas retrofitting is generally uneconomic except to large consumers.

- Catchment pollution surveillance is an essential part of sustainable stormwater harvesting.
- It is necessary to obtain the approval of SA Water to the maximum pressure allowed in any non potable water distribution system within the SA Water supply area. The general rule is that the non potable system maximum pressure must be at least 90 kPa (approx 9 m head) below the zone pressure hydraulic grade level of the SA Water reticulation.
- Salinities of harvested and ASR stored water are generally low in comparison to reclaimed sewage effluent. If effluent is to be used, there is an advantage in mixing stormwater with the sewage effluent to obtain a water quality more suited to sustainable irrigation.
- Water quality monitoring costs can be quite substantial (typically 4 to 8 cents/kL) and need to be taken into account in cost assessments.

5 Opportunities and impediments to optimising stormwater harvesting and use

In discussing barriers to implementation of schemes, it has become apparent that in general the SA planning and environmental health Acts are silent on requirements for stormwater harvesting so there are no practice guidelines in place. The national guidelines for stormwater management do not include harvesting, as mentioned previously.

A code of practice for ASR was issued in January 2004 (EPA SA 2004) and water quality requirements for stormwater quality and the aquatic environment were issued in 2003 (EPA SA 2003). There are no harvesting and use water quality guidelines in place for other than reclaimed sewage effluent, and these are often used as the default guidelines for stormwater harvesting and use.

The only institutional barrier to progressing stormwater harvesting is therefore uncertainty in the areas indicated above. This can be in the minds of the proponents, representatives of the approving agencies and consultants tasked with designing and implementing schemes.

5.1 RIGHTS TO WATER AND OWNERSHIP OF WATERCOURSES

The source of the material in this section is the Explanatory Documents volume of the State Water Plan (SA Government 2000). Comments relevant to harvesting of stormwater in the metropolitan Adelaide study area have been added.

In South Australia, allocations of and entitlements to water from natural sources, including allocation of water for the environment are set out in the Water Resources Act 1997 (WRA).

The WRA defines a water resource as a watercourse of lake, surface water, underground water and effluent. Surface water means water flowing over land following rain other than in a water course or from groundwater rising naturally to the surface. Surface water includes water flowing over land that has been collected in a dam or reservoir.

The WRA provides requirements for:

- access to and use of water resources (including surface runoff generally, not just water in defined watercourses and stormwater drains);
- establishment of prescribed water resources putting them under the control of the Minister;
- the issue of licences to take water from prescribed resources with the licences not being attached to land title and being tradeable by the licence holder;
- the preparation of water allocation plans for all prescribed water resources to provide for the granting, variation and transfer of licences;
- other water management matters including the way in which non traditional water resources such as harvested stormwater and treated sewage effluent are used, particularly in relation to the impact on natural water resources.

None of the metropolitan Adelaide study area has been prescribed in relation to the taking of stormwater. This means that councils and other bodies have those rights to the water as described below.

5.1.1 Ownership of water

One of the most important points to make about 'ownership' in relation to water rights is the difference between *ownership of water* and ownership of *the right to take water*.

Water, while it is still part of the natural resource, is considered to be a public commodity and cannot be said to be owned by any body. However, once legally captured from its natural source and taken under a person's control, that person could be said to own the right to that particular water.

5.1.2 Rights to take water

The WRA does not confer ownership of the water upon any person but sets out the rights to take water in a number of degrees. These progressive rights range from an occupier of land having an unlicensed right to stock and domestic water through to a licensed right to take a particular volume from a prescribed resource.

Crucial to the harvesting of urban stormwater is the right to stormwater in drains owned by a municipality or other body. This right to take water from a resource that has not been prescribed depends on the ownership or occupation of the land on which the water occurs—the right cannot be separated from the land. It would appear that council's (and other bodies) in the metropolitan Adelaide study area owning or having drainage easement rights over drainage reserves have the right to harvest the stormwater from those reserves without requiring a licence.

In the case of prescribed resources, the right to take water is given by a licence. This right to take constitutes a 'personal' right and does not depend on ownership of the land. The licence specifies the amount which may be taken and may specify the way it can be taken and the manner of its use. Although not applicable to the study area, as mentioned above, this may be the situation in the future as more call is made on urban water resources and there becomes a need to establish water allocation plans. Certainly this could be the mechanism used to ensure equitable resource allocation among councils.

Recently, the legal rights to take stormwater, discharge stormwater, and to reuse stormwater have been analysed (Dyson 2004).

The main outcomes of the investigations are that:

- policy issues relating to ownership and allocation of captured resources should be resolved;
- legislation should be developed to address:
  - certainty, adequacy and quality of supply of stormwater
  - value of the right to stormwater
  - liability to receive stormwater and to manage waters received.

5.2 SOCIAL, ECONOMIC AND ENVIRONMENTAL COSTS AND BENEFITS

Inclusion of WSUD, particularly stormwater harvesting and its local use increases the amenity value of urban areas. By encouraging harvesting and use at the household and neighbourhood level, an increased awareness of the value of water conservation is achieved and communities tend to feel that they have a share in the ecologic and aesthetic enhancements. Such enhancements include wetlands, selected green areas with lush vegetation such as boulevards, and water bodies all supplied from locally won resources.

It is shown elsewhere in this report that there is significant economy of size for stormwater harvesting and use schemes. However, development of local schemes with a relatively high cost per kilolitre compared to potable mains water may have social and environmental benefits which outweigh the higher relative costs. This triple bottom line approach requires alternative methods of assessment

Where space exists for larger schemes with urban catchments of 200 ha or more, the cost per kilolitre can become equal or lower than potable water. This should be the objective in the remaining broadacre areas of the metropolitan Adelaide planning strategy. Potential for schemes across Adelaide is discussed in the next section.

5.3 STORMWATER HARVESTING AND USE OPPORTUNITY IN SA METROPOLITAN COUNCILS

5.3.1 Information provided by councils

As part of the council interview process conducted in Study Part A: Audit of existing information, councils were asked to comment in regards to consideration and opportunity of adopting stormwater harvesting and use projects. In summary, of the total 19 councils interviewed in the Study, 9 (close to 50%) identified that they had stormwater harvesting and use schemes in operation at some scale and level of development. Of the remaining 10 councils, 7 identified that they were investigating or believed there was potential for implementation of stormwater harvesting and use schemes within their area.

The most common impediment to adopting harvesting and use schemes by metropolitan councils appears to be the lack of available land for capture or treatment works. This supports the more widely accepted fact that open space is a major contributing factor in the implementation of harvesting and use schemes at these catchment/development levels.

Lack of identification of potential users, particularly industrial users, is another common impediment to adoption of harvesting and use schemes. There needs to be greater consideration of the water quality requirements of potential users such that recycled water can be marketed towards providing an alternative source of water to the user that meets or exceeds those quality requirements.

The majority of councils expressed interest in further developing harvesting and use schemes or investigating the potential to incorporate ASR into stormwater management plans. Several sites were identified as being suitable for further investigation.

5.3.2 Broadacre stormwater harvesting opportunities

Residentially zoned broadacre land within the Adelaide statistical division as at 30 June 2002, which includes the study area, is analysed in Planning SA (2004). This gives information on residential broadacre land owned by companies, private individuals, SAHT, LMC, other Government agencies and associations.

A summary of the councils with larger broadacre areas of possible potential for siting of stormwater harvesting works is presented in Table 5.1, in order of magnitude of areas.

Table 5.1 Council areas with larger broadacre land at June 2002

Local Government Area	Broadacre land (ha)	State Government land for release (ha)	Total (ha)
Onkaparinga	1,166.36	6.48	1,172.84
Playford	1,110.13	3.80	1,113.93
Salisbury	583.85	5.16	589.01
Port Adelaide Enfield	185.60	61.26	245.86
Mitcham	215.65	1.8	217.45
Marion	138.34	56.00	194.34
Gawler	153.51	15.51	169.02
Campbelltown	54.02	-	54.02
West Torrens	27.02	8.08	35.15
Burnside	34.43	-	34.43

The areas in table 5.1 are of course in various parcels as well as ownerships, so it is not possible, without reference to a plan, to determine the potential for harvesting facilities. Nevertheless, it gives a general indication as to where more detailed assessments should be undertaken.

The availability of larger areas of broadacre land increases the potential for implementation of economical stormwater harvesting and use. Firstly, it means that the harvesting facilities can be included in the design of the drainage system and land allocated for the works. Secondly, it means that dual potable and non potable water reticulation can be installed economically as the lots are constructed, where some 70% of the water demand of the development can be met from non potable resources. The provision of harvesting works can also enable extension of the non potable reticulation to irrigate council reserves, recreation areas and school grounds in adjacent existing developed areas, plus industry. However, the additional land take for the enlargement of the harvesting works may be opposed by the developer of the broadacre land. Retrofitting dual reticulation services to houses is generally not economic.

Opportunities for larger schemes within the Urban Growth Boundary are limited as can be seen in Figure 9 of Planning SA (2003), included as Figure 5.1. The major broadacre areas are titled 'Future development areas concentrating on housing diversity (indicative)'.

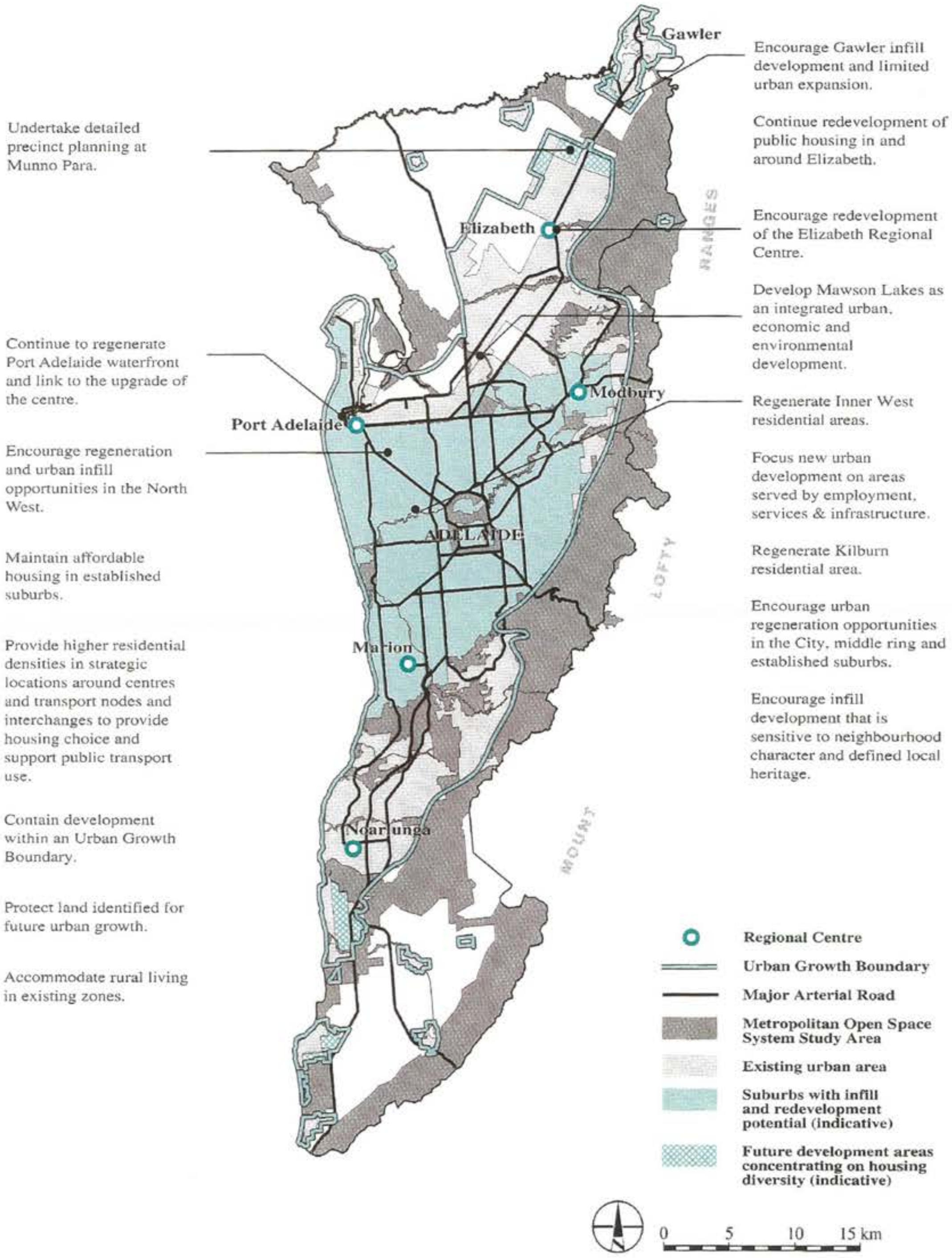

Figure 5.1
Significant broadacre land in study area

This plan identifies some 1000 ha of broadacre land in the Blakeview-Munna Para West-Andrews Farm area in the City of Playford which contains or is close to a main drainage lines and ideally suited to the installation of large scale stormwater harvesting. Some 2000 ML/a of runoff is known to pass through the Smithfield Plains and Andrews Farm area and this will increase significantly as the broadacre land in the catchment is developed. This area has access to the T1 and T2 aquifers.

Figure 5.2 is an aerial photo of the Adelaide area with existing built-up areas highlighted in green so as to make public open space and unoccupied land more visible. This indicates areas potentially large enough for economical harvesting works within about 5 to 10 km radius of the CBD, including the Adelaide City Parklands and the Adelaide Airport which are substantial areas.

The Adelaide City Parklands, including the golf courses and the Adelaide Cricket Ground, have an area of around 800 ha which would require about 4,000 to 5,000 ML/a of irrigation water at normal application rates (it is noted however, that a significant proportion of the Adelaide City Parklands are not irrigated). An ASR scheme harvesting water from First and Second Creeks, provided the catchment is at least 6,000 ha, could generate this amount of water. The capture, holding and wetland cleansing works would occupy about 30 ha and some nine ASR duty wells would be required, plus several standbys. A facility this large may not be feasible because of aquifer drawdown and mounding issues. The facility may have to be distributed over several sites to minimise this potential problem.

The Regency Park/Wingfield/Gepps Cross area to the north-west looks prospective as it has a major stormwater drain passing through it. Regency Golf Course in conjunction with the redeveloping Regency Institute of TAFE land could be a potential site subject to the availability of an adequate stormwater drainage system. However, there may be limitations on the amount of stormwater able to be harvested in this vicinity because of the environmental sensitivity of the Barker Inlet Wetlands.

Cheltenham Park Racecourse would have sufficient area for a scheme but the contours indicate that there may not be any large drains in the area from which to capture the water.

Moving further to the west, the Grange Golf Course has completed planning of a harvesting scheme as outlined in this report. There may be similar potential for the adjacent Royal Adelaide Gold Course.

Moving further south over the Torrens River, the Adelaide Airport appears to be a prime location for a large harvesting facility with major drains passing generally along its northern and southern boundaries. An airport scheme could supply internal demands and those of adjacent open space and industry by using areas for the works which would otherwise be undevelopable due to airport operational constraints.

Figure 5.2
Urban development and open space in study area

This is the basis of the Parafield facility. Netting of the basins as at Parafield Airport would provide the necessary from bird hazard control.

The other areas shown on the plan are between Noarlunga and Sellicks Beach in the south and these comprise six parcels totalling some 500 ha. Most are on high land away from watercourses so that the scope appears to be limited for large scale schemes. The availability of suitable aquifers for ASR is variable. Because of the undulating and sometime incised nature of the terrain, a detailed assessment would be necessary.

More detailed information has been obtained from Planning SA in the form of a 1:50,000 map of the Urban Growth Boundary showing smaller infill broadacre land, other sparsely developed areas and recreation areas with varying potentials for the installation of harvesting works.

A summary of these sites is provided in the table 5.2.

Table 5.2 Broadacre land with potential for stormwater harvesting sites

Municipality	Catchment	Location	Details
Playford	Smiths and Adams Creeks	Blakeview, Munna Para West, Andrews Farm	Approximately 900 ha in Blakeview and Munno Para with access to main drains and some 70 ha at Andrews Farm. Current catchment yield is reported to be some 2000 ML/a. Runoff will increase as the broadacre land is developed. T1 and T2 ASR feasible.
Salisbury	Smith and Adams Creeks and Cobbler and Dry Creeks	Scattered from Burton in the north to Cavan in the south and Salisbury Heights in the east.	Numerous small parcels some of which could have potential where catchments are of reasonable size but most are not close to major drainage routes. T1 and T2 ASR feasible.
Port Adelaide Enfield	Straddles the Torrens and Port Adelaide	Northfield	Approximately 90 ha with limited potential because of it straddling the catchment boundary and being distant from main water courses. May have scope for small schemes. T1 and T2 ASR feasible.
Onkaparinga	Sellicks and Aldinga	Sellicks Beach	Some 100 ha with a number of valleys from Sellicks Range draining through the land. The site has good potential except that access to a reasonable ASR may be limited and requires investigation.

A detailed assessment of each potential site is beyond the scope of this report.

5.3.3 The role of stormwater harvesting in waterproofing Adelaide

The following discussion focuses on the siting of schemes in the higher end of the district size (10 to 200 ML/a) and large schemes (above 200 ML/a). Schemes of this size are potentially able to provide supplies at costs below SA Water potable water tariff, resulting in an economic driver towards implementation.

This focus does not exclude emphasis being given to opportunities for the development of smaller schemes, particularly where it is feasible to surcharge existing or proposed wetlands for some or all of the capture or holding storage, with ASR to the shallower Quaternary aquifers, where feasible. Such schemes involve smaller areas and are more easily accommodated within drainage reserves and adjacent pockets of vacant land or public open space.

Key assessment factors with respect to suitability of sites for district and large size stormwater harvesting are:

1. A location on, or adjacent to, a stormwater course with an urban catchment (including hillsface) of at least 150 ha.
2. Space for the harvesting works (capture, holding, cleansing wetland, seasonal storage, and distribution), with a 150 ML/a scheme requiring 1 to 2 ha for ASR or 10 ha for surface storage, to a 1000 ML/a scheme requiring 11 ha for ASR or 50 ha for surface storage.
3. Either a nearby greenfields residential development site, major brownfield residential redevelopment site, large open spaces for irrigation, water using industry, or a combination of these.

Given the above, it is worthwhile exploring the feasibility of the vision that ASR based schemes can be distributed across the whole of the Adelaide metropolitan to harvest the 160,000 ML/a (160 GL/a) of stormwater (SA Government 2004) which discharges to the sea. An indication of this is the assessment in Clark (2003) of the stormwater resource generated by the metropolitan area and its upstream catchments amounting to 242,000 ML/a (242 GL/a). The 'drought proofing Adelaide' proposal put forward in the paper is on the basis that 50% (121 GL/a) of this stormwater could be harvested and that 925 ASR wells each with a discharge capacity of 10 L/s (0.9ML/d) would be required to supply the peak demand.

It is probable that the average discharge capacity of an ASR well would be more like 20 L/s (1.7 ML/d), assuming a mixture of Q, T1 and T2 wells. This would reduce the number of operating wells to about 450.

A two duty well facility requiring a works area of 4 ha would provide supply of about 0.5 GL/a provided it had an urban catchment not less than 650 ha, or a proportionate share of a larger catchment. Hence to supply the 121 GL/a some 240 facilities with a total of 480 ASR wells plus standbys would be required. The unit capital cost from Figure 3.1 is $5,000/ML/a ($5 million/GL/a) making the cost of a facility $2.5 million, or a total of $600 million. The works would occupy a total area of 960 ha. Allowing a possible developer's margin of $10,000 per equivalent house lot and 10 lots/ha, the land value is $96 million. Hence, the indicative total capital cost is $696 million. The production cost of the water would be about $0.75/kL plus $0.08/kL for the cost of the land, i.e. a total of $0.83/kL. If properties had to be purchased and demolished to provide space for the works, the production cost of the water would more than double.

The above costs do not include reticulation of the water from the harvesting facility to customers. Nevertheless, when compared to the options in the Water Proofing Adelaide discussion paper, (page 42), for increasing supply from existing sources and (page 48), options for increasing supply from new sources, the above ranks second to the Interstate Pipeline in volume supplied and is one of the most competitive in cost.

It is considered that it would be very difficult to implement a full 121 GL/a scheme given the disruption to existing developed areas and the discontinuity and variability of the shallow aquifer potential for ASR over the study area as shown in Figure 5.3 taken from Pavelic et al (1992). In the figure, the industry areas have a minimum well capacity of 0.5ML/d, municipal 0.2ML/d, and household 50kL/d. However, a distributed scheme as envisaged has the advantage of being incremental and there appear to be no barriers to development of those sites where space is available.

A study team for the Urban Stormwater Initiative is investigating the ASR capacity of aquifers throughout the study area and this will greatly assist in the assessment of the potential for a distributed system as envisaged above.

The Australian Water Conservation and Reuse Program (AWCRRP), a joint venture of 16 private and public organisations with representation from each State and led by CSIRO and the Australian Water Association, has identified a range of ways to reduce the fresh water demand of Australian cities. An exciting ASR investigation project under this program is underway adjacent to the Parafield Stormwater Harvesting Facility sponsored by CSIRO, United Water, City of Salisbury, SA Water, Northern Adelaide & Barossa Catchment Water Management Board and Mawson Lakes Development.

The proposal is the first in the world to inject stormwater into an aquifer via a well with the intention of recovering the water from another well as fit for continuous sustainable supply of potable quality. This is referred to as 'aquifer storage transfer and recovery' (ASTR). The separate injection and recovery well arrangement has the advantage of filtering the injected water through the aquifer before use. This process is known to remove pathogens and pollutants. This project has the potential of providing reserves of potable water quality throughout the metropolitan area, able to be directly pumped into the mains and not requiring duplicate reticulation. All other schemes discussed in this report have been based on non potable supplies which have required a dual pipe system. (Dillon 2004).

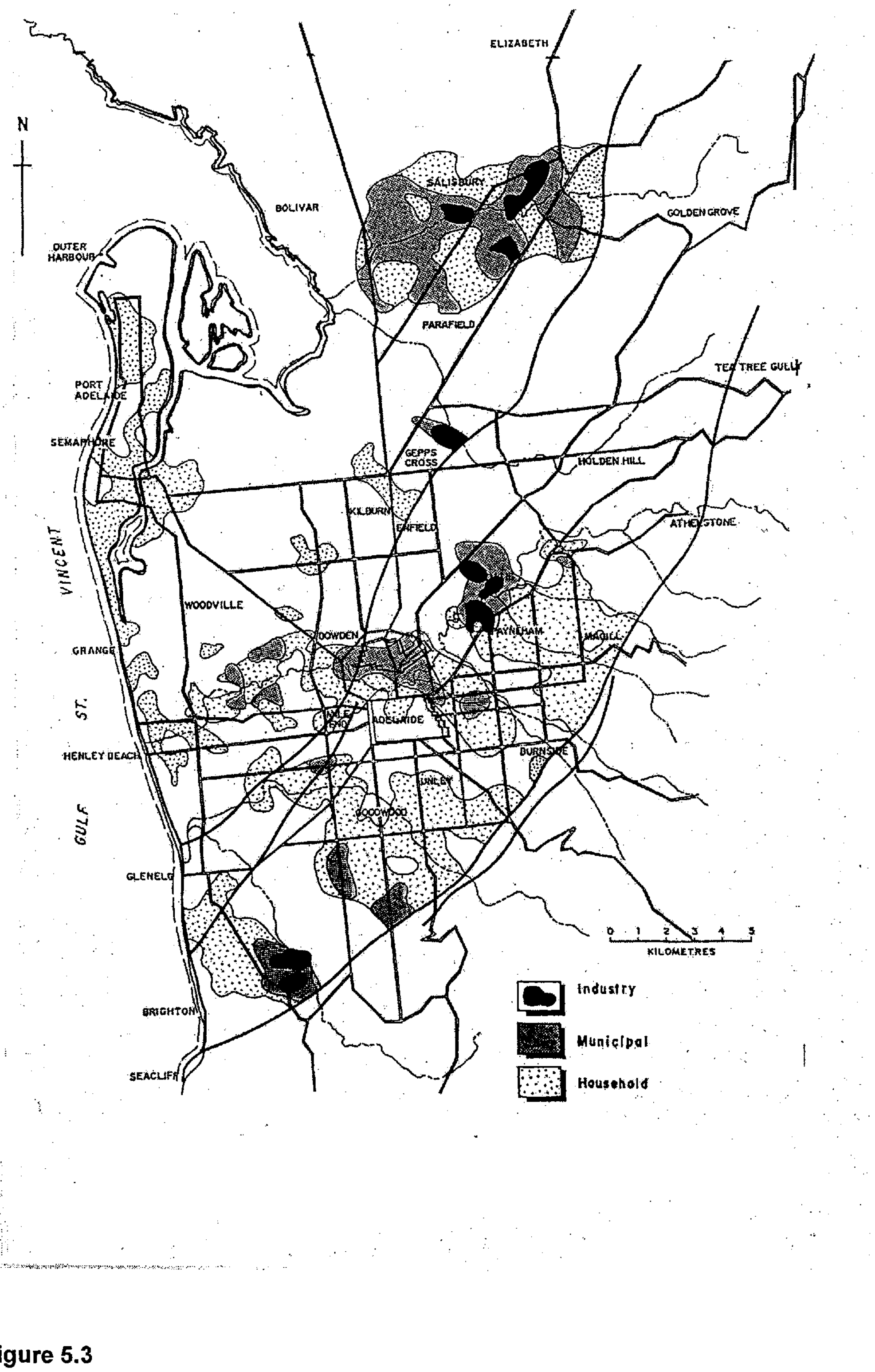

Figure 5.3
Shallow aquifer ASR capacity across metropolitan Adelaide

At the risk of being substantially in error, it is considered that the potential for stormwater harvesting within the current Urban Growth Boundary is of the order of 20 to 25 GL/a, not counting the effects of mandating rainwater tanks. Two thirds of this is expected to be located within the Cities of Salisbury and Playford, primarily in the form of large schemes. The balance will possibly come from smaller schemes opportunistically located throughout the remainder of Adelaide as discussed above. Water Proofing Adelaide (p. 48) lists the potential resource as 10 GL/a (with more being available at higher costs) and the supply cost being $0.50 to $1.50/kL.

It is considered that a detailed study should be undertaken of all main drainage routes to identify those locations where sufficient open space exists in proximity to favourable ASR sites to allow stormwater harvesting. This has been undertaken for the Northern Adelaide Plains (KBR 2003).

5.4 DESIRED STATUTORY FRAMEWORK

Ensuring consistency and integration across government and between governments is necessary to facilitate maximising the use of alternative water resources. To this end, amendments to the Metropolitan Adelaide volume of the Planning Strategy (Planning SA 2003) are being undertaken as part of a package of planning reforms which include amendments to the Development Act 1993.

The draft revised strategy advocates taking a whole of water cycle approach to water use and management and integrates this into the land use and development. These strategies are summarised as follows:

1. Ensure the most efficient use of water based on the hierarchy principles of avoidance, reduction, harvesting and use, recycle and appropriate disposal.
2. Minimise risk of flooding to persons and property.
3. Integrate the management, protection and use of water resources into the broader land use planning and management.
4. A coordinated multi-objective approach to the provision of infrastructure, from the perspective of stormwater as a resource as well as a potential hazard.

The above was summarised from Bellette (2004).

The WSUD strategy has been approved by Cabinet and is with the Minster for implementation.

These changes would move the current position of silence and inertia in relation to urban water resource management to a proactive position where planners, developers, and approving agencies in general would have to consider alternative water sources, including stormwater harvesting for each development. This would be a major step forward in maximising the use of urban water resources in a sustainable manner.

As discussed in Section 5.1, there appears to be no statutory barriers to the taking of water from council drains for harvesting and use.

In relation to the quality of stormwater for harvesting and use, there is no specific legislation or guidelines. Other states are moving towards combining all sources of non potable water in the one set of quality guidelines. By default, in South Australia the Reclaimed Water Guidelines (Treated Effluent) are used which give four classes of non potable water commencing with Class A which is approved for use in urban areas and houses without restrictions, including the irrigation of salad crops eaten raw. Classes B to D are of reducing quality with approved uses in accordance with the level of risk involved. These classes provide a satisfactory basis for stormwater harvesting and use. Systems can generally meet Classes A and B with ease.

A code of practice for aquifer storage and recovery (EPA SA 2004) has recently been released and this is considered a satisfactory document.

Licensing of ASR facilities is on an annual basis and this is perhaps the only critical area requiring some form of legislation or variation to existing procedures to give owners of the facilities some guarantee that their investment will be able to continue for its planned life. Because of the high costs of the facilities (e.g. one ASR well to the T1 or T2 aquifer can cost in the order of $0.5 million) and their long projected life, owners need a much longer surety of tenure for the assets than provided by the current licensing arrangements.

The possibility of one party being licensed to extract ASR water injected by another party without agreement has been raised as a legal technicality. In relation to this matter it is hard to imagine that the licensing agency would allow the issue of such a licence. This is a matter that could be rectified at the same time as the licence term.

Perhaps the main issue regarding development of schemes which has parallels in the flood management area, is that of catchment sharing. This is where a council uses a catchment area partly or fully within another municipality. There is a need for an agreement in perpetuity to give the harvesting council exclusive rights to an agreed proportion of the water from the catchment. It is considered that the statutory arrangements for the sharing of responsibilities for flood mitigation works could provide a basis for facilitation of agreements between councils in this regard.

This issue equally applies where a private entity wishes to undertake such a scheme, independent of council. Agreement to the rights over accessing the stormwater, again with a commitment for ongoing confidence over the security of that supply, is required to be reached and should be encouraged.

5.5 PRECONDITIONS AND OPPORTUNITIES FOR ATTRACTING PRIVATE SECTOR INTEREST/INVOLVEMENT

If the amendments to the Planning Strategy for Metropolitan Adelaide proceed the initiative for implementation of stormwater harvesting schemes will not be haphazard as it is at present. Developers will have to consider recycling at the outset and this will involve the private sector in devising, designing, and constructing the schemes. It is assumed that councils and SA Water will own the schemes, with some being implemented through BOOT (build, own, operate and transfer) arrangements, eventually being handed back to the council or SA Water at the end of the contract period.

Planning, design and operation of water supply schemes is not currently the core business of councils in SA and this is a possible barrier to the implementation of beneficial non potable water supply schemes within their municipalities. Whilst the benefits can be significant, the ownership and operation of such schemes involves a level of risk.

Councils could manage the risk by engaging locally represented companies such as United Water and United Utilities to operate and maintain the facilities under long term outsourcing contracts. This could be extended to build-own-operate (and transfer) contracts as outlined in Study Part A Report. SA Water, as well as companies such as United Water and United Utilities, have the skills to assess the hydrologic requirements and risks in producing contracted outcomes taking into account the vagaries of climate, the economy and consumers. It would be feasible to implement and operate harvesting works on an output based contract basis of a long term such as 20 years. Such an arrangement could include complete customer service.

As discussed previously, there is some scope to combine flood mitigation works and harvesting works and involvement of the private sector could assist with innovation in this area.

5.6 RECOMMENDATIONS

The impediments and potential impediments to implementation of stormwater harvesting have been discussed, including suggested solutions, in the various sections of the report. These are now listed with recommendations as follows:

It is recommended that:

- Potential stormwater harvesting sites are identified in each catchment where main drainage routes pass through open space in locations favourable to development of ASR.

- Proposals are initiated to establish South Australian and national guidelines for the use of stormwater for non potable purposes.

- The Minister be requested implement the proposed amendments to the Planning Strategy for Metropolitan Adelaide under the Development Act 1993, as approved by Cabinet, to provide for the inclusion of water sensitive urban design in development proposals.
- Legislative amendments are initiated to provide for the licensing of ASR wells to be extended for a period of at least ten years with rights for renewal to allow owners of facilities to obtain security of their works.
- Legislative amendments are initiated providing for the protection of agreements for the use by councils of the runoff from catchments fully or partially within another municipality for stormwater harvesting.
- Councils use long term output based contracts for the implementation and operation of stormwater harvesting schemes, to obtain the necessary level of expertise and management of risk.

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Appendix A

STORMWATER HARVESTING AND USE SCHEMES IN SA AND INTERSTATE

SCHEME	REUSE	CATCHMENT	CAPTURE	TREATMENT	STORAGE	COST
Large schemes						
Parafield SA	Stage 1: 1100 ML/a, 6 ML/d peak. GH Michell wool scouring. Mawson Lakes recycled water. Ultimate: 3000 ML/a	Stage 1: 1600 ha industrial & residential Ultimate: 4600 ha industrial and residential	Stage 1: 50 ML capture basin on Airport Drain plus 50 ML holding storage. Ultimate approximately 200 to 300 ML capture basin and holding storage capacity Captures approx. 70% of catchment runoff.	Sedimentation in capture basin and holding storage. Filtration through 2 ha reedbed at 6 ML/d (Stage 1). Average detention 10 days. Achieve >90% reduction in pollutants.	Stage 1: Two 2.4 ML/d aquifer injection wells (190 m deep) Ultimately six or more ASR wells. Stage 1 objective 2000 to 3000 ML buffer in aquifer to drought proof the scheme.	Stage 1: Capital cost $4.5 million. O&M $0.30/kL and 20 yr loan cost approx $0.30/kL, total $0.60/kL. User price confidential.
Sydney Olympic Park NSW	200 ML/a stormwater plus 700 ML/a sewage effluent for open space irrigation, water features, house gardens and toilets, fire fighting, env. flows Total supply 2.5 ML/day.	760 ha industrial and residential including 400 ha open space. Stormwater polluted from previous industrial use of site.	Stormwater drainage system discharging to Brick Pit, a former quarry. All stormwater retained due to contamination.	GPTs, swales, constructed wetlands, first flush ponds, micro-filtration, RO, chlorine disinfection, dechlorination. Capacity 7 ML/day	350 ML brickpit 140 ML wetlands	Capital cost $15.88 million O&M $30 mill over 25 years $1.80/kL and 20 year loan $1.76/kL, total $3.56/kL User price $0 775/kL fixed by regulator.

SCHEME	REUSE	CATCHMENT	CAPTURE	TREATMENT	STORAGE	COST
District schemes						
Northfield - Regent Gardens SA (Port Adelaide Enfield)	Approximately 40 ML/a for irrigation of reserves and lake makeup.	77 ha, 1250 allotments	Constructed wetlands Ponds (9.7 ML)	Wetlands	One well injects to aquifer at 80 m depth. Approx. 40 ML/a recharge	Capital (WSUD components) \$220,000. O&M \$5,500/a. Stormwater quality component- \$0.26/kL/a, well/recharge component \$0.28/kL/a, 20 year loan \$0.55/kL. Overall cost \$1.09/kL.
The Paddocks SA (City of Salisbury)	Data being provided by City of Salisbury Irrigation of Council reserves	46 ha community reserve	Four catchment drains roof and street drainage	Grassed swales and constructed wetlands	Approx. 75-80 ML/a harvested and injected to T1 aquifer.	Further information not available.
Morphettville Racecourse SA	Irrigation of racecourse approx. 200-250 ML/a	Diversion from 465 ha catchment	~	GPT, sediment trap Wetlands (~3.5 ha) designed for 7 days retention	Aquifer injection Approx. 600 ML/a recharge design. First year operation ~ 120 ML/a	Further information not available. \$250,000 C&CS funding

SCHEME	REUSE	CATCHMENT	CAPTURE	TREATMENT	STORAGE	COST
Kaurna Park SA (City of Salisbury)	Data being obtained from City of Salisbury	5,657 ha total including; 1090 ha hillsface 2080 ha Elizabeth City 1577 ha DSTO land 910 ha Kaurna Park	Aprrox. 2000 ML/a runoff from catchment 814 ML flood detention for 100 yr event	~	~	Further information not available.
Andrews Farm SA (City of Playford)	Approx. 35-60 ML/a reuse for irrigation of Council reserves and open space	3160 ha Smith Creek	A series of 3 'in-stream' flow control ponds Transferred to wetlands Approx. 120 ML/a harvestable	GPT Detention ponds Wetland reedbeds Filter by SS screen and geotextile prior to injection	Aquifer injection Approx. 80-100 ML/a recharge.	Further information not available. Total capital cost ~$5M
Kogarah NSW	70% of demand met irrigation, toilet flushing, water features, car washing	193 residential apartments 4500 sq m commercial and retail	All runoff to underground storage tanks	Sand filters Biological ecosoil	Underground storage tanks	$629,000 Environment Aust. - Urban Stormwater Initiative funding
Pine Lakes ASR Scheme (City of Salisbury)	15-20 ML/a used for irrigation of Council reserves	25 ha Pine Lakes sub-division Diversion from adjacent Parafield Drain	Potential yield of 45 ML/a based on existing wetland capacity	Wetland treatment		Further information not available.
Tea Tree Gully Golf Course	25-50 ML/a yield for irrigation of golf course	Diversion from part of Dry Creek catchment	Holding dam within golf course	Holding pond	Aquifer injection 25-50 ML/a Extraction during summer for irrigation	Further information not available.

SCHEME	REUSE	CATCHMENT	CAPTURE	TREATMENT	STORAGE	COST
Pooraka Triangle SA	Details being obtained from the City of Salisbury Current reuse 200 ML/a irrigation of Council reserves Future increase to 400 ML/a if demand arises	5300 ha catchment "off-line" wetland system fed by Dry Creek local catchment not utilised in ASR scheme	Wetlands capture and treatment	Wetlands and reedbeds	Aquifer injection of approx. 200 ML/a	Further information not available.
Oaklands Park VIC	Non-potable and fire fighting water Toilet flushing Some irrigation	174 ha (121 ha open space)	Runoff from roofs to supply potable water Paved runoff to swales	First flush diversion for roof runoff Open swale drains No specific water treatment performance requirements	49 ML lake system roof runoff to 70 kL tanks	Non-potable water supply components $73,000 $800/lot/a for supply of 150 kL
Neighbourhood schemes						
Parfitt Square City of Charles Sturt	5 extraction wells for irrigation of parks (0.6 ha)	Approx. 1 ha 27 residences ultimate development + 250 m length carriageway	Gravel based reedbed Swale Capture 1 in 100 yr event	Reedbed Gravel filled trench (400 m^2) Geotextile bore lining	4 bores inject to shallow (12 m) aquifer annual recharge 1.7 ML	Further information not available.
St Elizabeth Church City of Marion	Same bore extracts for irrigation of reserve and church garden	~0.3 ha impervious carpark 1200 sq m tennis ct 1000 sq m roof 300 sq m	Infiltration basin including grasspave carparks Gravel trench Capture 1 in 100 yr event	Grasspave Gravel filled trench Sediment trap and oil arrestor Geotextile bore lining	1 bore injects to Quaternary aquifer 45 m below ground level Approx. 1 ML/a	Further information not available.

SCHEME	REUSE	CATCHMENT	CAPTURE	TREATMENT	STORAGE	COST
New Brompton Estate City of Charles Sturt	Irrigation of central reserve No formal irrigation management plan	15 allotments (approx. 150 m^2 each)	Gravel trench (approx. 1 m x 1 m x 100 m long)	Perforated pipe for sediment removal Gravel trench	1 bore injects to aquifer 30 m below ground level (Q2) Approx. 1 ML/a	Further information not available.
Plympton Anglican Church	Passive irrigation of vegetated area above gravel trench	1600 sq m roof 400 sq m grass	Gravel trench First flush pond Excess to street drainage	Gravel trench Infiltration basin	Gravel filled trench	Further information not available.
Individual building schemes						
"Intelligent home"	Roof runoff to hot water system (65°C) Treated bathroom effluent to WC overflow to sewer	120 sq m roof	2 kL rain tank with overflow to stormwater drain. Effluent from bathroom	Roof runoff to tank Bathroom effluent to gravel reedbed	Raintank 2 kL Gravel reedbed	Further information not available.
Port Phillip Council - Vic	Pump to toilets Overflow to street Elwood boat washing	270 sq m roof 7 units	Central 15 kL tank	Filtration	15 kL central tank Top-up water from mains.	Capital cost $50,000
Figtree Place - NSW	Garden/open space irrigation Bus washing (2 ML/yr) Dual retic Hot water systems and toilet flushing	1.1 ha development 27 allotments	Paved runoff and lawn/garden runoff to detention basin Roof runoff via first flush to tanks Capture >80% for 1 in 50 yr	Infiltration basin, 250 sq m grassed depression over gravel layer Geofabric lining	Unconfined aquifer Raintanks 9 kL to 15 kL	$2.7 million basic development $109,900 WSUD principles. Total water saving 1190 kL/a, irrigation saving 830 kL/a, bus

SCHEME	REUSE	CATCHMENT	CAPTURE	TREATMENT	STORAGE	COST
						washing saving 1700 kL/a. O&M not known but 20 year loan payment cost is $2.95/kL. Reuse water tariff not known. Hunter Water cost (mains) -$0.92/kL.
New Haven SA	Stormwater component minor Subsurface irrigation, toilet flushing	65 allotments on 2 ha site	40 kL below ground tank captures stormwater runoff from development Overflow directed to soakage trench	Gross pollutant removal prior to storage Blended with sewage then undergoes aeration, UV disinfection, filtration	Two 22.5 kL below ground tanks	Further information not available.

Appendix B

PROJECT DETAIL SHEETS

SCHEME	**FIGTREE PLACE**
Location	Hamilton, NEWCASTLE, NSW
Stakeholders	Newcastle City Council Building Better Cities Program NSW Dept Housing
Source	SSUD 04, UWRC

SITE CHARACTERISTICS

Development type	Medium residential development
Catchment Size: (Catchment/Development size/No. allotments)	3 ha bus station site, 1.1 ha development, 27 allotments
Scale: (Household/Neighbourhood/Large)	Neighbourhood
No. years in operation	6

SYSTEM OBJECTIVES	Retain stormwater onsite and reduce potable water consumption Supply 50% in-house needs, 100% irrigation and 100% bus washing demand
Description of scheme and WSUD principles	

SYSTEM COMPONENTS	
CAPTURE	Runoff from paved areas, lawns and gardens to central detention basin recharge area Roof runoff via first flush to tanks
Capacity (Minor/major event)	Design capacity 83% of runoff for all events up to and including 1 in 50 yr event
Methodolgy	Internal kerbed roadways
HOLDING/TREATMENT	Infiltration basin Five central u/g tanks overflow to recharge trench
Capacity	
Methodology	Infiltrated through base of basin, 250 sq.m grassed depression, overlays 750 mm layer gravel enclosed in geofabric below 300 mm topsoil Optionally treated for colour removal (activated carbon)
STORAGE	Unconfined aquifer (ASR)
Capacity	Raintank from 9 to 15 kL
Methodology	No overflow from site up to 2000
REUSE	Garden and open space irrigation, bus washing at adjacent depot and other outdoor use
Capacity	Max 2000 kL./yr supplied to bus depot
Methodology	Submerged pump in infiltration basin Dual retic Prelim studies of water availability from roof and general runoff indicate ample supply for domestic uses Pumps supply hot water systems and toilet flushing

IMPLEMENTATION ISSUES	Provision made to convert to conventional system incase of shortage or quality Detention basin provides open space recreation during summer
Site restrictions	
Public safety	Irrigation occurs during night to minimise risk of ingestion Rainwater in hot water systems must comply with drinking water standards Backflow prevention devices to isolate supply
Possible problems	Groundwater contamination Groundwater mounding or excessive drawdown Water quality monitoring
Institutional	Delays caused by approval agencies Dual retic not compliant with AS No framework for acceptance of WSUD principles
Other	Delivery method crucial in success or failure of innovative projects Standard of design documentation be well above average Early involvement of approval agencies and construction contractor Fail-safe provisions and on-going monitoring program vital element of the project and reflect its experimental nature
OPERATION & MAINTENANCE	Monitoring of raintank water levels to ensure capacity maintained
Procedures	
MONITORING	Rainwater tanks, hotwater systems and potable supplies monitored monthly for faecal coliforms, total coliforms and range of parameters Groundwater quality monitored regularly Pressure sensors in tank adjacent to basin measure depths every 6 hours Similar for bores Monitoring of infiltration rates and quantity of runoff

PERFORMANCE	
Against objectives	65% reduction in potable water consumption (Dec 98)
Quality	Groundwater complies with drinking water standards except pH Acceptable for irrigation and bus washing Roof runoff, occasionally exceeded guideline values for ammonia, pH, iron and lead
Quantity	Raintanks ~11-44% reduction in mains water use
COST & BENEFITS	
Capital outlay	$2.7 M basic development, $109,900 for WSUD elements analysis redevelopment cost-effective when considered as a component of "beyond capacity" urban infrastructure
Annual operating ($/kL)	
User price	Payback period for WSUD elements would be longer than the anticipated life of project
Reduction on potable demand	Overall reduction in potable water demand of ~60% Designed to contain 83% of runoff for all events up to and including 1 in 50 yr event
Pollution control	
Infrastructure	Stormwater discharge almost completely eliminated, reduced downstream flood peak and reduced strain on stormwater infrastructure, including pollution control installations
Environmental flow	

SCHEME	**KAURNA PARK**
Location	CITY OF SALISBURY
Stakeholders	City of Salisbury
Source	KBR 2002

SITE CHARACTERISTICS

Development type	
Catchment Size: (Catchment/Development size/No. allotments)	5,657 ha total 1090 ha hillsface 2080 ha Elizabeth City Centre and residential 1577 ha DSTO 910 ha Kaurna Park
Scale: (Household/Neighbourhood/Large)	District
No. years in operation	Established 1994

SYSTEM OBJECTIVES

Description of scheme and WSUD principles	Environmental improvement wetland Flood mitigation detention basin

SYSTEM COMPONENTS	
CAPTURE	Approx. 2000 ML/a runoff from catchment (future 3475 ML/a)
Capacity (Minor/major event)	814 ML flood detention capable of mitigating 100 yr ARI event
HOLDING/TREATMENT	NA
Capacity	
STORAGE	NA
Capacity	
REUSE	
Capacity	

OPERATION & MAINTENANCE	Information not yet available
Procedures	
MONITORING	

PERFORMANCE

Against objectives

Quality

Quantity

COST & BENEFITS

Information not yet available

Capital outlay

Annual operating ($/kL)

User price

Reduction on potable demand

Pollution control

Infrastructure

Environmental flow

SCHEME	**KOGARAH TOWN SQUARE**
Location	SYDNEY, NSW
Stakeholders	Kogarah Council
Source	Kogarah Council

SITE CHARACTERISTICS

Development type	Town square development
Catchment Size: (Catchment/Development size/No. allotments)	193 residential apartments, 4500 sq m commercial and retail area
Scale: (Household/Neighbourhood/Large)	Neighbourhood
No. years in operation	

SYSTEM OBJECTIVES

Description of scheme and WSUD principles	Collection and treatment of stormwater Reuse of stormwater in toilet flushing, car washing, and water features Use of AAA-rated water saving devices

SYSTEM COMPONENTS	
CAPTURE	Private terraces 770 sq m Roofs 5172 sq m Town Square 1257 sq m Landscape courts 1497 sq m
Capacity (Minor/major event)	Annual rainfall 8230 kL Annual stormwater captured 6997 kL (85%)
Methodolgy	Roof runoff collected separately from paved surface runoff
HOLDING/TREATMENT	Paved runoff treated by GPT then directed to high level control tank topped up from mains water Roof runoff directed to low level storage tank. Screen and silt trap - filter/disinfection - water feature
Capacity	
STORAGE	Two control tanks and two main storage tanks (below ground)
Capacity	Size of Olympic swimming pool...
REUSE	Roof runoff to water feature, toilet flushing and car washing Paved runoff for irrigation
Capacity	42% reduction in mains water use

COST & BENEFITS	Water component - $629,000 Environment Australia - Urban Stormwater Initiative
Capital outlay	Not available
Annual operating ($/kL)	
User price	

SCHEME	**MAWSON LAKES**
Location	MAWSON LAKES, SA
Stakeholders	CITY OF SALISBURY, Delfin - Lend Lease Consortium
Source	KBR

SITE CHARACTERISTICS

Development type	Residential Development
Catchment Size: (Catchment/Development size/No. allotments)	600 ha, approx. 3500 residences,
Scale: (Household/Neighbourhood/Large)	Large residential
No. years in operation	2

SYSTEM OBJECTIVES

Description of scheme and WSUD principles	Provide at least 50% of household water and open space irrigation with recycled water Estimated 70% of total 1600 ML/a demand supplied by recycled water

SYSTEM COMPONENTS	
CAPTURE	Stormwater roofs, roads harvested and cleansed in wetlands prior to disinfection and filtration for distribution
Capacity (Minor/major event)	
Methodolgy	
HOLDING/TREATMENT	
Capacity	
Methodology	
STORAGE	Surplus stormwater injected to aquifer for storage and recovery during summer
Capacity	
Methodology	
REUSE	Approximately 400 ML/a stormwater reuse
Capacity	
Methodology	Dual household connections for toilet flushing, garden watering and car washing

	Public open space irrigation
IMPLEMENTATION ISSUES	Further information not available at time of publishing
Site restrictions	
Public safety	
Possible problems	
Institutional	
Other	
OPERATION & MAINTENANCE	Further information not available at time of publishing
Procedures	
MONITORING	Further information not available at time of publishing
PERFORMANCE	Further information not available at time of publishing
Against objectives	
Quality	
Quantity	

COST & BENEFITS

Capital outlay	Estimated $11.2 million for recycled water system $3,300 per lot ($1,700 retic. and $1,600 headworks)
Annual operating ($/kL)	
User price	
Reduction on potable demand	Approx. 10% at present stage

SCHEME	**MORPHETTVILLE RACECOURSE WETLANDS AND ASR SCHEME**
Location	MORPHETTVILLE
Stakeholders	SAJC, CMSS, CCS, Koukourou Engineers, AGT
Source	Patawalonga CWMB, SAJC (Brenton Wilkinson)

SITE CHARACTERISTICS

Development type	Racecourse Wetlands
Catchment Size: (Catchment/Development size/No. allotments)	Diversion from 465 ha Mitcham catchment
Scale: (Household/Neighbourhood/Large)	Local catchment
No. years in operation	ASR component in operation since 2003

SYSTEM OBJECTIVES

Description of scheme and WSUD principles	Improve water quality in catchment and improve the quality of the racecourse Reduce downstream discharge

SYSTEM COMPONENTS	
CAPTURE	Approx. 500 ML/a
Capacity (Minor/major event)	Overflow from Wetlands to Sturt River
Methodology	Stormwater diversion from local catchment via adjacent stormwater drains
HOLDING/TREATMENT	3.5 ha wetlands, comprising deep open water sections and deep and shallow marshes vegetated with over 100,000 aquatic plants. Sediment ponds, litter traps Active storage depth of 1 m to achieve required treatment
Capacity	Approx. 35 ML active storage in wetlands Released to achieve residency time of 4-7 days
Methodology	Stormwater diverted from adjacent drain to GPT and sediment trap
STORAGE	Aquifer injection
Capacity	Approx. 500-600 ML/a injected during fully operational stage 2003 figures indicate 120 ML injected during commissioning
REUSE	Irrigation of racecourse approx. 200-250 ML/a when operational
Capacity	
IMPLEMENTATION ISSUES	Redevelopment of the racecourse track took place at the same time Number concerns including mosquito management, access to the wetlands

OPERATION & MAINTENANCE	SAJC
Procedures	
MONITORING	SAJC hold EPA license and monitor water quality Automatic sampling of water quality to determine when aquifer injection can occur
PERFORMANCE	
Against objectives	Has only been operational for 1 year - limited information
Quality	No quality issues at present
Quantity	2 bores provide approx. 30-40 L/s injection each
COST & BENEFITS	Redevelopment of the track during earthworks for the reuse scheme resulted in cost savings
Capital outlay	Joint venture - $250,000 funding from Catchment Board, State and Federal Govt. SAJC provided funding for ASR component + track redevelopment
Annual operating/maintenance ($/kL)	Awaiting information from SAJC
User price	NA
Reduction on potable demand	200-250 ML/a for irrigation of racecourse
Pollution control	Reduction in the amount of pollution discharging to the marine environment of Gulf St. Vincent

SCHEME	**NEW BROMPTON ESTATE**
Location	BROMPTON, ADELAIDE
Stakeholders	City of Charles Sturt
Source	UWRC

SITE CHARACTERISTICS	
Development type	New residential development
Catchment Size: (Catchment/Development size/No. allotments)	15 allotments surrounding a 50 m by 45 m central reserve
Scale: (Household/Neighbourhood/Large)	Neighbourhood
No. years in operation	13
SYSTEM OBJECTIVES	Aquifer Storage and Recovery.
Description of scheme and WSUD principles	Scheme designed to collect, treat and use runoff generated from roofs and stored in aquifer.

SYSTEM COMPONENTS	
CAPTURE	Roof runoff passes to gravel filled trench 106 m long around reserve via gutter and downpipes Overflow passes to street drainage system
Capacity (Minor/major event)	
HOLDING/TREATMENT	Sediment trap Gravel filled trench
Capacity	
STORAGE	Treated stormwater recharged into aquifer Q2 (30 m below ground) via central bore
Capacity	
REUSE	Submersible pump placed in bore for extraction during summer
Capacity	Expected up to 1 ML/a recharge. No formal irrigation procedures in place
IMPLEMENTATION ISSUES	Need for public open space for recreation
OPERATION & MAINTENANCE	
Procedures	
MONITORING	EPA licence required for aquifer recharge for developments/catchments over 1 ha

PERFORMANCE	Information not available at time of publishing
Against objectives	
Quality	
Quantity	
COST & BENEFITS	Information not available at time of publishing
Capital	
Annual operating and maintenance ($/kL)	
User price	

SCHEME	**NEW HAVEN VILLAGE**
Location	NORTH HAVEN (OSBORNE)
Stakeholders	SAHT,
Source	

SITE CHARACTERISTICS

Development type	Residential
Catchment Size: (Catchment/Development size/No. allotments)	65 allotments, 2 ha site
Scale: (Household/Neighbourhood/Large)	Neighbourhood
No. years in operation	12

SYSTEM OBJECTIVES	To reduce potable water demand Reduce/avoid D/S pollution by on-site treatment and reuse of all wastewater Implement env. friendly water, wastewater, and energy strategies Increase amenity of area
Description of scheme and WSUD principles	Stormwater and wastewater treatment and reuse

SYSTEM COMPONENTS	
CAPTURE	40 kL underground tank collects stormwater runoff
Capacity (Minor/major event)	Overflow directed to a soakage trench with overflow to adjacent sports field Field design emptying time 3 hours
HOLDING/TREATMENT	Stormwater pumped to treatment plant with sewage and undergoes treatment
Capacity	Aeration Sand filter UV disinfection
STORAGE	Treated effluent/stormwater stored in two 22,500 L underground tanks
Capacity	
REUSE	Sub-surface irrigation of gardens Toilet flushing
Capacity	

OPERATION & MAINTENANCE	
Procedures	

MONITORING	
PERFORMANCE	Information not available at time of publishing
Against objectives	
Quality	
Quantity	
COST & BENEFITS	Information not available at time of publishing
Capital outlay	$162,000
Annual operating ($/kL)	O&M $15,350
User price	
Pollution control	Water quality meets ANZECC Guidelines for irrigation water quality

SCHEME	**NORTHFIELD RESIDENTIAL DEVELOPMENT**
Location	REGENT GARDENS
Stakeholders	CITY OF PORT ADELAIDE/ENFIELD
Source	PAE

SITE CHARACTERISTICS

Development type	Residential
Catchment Size: (Catchment/Development size/No. allotments)	77 ha, 1250 allotments, 10.6 ha open space
Scale: (Household/Neighbourhood/Large)	Neighbourhood
No. years in operation	

SYSTEM OBJECTIVES

Description of scheme and WSUD principles	Reduce D/S runoff from development Improve water quality Assess potential for ASR in this area Increase aesthetics by greening reserves

SYSTEM COMPONENTS	
CAPTURE	Series of constructed wetland ponds
Capacity (Minor/major event)	
HOLDING/TREATMENT	
Capacity	Reserve area 4.8 ha Lakes surface area 1.7 ha Lakes volume 9.7 ML
STORAGE	Maximum storage 37 ML
Capacity	ASR production well - 80 m below ground Well yield 20 L/s Recharge at 6-8 L/s
REUSE	Expected recharge 40 ML/a Salinity recharge water 200 - 600 mg/l Salinity recovered water < 1500 mg/l
Capacity	
Methodology	Irrigation of reserves and make up water

OPERATION & MAINTENANCE	
Procedures	
MONITORING	Automated monitoring of water quality pond to determine when water acceptable to inject Control system monitors water level in 3 ponds
PERFORMANCE	Information not available
Against objectives	
Quality	
Quantity	
COST & BENEFITS	
Capital outlay	Establishment of wetlands, GPT, ASR facility $220,000
Annual operating ($/kL)	$5,500/yr
User price	26 c/kL - stormwater quality improvement component 28 c/kL - bore recharge component
Reduction on potable demand	
Pollution control	Water quality meets ANZECC Guidelines for irrigation water quality

SCHEME	**OAKLANDS PARK**
Location	MELBOURNE, VIC
Stakeholders	HNJ Holdings Pty Ltd
Source	Stormwater Sensitive Urban Design (Jan '04)

SITE CHARACTERISTICS

Development type	Greenfields
Catchment Size: (Catchment/Development size/No. allotments)	174 ha (121 ha open space)
Scale: (Household/Neighbourhood/Large)	Neighbourhood
No. years in operation	7

SYSTEM OBJECTIVES	Pioneer ecological sustainable principles (triple bottom line)
Description of scheme and WSUD principles	

SYSTEM COMPONENTS	
CAPTURE	Roof-runoff to harvest potable water Runoff from roads, open space to open swale drains along roads (Pumping from nearby river as backup source)
Capacity (Minor/major event)	Swales designed to convey 5 year ARI flow
Methodolgy	
HOLDING/TREATMENT	Non-potable water conveyed through open swale grass drains for removal of sediment First flush diversion devices for roof runoff and sedimentation process in tanks
Capacity	
Methodology	No specific treatment performance requirements
STORAGE	Three lake system with transfer between lakes and with reticulation back to individual lots
Capacity	Up to 49 ML lake system Roof runoff to 70 kL tanks (x 80 lots = 5.6 ML) 64% tank storage volume/potable water demand
Methodology	Based on projected demand for summer months, peak 80 kL/lot/month and remaining period 6 kL/lot/month Evaporation important (ie surface area:volume)
REUSE	Non-potable and fire fighting Some toilet flushing Roof runoff
Capacity	Supply to 80 lots of 80 kL/month/lot in summer, 6 kL/month/lot other times Typical annual non-potable demand 6.9 ML/a ~ 10% mean annual runoff (75 ML)

Methodology	
IMPLEMENTATION ISSUES	Provision for water to be pumped from River to supplement storage ponds 180 m^2 min house size (to ensure adequate collection of potable water)
Site restrictions	
Public safety	Storage spillways capacity up to 100 year ARI
Possible problems	Initial buyer reluctance due to difference in scheme
Institutional	Little support or involvement from relevant institutions
Other	
OPERATION & MAINTENANCE	Weed management and removal programme for open space Pumps require quarterly maintenance (also backwashed every week) Maintenance of lakes; grass cover, leakage, silt removal etc
Procedures	Transfer water between storages Little maintenance required
MONITORING	
PERFORMANCE	
Against objectives	Supply adequate for non-potable requirements, no residents have used their full 150 kL/a allocation
Quality	Site manager drinks water from lakes

	Pumping from River only required once to initially fill the lakes
Quantity	Only shortage due to power supply (pumps off)

COST & BENEFITS

Capital outlay	Non-potable water supply $73,000
Annual operating ($/kL)	
User price	Body corporate fee $800/lot/a includes cost of 150 kL recycled water Users charged for excess
Reduction on potable demand	No mains connection

SCHEME	**HOMEBUSH BAY**
Location	SYDNEY, NSW
Stakeholders	Sydney Olympic Park Authority
Source	

SITE CHARACTERISTICS

Development type	Redevelopment (residential, sporting facilities, business, open space)
Catchment Size: (Catchment/Development size/No. allotments)	760 ha (400 ha open space)
Scale: (Household/Neighbourhood/Large)	Large
No. years in operation	4

SYSTEM OBJECTIVES	Reduce demand for potable water from Sydney Water system Improve quality of stormwater entering Homebush Bay and Parramatta River from the site
Description of scheme and WSUD principles	Encourage development of innovative and effective wastewater treatment technologies and management practices Position the NSW Government in a leading role by demonstrating sound, sustainable water resource management in a high profile project

SYSTEM COMPONENTS	
CAPTURE	Gutter and pipe system for high traffic areas, swales in low traffic areas Permeable pavers and engineered soils, to maximise infiltration to trees
Capacity (Minor/major event)	
Methodolgy	
HOLDING/TREATMENT	GPT's, swales and constructed wetlands First flush ponds allow sediments to settle, removal of nutrients via plants Microfiltration, reverse osmosis, chlorine disinfection, dechlorination
Capacity	Treatment plant capacity 7 ML/day
Methodology	Runoff directed to litter and sediment control devices (GPT's, swales etc) then flow to constructed wetlands From wetlands to treatment plant
STORAGE	Storage in lower levels of disused brickpit Wetlands Separate ponds for amenity and drawdown uses
Capacity	350 ML storage in Brickpit 140 ML wetlands
Methodology	Brickpit storage capacity far greater than demands, drawdown to ~55% during summer 02/03 No top up water required since inception High nutrient levels and visible algal growth in storage
REUSE	Irrigation, water features, toilet flushing, fire fighting and environmental flows Dual retic (30 kms retic pipeline) Low volume (application) irrigation systems where possible
Capacity	Up to 2.5 ML/day

Methodology	On ave. scheme utilises 700 ML sewage and 200 ML stormwater used per year
IMPLEMENTATION ISSUES	
Site restrictions	450 ha parklands incorporating conservation of fauna and flora
Public safety	Over 200 ha of contaminated soils were reclaimed and treated prior to construction taking place. Signs were erected for non-potable taps for public safety i.e. Do Not Drink
Possible problems	Water quality issues with large storage volumes underground.
Institutional	Environmental Management System (EMS) developed Water Reclamation and Management Scheme (WRMS) operates treatment plant however Sydney Water charges users.
Other	Provision made for conversion to mains supply for emergency/infrequent events Low water tolerant landscape species Recently received approval to use recycled water in washing machines
OPERATION & MAINTENANCE	
Procedures	System audits undertaken as part of EMS requirements
MONITORING	Continuous monitoring of recycled water (metals, nutrients, bacteria etc) 20 monitoring points Ecological monitoring of fauna/flora
PERFORMANCE	

Against objectives	Compliance reports and certificates, audit reports, monthly and quarterly env reports
Quality	Reduction in TN, TP, TSS in stormwater passing through water quality ponds ~180 tonnes gross pollution removed per year
Quantity	

COST & BENEFITS

Capital outlay	WRAMS budget $15.88M
Annual operating ($/kL)	$30M over 25 years (O&M) $1.80/kL
User price	77.5c/kL (set at 15c cheaper than potable)
Reduction on potable demand	~50% (850 ML) reduction in annual consumption of potable water
Pollution control	Receiving waters protected from stormwater and wastewater discharges
Infrastructure	Reduced volume to conventional sewage system
Environmental flow	Habitat for threatened flora and fauna species protected and enhanced

SCHEME	**THE PADDOCKS**
Location	PARA HILLS
Stakeholders	CITY OF SALISBURY
Source	EW&S (1993)

SITE CHARACTERISTICS

Development type	Community sport/recreation complex
Catchment Size: (Catchment/Development size/No. allotments)	60 ha (36.4 pervious: 23.3 impervious)
Scale: (Household/Neighbourhood/Large)	Medium
No. years in operation	

SYSTEM OBJECTIVES

Description of scheme and WSUD principles	Reduce flood threat to residents (flood mitigation) increase runoff water quality Improve aesthetics of area, greener reserves

SYSTEM COMPONENTS

CAPTURE

Capacity (Minor/major event)

HOLDING/TREATMENT

Capacity

STORAGE

Capacity

REUSE

Capacity

OPERATION & MAINTENANCE

Procedures

MONITORING	Not available
PERFORMANCE	
Against objectives	
Quality	
Quantity	
COST & BENEFITS	Information not yet available
Capital outlay	
Annual operating ($/kL)	
User price	
Reduction on potable demand	
Pollution control	
Infrastructure	
Environmental flow	

SCHEME	**PARAFIELD STORMWATER MANAGEMENT AND SUPPLY PROJECT (DRAFT REV A 15-4-04)**
Location	PARAFIELD - CITY OF SALISBURY ADELAIDE - SOUTH AUSTRALIA
Stakeholders	City of Salisbury, Parafield Airport Management, SA Govt, NABCWMB, GH Michell
Source	KBR 2003, ...

SITE CHARACTERISTICS	
Development type	Retrofit
Catchment Size: (Catchment/Development size/No. allotments)	1600 ha catchment for stage 1 / 11.2 ha harvesting works site for stage 1
Scale: (Household/Neighbourhood/Large)	Large
No. years in operation	1

SYSTEM OBJECTIVES	Low cost industrial water supply Low cost public open space irrigation water supply Water quality superior to mains water for industry and irrigation Economic development Reduction in environmental pollution
Description of scheme and WSUD principles	Showcase development in converting stormwater from an urban nuisance and pollutant threat into a valuable resource for industry and community

SYSTEM COMPONENTS	
CAPTURE	Stormwater diverted from local catchment drain to capture basin and holding storage
Capacity (Minor/major event)	Designed for capture of a 1 yr ARI storm event 50 ML capture basin and similar size holding storage
Methodolgy	Provide 'on-stream' capture basin of 1 year ARI storm volume Transfer in 24 hours to holding storage of same volume Transfer holding storage volume through reedbed in 10 days to users and ASR Harvests approximately 70% of catchment yield
HOLDING/TREATMENT	Capture basin and holding storage allow sedimentation Reedbed filters final water for use and ASR. Average detention about 10 days in harvesting season.
Capacity	Capture basin 50ML, holding storage 50ML, reedbed 2 ha 0.3 m deep
Methodology	See above Removes approximately 90% of nutrient and pollutant load
STORAGE	Excess to direct supply to users is injected into the T2 aquifer for recovery in the non harvesting season.
Capacity	600 to 900 ML/a injected to aquifer and 500 to 700 ML/a recovered when full Stage 1 demand reached. Objective build up some 2000 ML reserve in the aquifer to drought proof the system.
Methodology	Initially two injection and extraction wells 186m deep. Injection rate 2.5 to 4.0 ML/d per well
REUSE	Major user GH Michell wool processing operations 500 ML/a Mawson Lakes development up to 600 ML/a for recycled water network.
Capacity	Stage 1 Parafield Drain - 1,050 ML/a from 1,580 ha Stage 2 Bennett Drain - 1,300 ML/a from 2,023 ha Stage 3 Cobblers Creek - 600 ML/a from 1,044 ha
Methodology	3 km pipeline to GH Michell and ultimately up to 450 ML/a to enroute consumers 2 km pipeline to Mawson Lakes

	Water pumped direct from reedbed or from ASR facility
IMPLEMENTATION ISSUES	
Site restrictions	Minor compared to retrofitting such a scheme into a closely developed area. On airport land. Main access through security gate system.
Public safety	Aircraft bird strike management Aircraft feral animal strike management Mosquito management
Possible problems	Securing injected water from access by others Managing catchment pollution event
Institutional	Council opted for payback period of 10 yrs and will ensure recycled water is always competitively priced compared to mains water Model for industry, local, State and Federal govt partnership
Other	Council provides economic incentives to existing and new industries in the region
OPERATION & MAINTENANCE	Managed by Council staff with services by local contractors. Council and user management committee.
Procedures	O&M manual developed for project Management committee with users SCADA centred at Council offices for direct monitoring and operation On-going quality control from Stakeholders Removal of debris on regular basis and removal of sediment annually Close monitoring of wells for clogging and sand removal Continuous on-line monitoring of quantity and quality Sampling and laboratory testing program to EPA requirements.
MONITORING	Parafield Drain, basins, groundwater Real time monitoring, grab samples and composite samples (pH, TDS and turbidity) Groundwater injection and extraction volumes and quality Wildlife monitoring, fish, macro-invertebrates, etc
PERFORMANCE	
Against objectives	Stringent EPA water quality requirements for ASR dictate water quality requirements.

Quality	Wetlands reduce nutrient and pollutant loads by up to 90% while average salinity is below 250 mg/L TDS
Quantity	About 70% of catchment flow is harvested Quantity and quality data compared to the license requirements Michell happy with quality of water
COST & BENEFITS	Cheaper than mains water to Michell Replaces drinking water resources Better quality water for industry and irrigation than mains water Site rental income aids in offsettingt cost of running airport Removes pollution load from stormwater entering environmentally sensitive Barker Inlet
Capital outlay	$4.5 million Initial funding approx. $1.4 M Environment Australia Urban Stormwater Initiative $1 M GH Michell & Sons $140,000 NAPBC Water Management Board $40,000 former SA Dept Water Resources City of Salisbury
Annual operating ($/kL)	Approx $0.30/kL Operation & Maintenance and $0.30/kL loan payments (20 year), total $0.60/kL, compared with greater than $1.0/kL for mains water
User price	Confidential terms under 47 year agreement plus 50 year option for Michell. Terms of bulk supply to SA Water for Mawson Lakes non potable supply yet to be established.
Reduction on potable demand	SA Water potable demand reduced by 1100 ML/yr for Stage 1 rising to 3000 ML/yr for ultimate scheme
Pollution control	Prevents 1100 ML/yr of polluted stormwater from flowing into Barker Inlet (up to 3000 ML/yr for the ultimate scheme)
Infrastructure	Enhanced local job opportunities and economic stability
Environmental flow	Reduces demand on River Murray by some 500 ML/yr (based on 40% of SA Water supply coming from Murray) and makes this water available for increased environmental flows.

SCHEME	**PARFITT SQUARE**
Location	BOWDEN, ADELAIDE
Stakeholders	City of Charles Sturt
Source	UWRC

SITE CHARACTERISTICS

Development type	Redevelopment of former basketball stadium (residential, recreational space)
Catchment Size: (Catchment/Development size/No. allotments)	1 ha site, 27 residences + 250 m roadway and carpark
Scale: (Household/Neighbourhood/Large)	Neighbourhood
No. years in operation	7

SYSTEM OBJECTIVES	Aquifer Storage and Recovery.
Description of scheme and WSUD principles	Includes a number of innovative stormwater management systems, providing the community with outdoor recreational space as well as helping to further knowledge in water conservation and sustainability in urban environments. Runoff from the site is cleansed via a number of water treatment processes and is stored in an underground aquifer (ancient river bed). The retained water is then used during summer months for irrigation of the central reserve.

SYSTEM COMPONENTS	
CAPTURE	Stormwater from upstream catchment diverted to sediment trap and reedbed where majority of sediment and pollutants removed. Outlet from the reedbed directed to subsurface gravel filled trench 100 m long. The trench conveys water to four recharge wells which recharge shallow aquifer (12 m below surface)
Capacity (Minor/major event)	Retain all storm runoff flows up to and including the 1 in 100 year flow.
HOLDING/TREATMENT	Sediment trap 300 m^2 reedbed Gravel filled trench
Capacity	
STORAGE	Treated stormwater recharged into aquifer via 4 bores
Capacity	Capacity of aquifer approx. 50,000 ML.
REUSE	Extraction via 5th bore 10 m downstream from nearest recharge bore Expected salinity of extracted water approx. 500 mg/L. Irrigation of 0.6 ha reserve
Capacity	Expected up to 1.7 ML/a recharge. Currently no reuse taking place
IMPLEMENTATION ISSUES	Need for public open space for recreation

OPERATION & MAINTENANCE	
Procedures	
MONITORING	EPA licence required for aquifer recharge for developments/catchments over 1 ha
PERFORMANCE	
Against objectives	Currently no extraction taking place
Quality	
Quantity	No information supplied, recharge could be slightly lower than design
COST & BENEFITS	Reduction in mains water required for irrigation. Flood mitigation, reducing downstream flooding for up to the 1 in 100 yr storm event. Reduction in amount of pollution conveyed downstream. Recharge of aquifer.
Capital	No information available at time of publishing.
Annual operating and maintenance ($/kL)	
User price	

SCHEME	**PINE LAKES ASR SCHEME**
Location	SALISBURY
Stakeholders	CITY OF SALISBURY
Source	KBR 2003

SITE CHARACTERISTICS

Development type	Pine Lakes Subdivision
Catchment Size: (Catchment/Development size/No. allotments)	25 ha
Scale: (Household/Neighbourhood/Large)	Neighbourhood
No. years in operation	

SYSTEM OBJECTIVES

Description of scheme and WSUD principles	Irrigation of local reserves Collects runoff from Pine Lakes subdivision Some diversion from Parafield Drain

SYSTEM COMPONENTS	
CAPTURE	Approx. yield 15-20 ML/a Potential yield of 45 ML/a
Capacity (Minor/major event)	
HOLDING/TREATMENT	
Capacity	
STORAGE	
Capacity	
REUSE	Irrigation of Council reserves
Capacity	15-20 ML/a

OPERATION & MAINTENANCE	
Procedures	

MONITORING	
PERFORMANCE	NA
Against objectives	
Quality	
Quantity	
COST & BENEFITS	Further information to be provided by City of Salisbury
Capital outlay	NA
Annual operating ($/kL)	Further information not available at the time of publishing.

SCHEME	**POORAKA TRIANGLE WETLAND**
Location	POORAKA
Stakeholders	CITY OF SALISBURY
Source	KBR 2003

SITE CHARACTERISTICS

Development type	Wetlands
Catchment Size: (Catchment/Development size/No. allotments)	Approx. 5300 ha.
Scale: (Household/Neighbourhood/Large)	Large
No. years in operation	

SYSTEM OBJECTIVES

Description of scheme and WSUD principles	Reduce flood threat to residents (flood mitigation) increase runoff water quality Improve aesthetics of area, greener reserves

SYSTEM COMPONENTS	Further information not available at time of publishing.
CAPTURE	
Capacity (Minor/major event)	
HOLDING/TREATMENT	
Capacity	
STORAGE	Harvest approx. 200 ML/a
Capacity	
REUSE	Irrigation of Council reserves
Capacity	200 ML/a Approx. 0.04% of total Dry Creek flow Possibility to increase to 400 ML/a in future

OPERATION & MAINTENANCE Procedures	Further information not available at time of publishing.
MONITORING	Further information not available at time of publishing.
PERFORMANCE Against objectives Quality Quantity	Further information not available at time of publishing.
COST & BENEFITS Capital outlay Annual operating ($/kL) User price	Further information not available at time of publishing.

SCHEME	**STEBONHEATH FLOW CONTROL PARK**
Location	ANDREWS FARM, SA
Stakeholders	City of Playford
Source	City of Playford

SITE CHARACTERISTICS

Development type	Flood mitigation
Catchment Size: (Catchment/Development size/No. allotments)	3,160 ha
Scale: (Household/Neighbourhood/Large)	Catchment
No. years in operation	10

SYSTEM OBJECTIVES

Description of scheme and WSUD principles	Flow control park Flood mitigation and water improvement to stormwater from the Munno Para catchment east of Stebonheath Road, using a series of 3 ponds and wetlands. Opportunities exist for underground storage of stormwater harvested during the winter months for subsequent reuse during summer.

SYSTEM COMPONENTS	
CAPTURE	3 'on-stream' capture basins
Capacity (Minor/major event)	Approximately 60 ML based on historical rainfall records and an aquifer injection rate of 8 L/s. Capture could increase to 120 ML per year if recharge rate increased to 16-18 L/s.
Methodolgy	Series of capture and holding basins within the Park. Downstream flows are maintained by overflow from the basins (estimated at approximately 3000 ML/a).
HOLDING/TREATMENT	Trash rack at inlet to ponds to remove gross pollutants Ponds provide 10 days residency for 1 in 1 yr event to achieve pollutant load reductions. Reedbeds upstream provide physical filtering mechanism. Reeds also reduce the effect of wave action on the banks thereby reducing the level of suspended solids. Aquifer recharge only occurs during wetter months of the year, reducing the possibility of contaminants (oils and heavy metals) from entering the aquifer.
Capacity	
STORAGE	Aquifer injection
Capacity	Approx. 80 - 100 ML/a injection (16-18 L/s)
REUSE	Council reserves St Columba College oval irrigation
Capacity	Current demand 35-60 ML/a

OPERATION & MAINTENANCE

Procedures

MONITORING

Online monitoring - total dissolved solids monitored continuously for captured and extracted water. Levels control when recharge to aquifer occurs.
Lake water level - sensors determine levels which in turn control aquifer recharge and lake refill operations.
Aquifer water levels are continuously monitored through injection and extraction wells to monitor levels and protect pump equipment.
Salinity levels of the water extracted from the aquifer are continuously monitored. Extraction only occurs between acceptable salinity levels.
Injection pumping head is monitored to determine the level of clogging of the well. Backwashing may be required where this occurs.
Detailed monitoring programme implemented by Council.

PERFORMANCE

Further information not available at time of publishing.

Against objectives

Quality

Quantity

COST & BENEFITS

Further information not available at time of publishing.

Capital outlay: Approximately $5 M

Annual operating ($/kL)