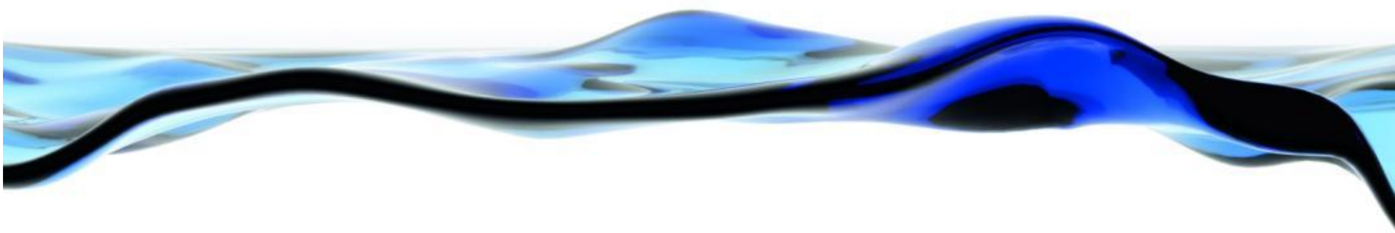
Water Sensitive Urban Design Impediments and Potential: Contributions to the SA Urban Water Blueprint

Post-implementation assessment and impediments to WSUD



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Executive summary

The project *Water Sensitive Urban Design Impediments and Potential: Contributions to the SA Urban Water Blueprint,* funded by the Goyder Institute, aimed to identify and address the factors impeding Water Sensitive Urban Design (WSUD) uptake in South Australia. This report examined the status of WSUD uptake in South Australia and identified the impediments to greater mainstream adoption of WSUD. The findings of this report are based on four main work programs, which were:

1. Summary of the current status of WSUD uptake in South Australia. This was achieved by developing an inventory of WSUD sites across South Australia;
2. Detailed assessment of South Australian legislation for WSUD, and a comparative analysis with other Australian states;
3. Engagement of key WSUD stakeholders in South Australia through interviews and surveys. The sectors included in this analysis were: local government, developers, policy makers, utilities, consultants, state agencies and relevant industry bodies. This engagement revealed stakeholders' experiences with WSUD implementation and perceptions of the critical impediments for greater mainstream uptake; and,
4. Post-implementation assessment was undertaken on seven WSUD case studies in Greater Adelaide, which evaluated the outcomes of WSUD implementation and the impediments that were faced in realising design objectives. This assessment was complemented by community surveys and focus groups in six of these case studies, with the findings reported in an associated Goyder Institute report for this project - *Community Acceptance of Water Sensitive Urban Design: Six Case Studies*.

The inventory showed that in South Australia WSUD uptake has largely been stormwater management features implemented by local councils. Flow management was the primary driver for WSUD uptake in councils, with WSUD elements designed to control flooding and reduce peak flows. WSUD features implemented included large stormwater harvesting schemes, including wetlands, managed aquifer recharge and bio-retention features. South Australia has been a global leader in stormwater harvesting through wetlands and aquifer storage and recovery schemes. Such large schemes were mainly developed in the northern and western fringes of Adelaide and were made possible through land availability and government funding. The inventory also found there was a growing number of street and allotment scale WSUD initiatives across the Greater Adelaide area. The trends for increased infill development in Greater Adelaide, with associated increases in impervious surfaces, means that the source control of runoff will continue to be a key driver for WSUD adoption into the future.

In addition to flow management, WSUD approaches were adopted in South Australia to achieve other benefits such as providing alternative water supply sources, with the objective of reducing drinking water demand. The stated benefits of WSUD also included alleviating capacity constraints on centralised urban water infrastructure systems, and the enhancement of public open spaces for recreational and environmental benefits. In addition, a significant driver for WSUD adoption in South Australia was the need to mitigate the environmental impact of urban development on receiving waterways and coastal waters.

The project found a number of common themes emerged when considering strategies to address impediments for the greater mainstream adoption of WSUD in South Australia. The following highlights these themes based on findings from the project activities, and considers the implications for South Australia:

(1) *Consistent and coordinated application of WSUD in planning frameworks and development approvals processes*. WSUD as a practice cuts across many professional disciplines and traditional management and policy areas. Therefore, there is a need to consider how WSUD is integrated across sectors in a consistent way that achieves multiple objectives. The objectives of WSUD can include flood risk reduction, improved stormwater quality, mains water conservation, improvements to local ecosystems and enhancing landscape amenity. The planning of WSUD needs to consider how the design can best achieve these objectives, and make clear where there is a trade-off between objectives. There is a

need to develop transparent and efficient processes for incorporating WSUD objectives in development planning and approvals. This includes ensuring that WSUD initiatives address broader flood management and water quality objectives for the local government area and catchment. It has been suggested that this could be achieved by linking development approvals to stormwater management plans.

(2) *Further development of local government capacity for WSUD implementation*. The project has found that capacity for WSUD varies both among local governments, and also among departments of a local government. Local governments play a vital role in the implementation of WSUD in South Australia through urban and landscape planning, processing of development approvals and maintenance of community infrastructure. A particular need identified was improving local government capacity to develop WSUD guidelines that are clear and appropriate to the local context. Local governments also need to develop the capacity to plan for WSUD that addresses broader catchment-level objectives, and understand where there are trade-offs between objectives so that local government priorities for WSUD can be established.

(3) *Enabling WSUD adoption through state-level targets and policy*. It was found that South Australian policy provides in-principle support for WSUD, but further clarity in policy, objectives, institutional responsibilities and roles regarding WSUD is required that offers clear mechanisms to facilitate WSUD implementation. Stakeholders showed a preference for policies that specified performance-based WSUD targets over prescribed actions. This enables greater flexibility to adapt the WSUD approach to the local context. This is consistent with the recently released South Australian policy on WSUD, which specifies performance based targets for water quality and stormwater flows.

(4) *Developing the knowledge-base for WSUD in the South Australian context*. The design and expected performance of WSUD features in South Australia was found to be frequently based on interstate guidelines and monitoring data. Also, detailed assessment of WSUD sites in Greater Adelaide revealed there was a lack of post-implementation monitoring studies to validate performance. The lack of data on WSUD performance that is specific to South Australian climates, soils and urban form can impede the development of improved guidelines for the design of WSUD systems. It was also found that local government can be reluctant to adopt WSUD approaches due to a lack of information on the ongoing costs for operation and maintenance. Monitoring and validation of WSUD systems and the collation of data and maintenance costs from existing projects would enable an improved understanding of life-cycle costs, externalities and management requirements in the South Australian context. This information is critical for the development of business cases that make clear the expected benefits and costs, including the ongoing costs. Uncertainty in WSUD costs and benefits is a major barrier to greater mainstream adoption of these approaches. In the absence of any regulatory policy in the planning approval process, addressing knowledge gaps would enable local council to develop robust technical and economic justification for greater WSUD implementation.

(5) *Improved understanding of how small-scale distributed WSUD systems can address catchment-level objectives*. Trends in Greater Adelaide for urban consolidation through infill development means there will be a need for more small-scale, distributed, implementation of WSUD. There is a need for improved understanding of how to select and design WSUD small-scale systems, which when aggregated, can assist in achieving catchment-level objectives for flood management and water quality. This would complement existing knowledge on large-scale system design and improve the understanding of appropriate WSUD treatment train options at various scales.

Part I Introduction and Background

1 Introduction

1.1 Project Background

The project *Water Sensitive Urban Design Impediments and Potential: Contributions to the SA Urban Water Blueprint* (the WSUD project) was funded by the Goyder Institute for Water Research. It aimed to identify and address the impediments and constraints, and identify opportunities and enabling mechanisms that will contribute in the strategic uptake of Water Sensitive Urban Design (WSUD) with a focus on local capacity building and cost of living for South Australia (SA).

The project will provide government agencies and other stakeholders with the scientific, technical, social and economic background to target further specific actions in support of the implementation of WSUD in SA. This information can inform government in effectively implementing the relevant actions identified in the Water for Good plan. In addition, the project aligns with the activities and outcomes from the *Business Case for a Water Sensitive Urban Design Capacity-Building Program for South Australia* (Alluvium and Kate Black Consulting 2012) and supports the current WSUD capacity building program implementation initiative from the Adelaide and Mount Lofty Natural Resources Management Board (AMLR NRM Board). A primary objective of the WSUD project was to provide the knowledge-base that will support WSUD capacity building initiatives and in addition the SA Urban Water Blueprint. This Blueprint is being developed by DEWNR and aims to establish an integrated and strategic plan for urban water infrastructure investment in SA, including the strategic uptake of WSUD.

The *30-Year Plan for Greater Adelaide* (the Plan) seeks to create a most efficient planning system for Adelaide up to 2040 (Government of South Australia, 2012). The Plan projects a steady population growth of 560,000 people and the development of an additional 258,000 homes by the Year 2040. It aims to provide for population and economic growth, whilst protecting the environment and heritage values of Greater Adelaide. The Plan envisages a Greater Adelaide made up of vibrant and liveable communities that are resilient to climate change impacts. Key principles of the Plan include the protection of natural resources and the engagement with communities (Government of South Australia 2012). The Plan also aims to increase the urban density in greater Adelaide, with a target of 70% of new housing comprised of infill development in existing urban areas and 30% of fringe development. WSUD can be a key approach for ensuring the sustainable development of Greater Adelaide.

1.2 Water Sensitive Urban Design

The *Water sensitive urban design – creating more liveable and water sensitive cities in South Australia* policy statement (Government of South Australia, 2013) adopts the following WSUD definition:

> 'an approach to urban planning and design that integrates the management of the total water cycle into the land use and development process' (Government of South Australia, 2011a).

WSUD encompasses the integrated management of all water sources (rainwater, groundwater, surface run-off, drinking water and wastewater), including the efficient utilisation, storage, treatment and reuse of all streams in the urban environment to maximise the economic environmental, recreational and cultural value of the water (Government of South Australia, 2010). Traditionally, Australian water supply, stormwater and wastewater infrastructure systems were planned, designed, constructed and managed separately to satisfactorily deliver the service requirements of: reliable and safe potable water supply, efficient wastewater treatment and disposal, and flood risk mitigation through drainage management. However, over the last 25-30 years it was recognised by water policy makers and managers that there was a need to manage the urban water cycle in a way that minimises disturbance to catchment hydrology and that helps to achieve the objectives of ecologically sustainable development (Mitchell, 2006). The Joint Steering Committee for Water Sensitive Cities (2009) identified that the impacts of urban development extends beyond the extent of the developed area, and when considering water management these impacts include:

- The requirement for large (upstream) land areas to supply, capture and store water for urban use;
- The discharge to downstream receiving waters of stormwater and treated wastewater; and,
- The significant modification to natural hydrological regimes and associated processes in waterways upstream, and within the downstream area of the urban areas.

In combination with the pressure on natural catchments, Australian cities are faced with the challenges of accommodating growing populations with finite freshwater resources and adapting to the potential impacts of climate change. These challenges are driving the need for a more integrated approach to managing urban water systems (Moglia et al., 2012). The term WSUD was first used in Australia during the early 1990s, as practitioners started to explore and formalise approaches for more integrated water management (Lloyd, 2001). WSUD aims to minimise the impact of urbanisation on the natural water cycle, and its principles can be applied at the scale of a single household up to a whole subdivision (Lloyd, 2001).

The National Water Initiative incorporated the concepts of WSUD into its urban water reform agenda, and defined WSUD as (NWC, 2004, pg. 30):

> "The integration of urban planning with the management, protection and conservation of the urban water cycle that ensures urban water management is sensitive to natural hydrological and ecological processes"

Davies (1996) proposed that fundamentally the concept of WSUD involves maintaining the water balance and water quality of an urbanised environment in the same state as prior to urbanisation. However, Davies (1996) also noted that despite the emergence of best management practices there has been a lack of demonstrated examples of WSUD that has led to some scepticism in the scientific community whether WSUD can deliver its assumed benefits.

Wong (2006) identified that the objectives of WSUD can include:

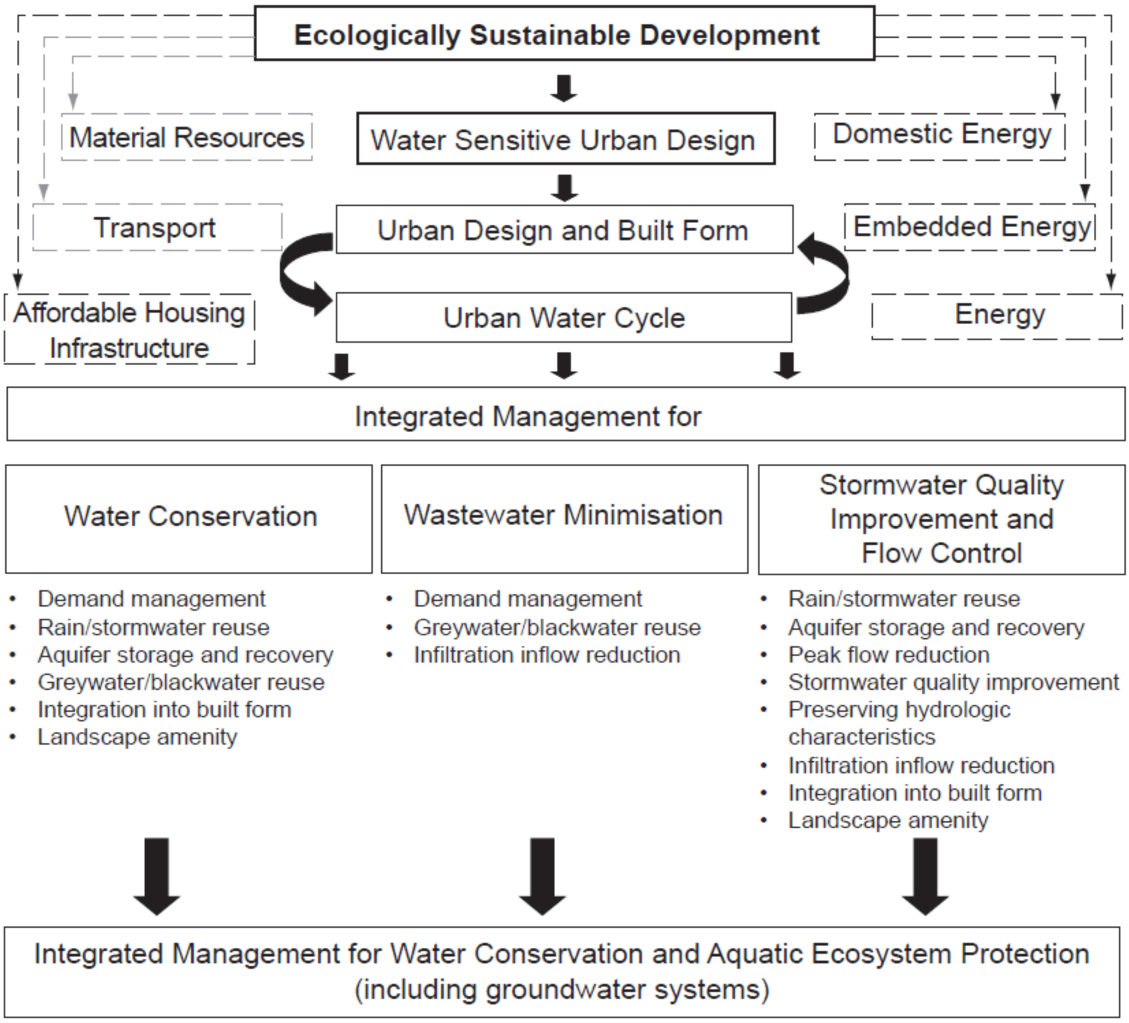
- Reducing potable water demand through water efficient appliances, rainwater and greywater reuse;
- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or release to receiving waters; and,
- Preserving the hydrological regime of catchments.

The elements that can be used to achieve WSUD objectives are flexible to the needs of site specific conditions and development objectives. In South Australia, the Department of Planning and Local Government (2010) developed the: *Water Sensitive Urban Design Technical Manual – Greater Adelaide*, which included guidance for the implementation of the following 12 WSUD tools:

- Demand reduction
- Rainwater tanks
- Rain gardens, green roofs and infiltration systems
- Pervious pavements
- Urban water harvesting and reuse
- Gross pollutant traps
- Bioretention systems for streetscapes
- Swales and buffer strips
- Sedimentation basins
- Constructed wetlands
- Wastewater management
- Siphonic roofwater systems

The tools listed above give an indication of the breadth of approaches that can be applied, according to local conditions, in achieving the objectives of WSUD in South Australia.

WSUD, ecologically sustainable development and integrated water cycle management are intrinsically linked and complementary. Figure 1.1 depicts the framework for WSUD as developed by Wong (2006) that captures the interactions among built urban form, material and energy flows, and urban water cycle management in delivering an integrated approach to water conservation and aquatic ecosystem protection. Wong (2006) in the introduction to the *Australian Runoff Quality – A guide to water sensitive urban design,* highlighted that there are technical and non-technical issues associated with the implementation of WSUD principles and practices, and that the major benefits from WSUD are likely to come from mainstream adoption and integration of WSUD approaches across urban development disciplines.



Source: Wong (2006), pg. 1-3.

Figure 1-1 - The water sensitive urban design framework

The strategic adoption of WSUD in South Australia can play a major role in the implementation of the SA Urban Water Blueprint and in the realisation of the 30 Year plan for Greater Adelaide. In particular, WSUD strategies can be adopted that are sensitive to the development context and alleviate pressure on existing water infrastructure systems from greenfield and infill development. The 30 Year Plan estimates that around 70% of new dwellings in Greater Adelaide are expected to occur within the existing metropolitan area, which will increase impervious surface coverage and progressively require the upgrade of existing infrastructure to manage stormwater run-off, thus creating opportunities for WSUD incorporation. Thus there will be a need to examine the performance of WSUD systems to minimise the load on existing infrastructure, together with other functions in the areas of water quality and water conservation.

To date the adoption of WSUD systems in SA has occurred in a fragmented manner driven by initiatives from individual developers, local councils or government funding opportunities. WSUD is not yet integrated into the SA urban planning process like in other Australian states, and this may be attributed to local impediments and constraints.

1.3 Report Objectives

This report assessed the impediments and drivers for greater WSUD adoption in the South Australian context. The specific objectives of the tasks detailed in this report were:

- Develop an inventory of WSUD systems in SA. The purpose was to identify the range of approaches and development contexts for WSUD implementation in SA. This activity highlighted trends in WSUD adoption in SA including purpose of WSUD features adopted, spatial trends in WSUD uptake, scale of features and rainfall zone;
- Review institutional and legislative framework for WSUD in SA. The focus of this task was to understand the current status of policies and legislation in SA, while also undertaking a comparative analysis with WSUD enabling legislation in other states of Australia;
- Understand the perceptions of stakeholders of the impediments for greater mainstream adoption of WSUD in SA. Surveys and interviews were undertaken with the following stakeholder groups to understand perceived barriers to greater WSUD adoption in SA: state government departments, water utility, local governments, developers, consultants and residents;
- Undertake a post-implementation assessment of WSUD systems at seven selected developments in SA. The purpose of the assessment was to compare the actual performance of the WSUD systems against the design objectives. The assessment also highlighted the impediments that were faced in implementing WSUD initiatives.
- Provide a thematic analysis that classifies the impediments for the greater mainstream adoption of WSUD in SA based on analysis of project outputs.

1.4 Report Structure

The report is divided as follows:

Part I: Introduction and background – This section outlines the report objectives, structure and an overview of the research methodology.

Part II: The status of WSUD in SA – This section provides a summary of the inventory of WSUD features in the State.

Part III: Mapping of WSUD stakeholders and legislative review –This section summarises the institutional and legislative setting for WSUD in SA, including barriers and enablers from the perspectives of key stakeholders.

Part IV: Post implementation assessment of developments with WSUD in SA – A summary of the analysis of seven individual case studies that highlights their performance in the field and impediments faced in successful implementation of WSUD systems.

Part V: Thematic analysis of outputs and findings from the tasks undertaken for this project. The analysis will classify the main impediments that need to be addressed to enable mainstream adoption of WSUD in SA cities and towns.

2 Methodology Overview

The methodology adopted for the research project is summarised in Figure 2-1. The project aimed to provide a comprehensive assessment of the current status of WSUD in SA and to examine data on barriers and challenges collected from a variety of sources including scientific and grey literature, selected case studies and key stakeholder groups.

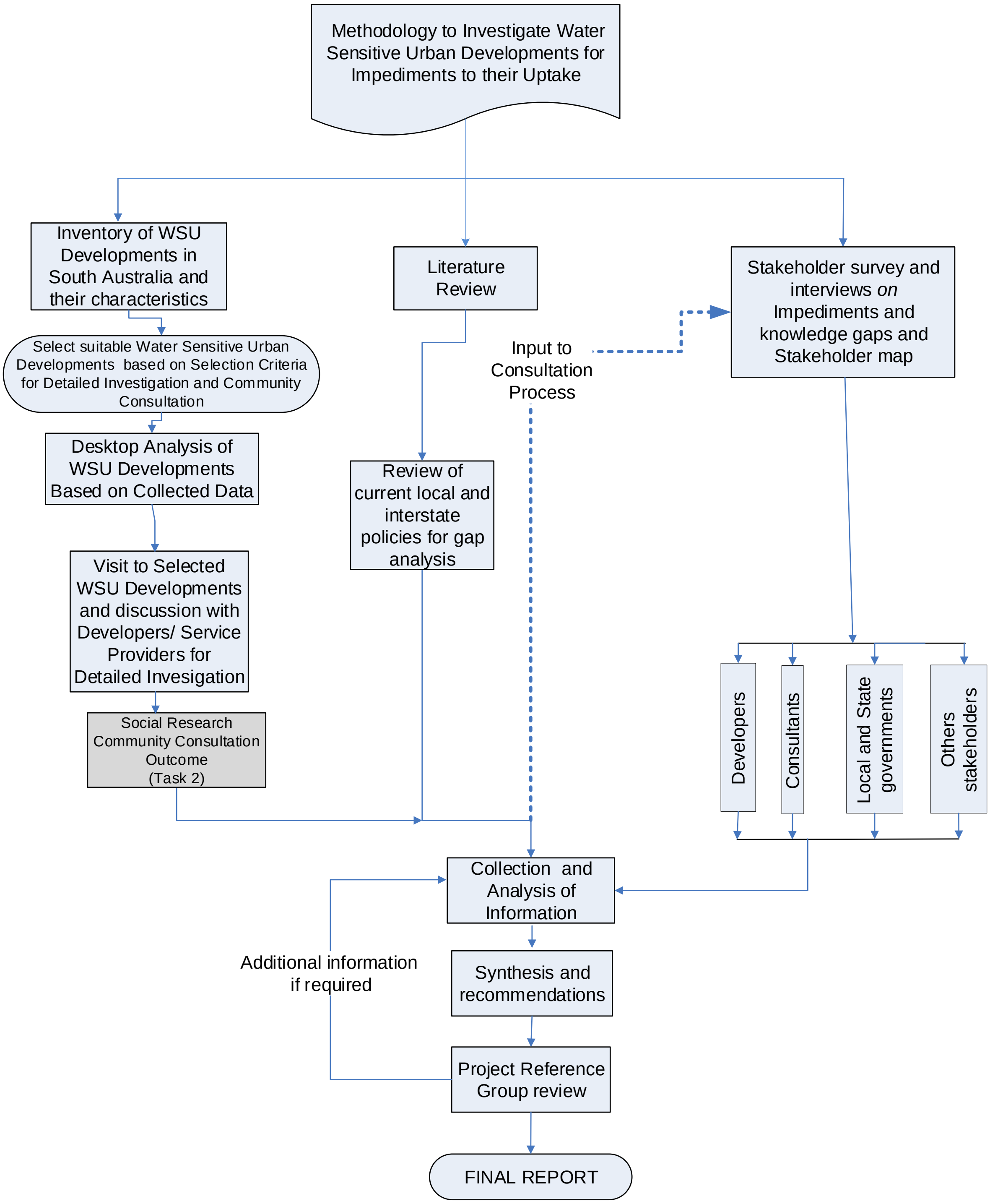


Figure 2-1: Summary of research methodology.

Data inputs included:

(a) Review of the status of WSUD in SA;
(b) Review of the institutional, political and legislative set-up for WSUD in SA;
(c) Post-implementation assessment of selected WSUD development case studies;
(d) Social research and community consultation on WSUD case studies; and
(e) Development of a stakeholder map and analysis of their perception on WSUD.

Descriptions of the methods adopted for each task are provided in the following sections.

2.1 Inventory of Water sensitive urban developments in South Australia

Myers et al. (2013) examined the status of WSUD developments in SA up to January 2012 and developed an inventory of developments with WSUD features. The data sources used to develop the inventory included analysis of the literature, follow-up of information from web searches, consultation with local governments via interviews and the solicitation of WSUD development information from natural resources management boards and practitioners in SA via email (Myers et al., 2013).

In this report, using the same methodology as Myers et al. (2013), the inventory was expanded from 176 to 220 WSUD sites across SA and all the local councils across the Greater Adelaide region (26 local councils) were interviewed. The inventory analysis and the drivers for WSUD were updated based on the revised sample.

2.2 Review of the institutional and legislative set-up for WSUD

To understand the institutional context of WSUD in SA two activities were conducted: a review of the legislation and policy set-up for WSUD, and the development of a WSUD stakeholder map.

2.2.1 Review of policy and legislative set-up

A review of government policy and legislation was used to identify the various institutional stakeholders relevant to WSUD and the formal process of WSUD implementation.

The review of WSUD legislation and policy framework in SA and across the rest of Australia covered the period of November 2012 to December 2013. Information sources examined included scientific literature, conference proceedings, government sources (policy and legislation) and consultation with representatives from government agencies.

2.2.2 Development of a WSUD stakeholder map

Interviews were conducted with institutional stakeholders to gain further understanding of the institutional set-up for WSUD, its operation and effectiveness based on stakeholders' perceptions. Institutional stakeholders were queried about their perceptions on:

- The status of WSUD in SA;
- Barriers to greater adoption of WSUD;
- Their organisation's role in WSUD, and
- The way forward.

Interviewees were also given the opportunity to express their views on any other issues of relevance to WSUD uptake in SA.

The institutional stakeholders interviewed included:

(a) State government agencies: Department of Environment, Water and Natural Resources (DEWNR), Department of Planning, Transport and Infrastructure (DPTI) (including both the Planning and Transport divisions), Department of Health and Ageing (DHA), Environment Protection Authority SA (EPA SA), the Adelaide and Mount Lofty Natural Resources Management Board (AMLR NRM Board), SA Water and Stormwater Management Authority (SMA);

(b) Local government: 26 Councils in the greater Adelaide region had been previously interviewed in Myers et al. (2013). The report from Myers et al (2013) was adopted as a reference ;
(c) Consultants: Tonkin, Design Flow and KBR (again originally interviewed in Myers et al. (2013);
(d) Professional organisations: Stormwater Industry Association (SIA), Planning Institute of Australia SA chapter (Planning SA), Local Government Association SA (LGA SA), Plumbing Industry Association of SA (Plumbing SA);
(e) Representative bodies from the development industry: Urban Development Industry Association (UDIA), Master Builders Association of SA (MBA SA), Green Building Council of Australia (GBCA), Housing Industry Association (HIA) and Renewal SA.

In addition, other organisations were approached but were unable to participate in the interviews at the time. These included the Australian Water Association, the Property Council of Australia and two community organisations (Friends of the Gulf of St. Vincent and Conservation SA).

In the absence of direct input from community groups, the outcomes from Leonard et al. (2013) were adopted as indicative of the broader South Australian community perceptions of WSUD. Leonard et al. (2013) undertook community focus groups and surveys of residents involved in six South Australian developments with WSUD features under Task 2 of the WSUD project.

The input provided by institutional stakeholders was complemented by analysis of additional data collected for the project: "WSUD capacity building business case" (Alluvium and Kate Black Consulting, 2012) coordinated by the AMLR NRM Board. This project conducted a web-based survey of 348 practitioners in SA who were questioned on: experience with WSUD, identification and rating of barriers to WSUD (question 15 in Alluvium and Kate Black Consulting, 2012) and knowledge gaps areas which respondents would like to improve (question 18 in Alluvium and Kate Black Consulting, 2012). We re-analysed the data to determine the perceptions of barriers and needs of respondents based on sectoral groups (State government, local government, consulting, researchers, non-government organisations, industry associations and other). It is noted that participants in the Alluvium survey responded to questions as individuals and based on their own experiences not as representatives of the organisations where they were employed.

Historically there has been limited information on the perceptions of WSUD within the development industry. Therefore two additional activities were conducted: (a) Interviews with six development companies that operate in South Australia; and (b) a web-survey on WSUD uptake in the development industry.

The additional interviews were conducted with six development companies that represent a cross-section of the types of developers operating in Adelaide. Interviewees were drawn from medium to large developers, from the private and government sectors and those operating in greenfield, infill and boutique developments.

A web-based survey was developed in an attempt to obtain further input from members of the development industry and distributed with the assistance of UDIA and MBA SA. However, a low response rate was obtained (8 responses).

Samples of the interview questions and survey forms used for councils and other stakeholders are provided in Appendices A and B, respectively.

2.3 Post implementation assessment of WSUD developments

Seven of the WSUD sites identified through the inventory of WSUD sites in SA (Myers et al., 2013) were selected for detailed post-implementation assessment.

Table 2-1 details the criteria that were used to guide the selection of the WSUD sites for post-implementation assessment. The criteria were structured in order to ensure that the case studies selected represented a range of different development context and WSUD systems in South Australia.

Table 2-1. Selection criteria for post-implementation assessment

Criterion	Justification
1. Select a case study for each of the rainfall zones in Greater Adelaide, as defined for the Goyder targets project	A selection of a case study site in each of the zones will capture the diversity in rainfall patterns that impact on stormwater management issues, and also influences the demand and supply of local water sources
2. Select a case study for each alternative water source used (recycled water, rainwater, stormwater (aboveground and ASR))	The community perceptions of risks and acceptance are likely to vary depending on the alternative water source being used. Also, the issues associated with maintenance and operation is also likely to be different for these water sources.
3. Select a case study for each major WSUD approach for stormwater management (permeable paving, bio-retention swales, wetlands etc.)	The community acceptance are likely to vary depending on the WSUD approach, and how noticeable the feature is in the urban environment or if the functioning of the system is integrated with the landscape and out of sight
4. Select a case study representing different development types (infill, retrofit and greenfield)	The drivers for implementing WSUD may vary depending on the development type, and it will also influence the community perceptions if the WSUD approach is either imposed as change in an existing context (retrofit), or is implemented at the time of development prior to being occupied (greenfield)
5. Density of development - medium density and low density housing)	Same as for 4
6. Scale of development (lot, street, cluster, development)	The scale of development will influence both the resources that were available for the planning and implementation, and also the appropriate models for ongoing operation and maintenance
7. Availability of monitoring studies and supporting information (yes/no)	To enable in-depth case studies supporting information in the form of reports, monitoring studies will be useful to allow the case study developments to be described. In some cases there may have been previous community consultation processes, while this may mean the issues have already been explored it could provide some good validation to findings and background to issues

Part II Status of WSUD in South Australia

3 Status of WSUD in South Australia

3.1 Inventory of developments with WSUD features in South Australia

The WSUD inventory was structured to understand the quantity, location and type of WSUD features in SA. WSUD features are not just related to the management of stormwater quality and quantity but also include alternative water supply systems and mains water conservation approaches. WSUD sites were defined as physical locations where structural WSUD features were known to exist. For some sites several types of structural WSUD features have been implemented.

The inventory now has 220 WSUD sites identified (to 10th January 2014) across SA, with a large predominance of sites in the Greater Adelaide area. The total number of WSUD features on these sites was 455. As previously reported in Myers et al. (2013), the majority of the sites (>80%) are located within the 400-600mm rainfall zone. The geographical distribution of sites with WSUD features will be available through the WSUD Capacity Building Program website.

3.1.1 WSUD features

The list documented 220 sites with a range of WSUD features including:

- 82 wetland sites;
- 192 bioretention systems at 50 sites
- 32 infiltration only systems at 30 sites;
- 2 ponds;
- 8 greenroofs at 5 sites;
- 17 permeable pavement sites;
- 17 wastewater reuse schemes;
- 24 community wastewater management schemes;
- 23 projects incorporating harvesting and reuse (onsite and distributed excluding ASR); and,
- 55 ASR sites (some sites have multiple bores; some may not be functional).

However, the actual number of sites is likely to be much larger as not all WSUD and reuse sites in the state have been identified as the inventory relied on self-reporting of the sites. In addition, given the variability in the understanding of WSUD, the self-identification process depends on each individual's subjective interpretation of WSUD.

Examples of the WSUD features identified are pictured in Figure 3-1. While, the breakdown of the types of WSUD features identified are shown in Figure 3-2 and Figure 3-3. The WSUD features identified were characterised by the prevalence of stormwater management sites, in particular wetlands, bioretention, managed aquifers and infiltration (swales), which comprised respectively 26%, 16%, 18% and 10% of the WSUD sites, as seen in Figure 3-2.

The majority of sites were located in the inner-urban areas of Adelaide and are dominated by smaller scale systems (Myers et al., 2013). Larger scale schemes, such as ASR, tended to be located several kilometres from the CBD where new land release was made in the last few decades, which coincided with an increased awareness of the need for more water sensitive approaches in urban development.

ASR schemes have been predominantly located to the north of Adelaide due to the availability of suitable aquifers and catchments. However, ASR schemes are currently being implemented in the South and Western suburbs of Adelaide, with plans to proceed with further harvesting in the East of Adelaide. Hence, space and scale are major criteria for feature selection. Councils possessing large open space tend to prefer large scale systems as these can be effectively managed and are more economically sustainable, whereas inner urban councils have to depend on smaller scale WSUD features such as opportunistic installation of street-scale bio-retention systems due to a lack of available open space and the cost of retrofit with existing urban infrastructure.

(a) Parafield Wetlands, City of Salisbury

(b) Street scale bio retention basin, Mile End, City of West Torrens

(c) Rock swale and (d) Turf swale infiltration systems at Harbrow Grove Reserve, City of Marion

(e) Permeable Paver at on back street, City of Unley

(f) Pump station at the Parafield ASR site, City of Salisbury

Figure 3-1: Examples of WSUD features in the greater Adelaide region (Myers et al., 2013)

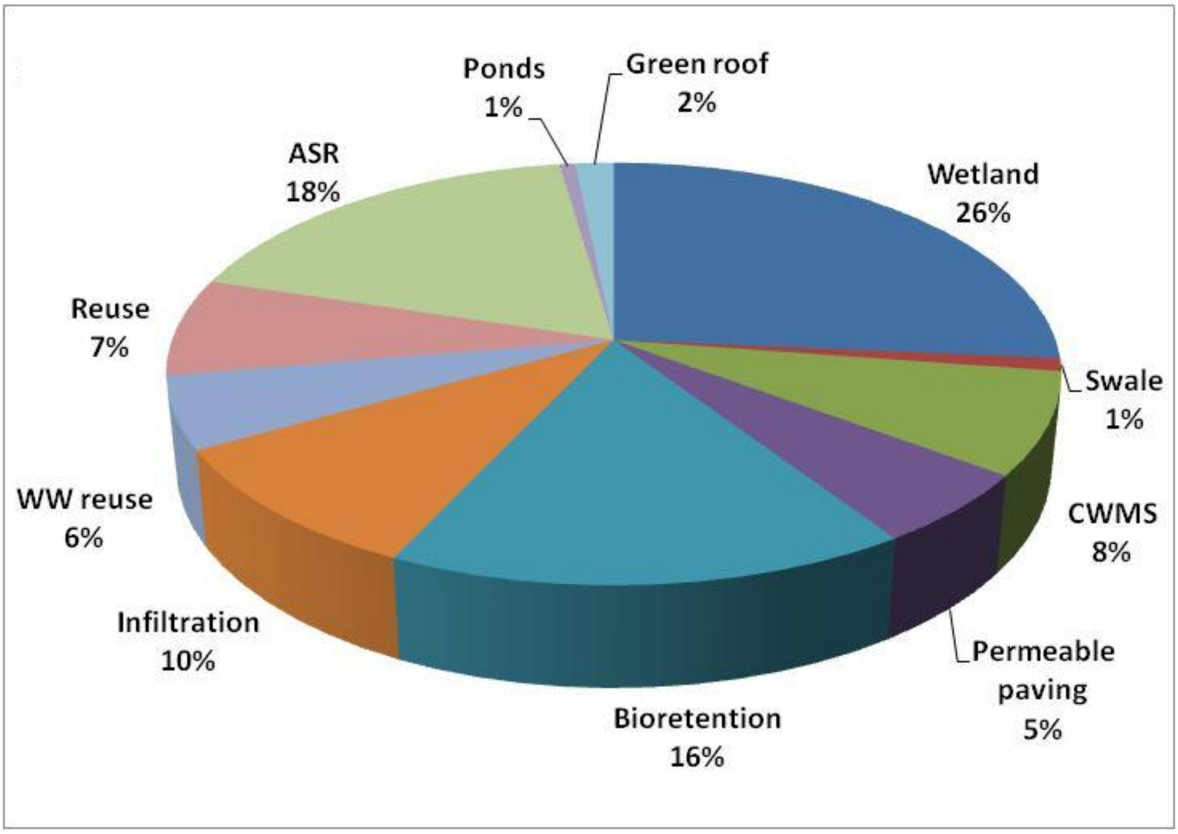


Figure 3-2: WSUD features in the sample of 220 sites in the greater Adelaide region.

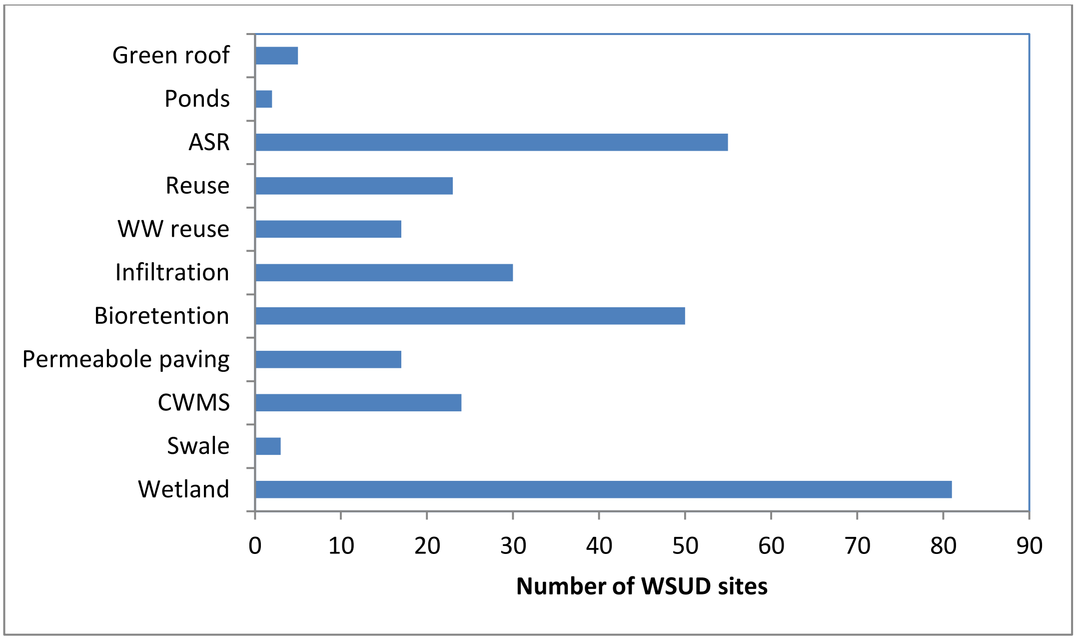


Figure 3-3: WSUD (220) sites in the greater Adelaide region with various WSUD features.

The distribution of WSUD features across the 220 sites is shown in Figure 3-4 and Figure 3-5. Figure 3-4 shows a percentage breakdown of WSUD feature types across all sites, while Figure 3-5 shows the actual number of WSUD features.

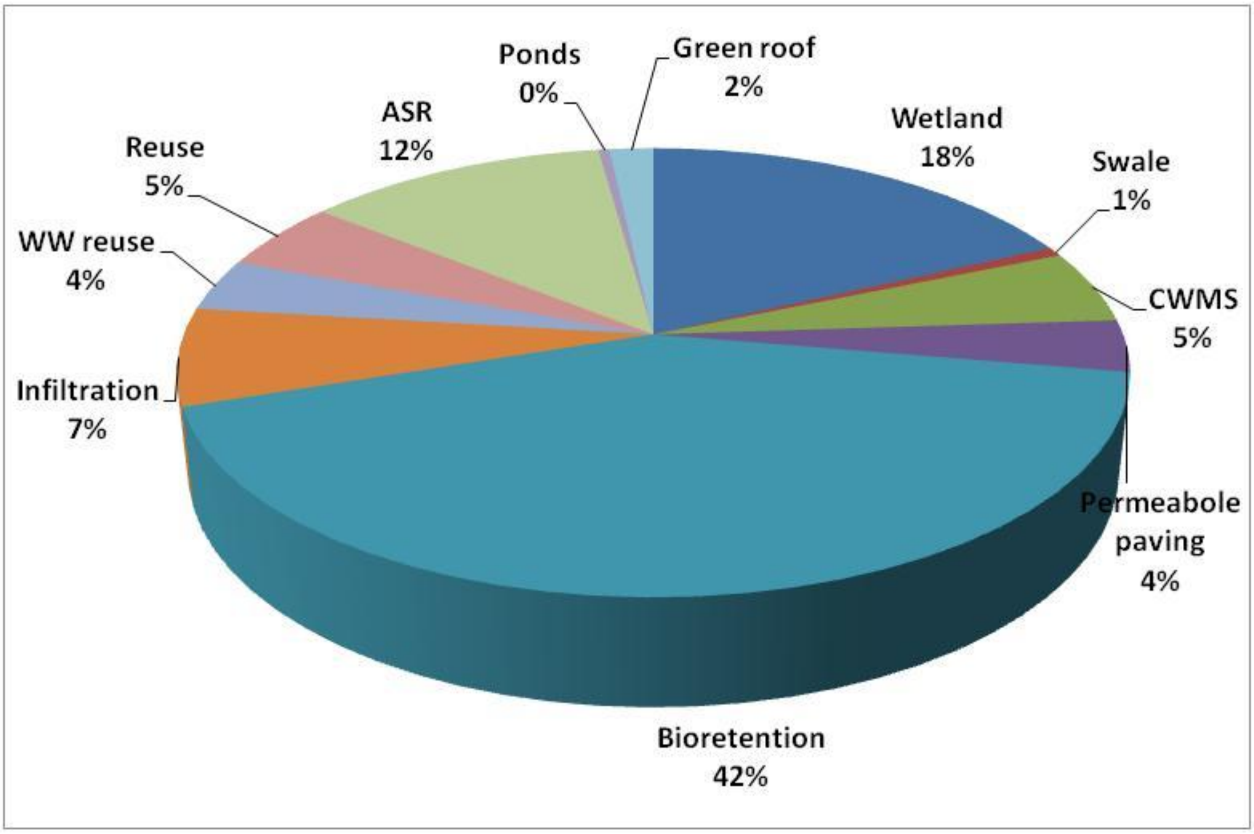


Figure 3-4: Distribution of various WSUD features in percentage across Adelaide based on the survey.

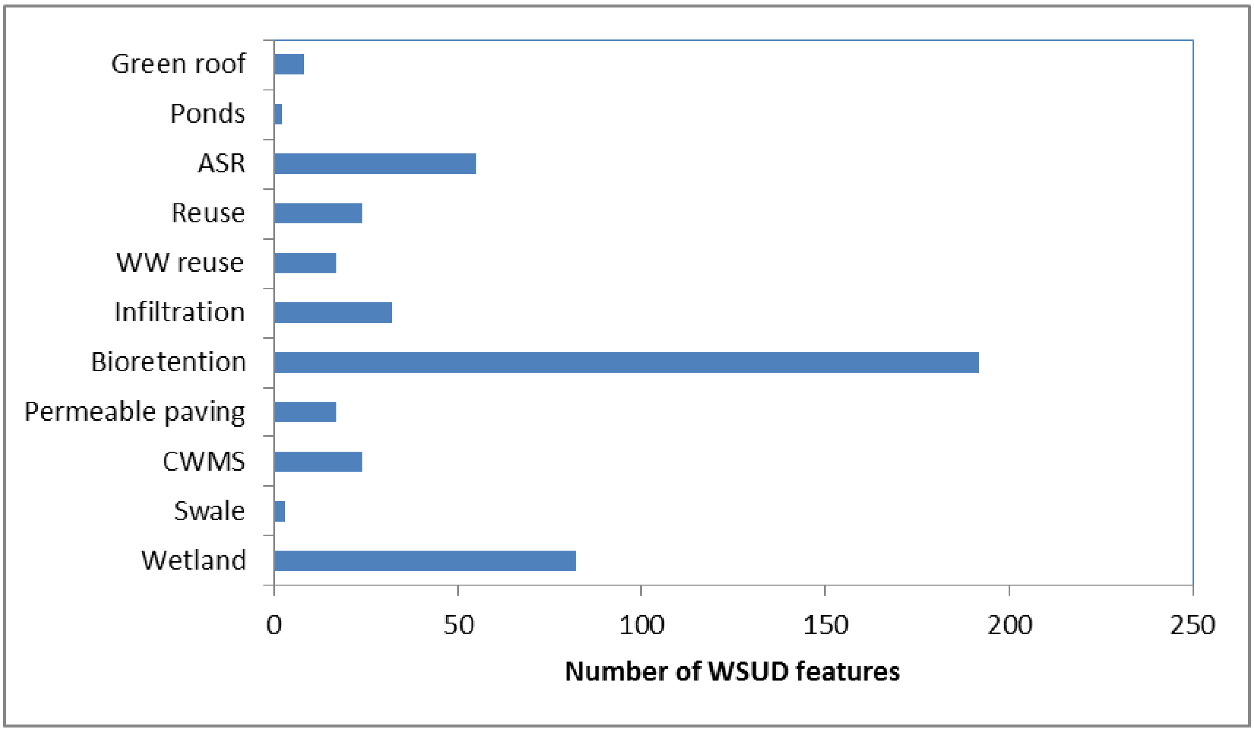


Figure 3-5: Distribution of various WSUD features in numbers

3.2 Drivers for WSUD Adoption in South Australia

The reasons reported by respondents for the adoption of WSUD features ranged from the need to manage stormwater flows and improve stormwater quality, to the desire to reduce mains water demand, minimise financial costs and preserve native vegetation or enhance landscape amenity. The most common drivers identified were flow reduction, water conservation and quality improvement, which received 48%, 45% and 35% mentions respectively (Figure 3-6). Often there were multiple drivers for WSUD implementation at a given site.

Water professionals at 26 local councils were interviewed. These interviews revealed a key driver for the implementation of WSUD in Greater Adelaide region seemed to be to 'do the right thing' when the opportunity arose. For example, local governments including City of West Torrens, City of Mitcham, City of Burnside, and City of Port Adelaide Enfield were keen to include WSUD measures in conjunction with road or drainage upgrade works as the existing routine works allow for economically efficient incorporation of WSUD features. Retrofitting of WSUD into these areas in isolation was considered too expensive. The overarching strategy for most of the street scale systems was to make use of local government owned open space on road sides and to manage and reuse stormwater runoff.

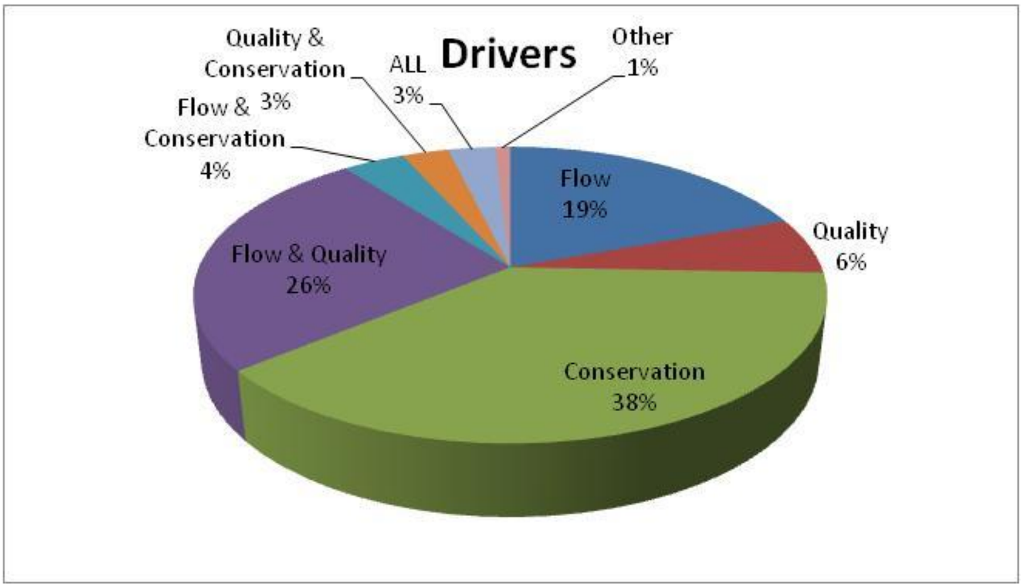


Figure 3-6: Major reasons for adoption of WSUD features in sample of 211 sites in greater Adelaide.

The list of drivers mentioned during the interviews with local government included: need for low management, funding availability and cost effectiveness, improved amenity, local champions, and consultants with expertise in WSUD design and policies. These are described in detail in Myers et al., (2013).

The inventory showed that the uptake of WSUD in South Australia has predominantly been stormwater management features adopted by councils. This trend continues to today, with flow management remaining as one of the primary drivers for WSUD uptake in councils, particularly with the objective to control flooding by reducing peak stormwater flows. This trend is likely to persist with the projected growth in infill developments, which will increase urban runoff through increased impervious surfaces.

Most commonly WSUD was adopted to achieve multiple benefits such as flow management, water quality improvement and an alternative water source, while also being cost-effective and improving landscape amenity. The uptake of alternative water sources was partly driven by pressures on mains water supply, where extended dry periods meant restrictions were imposed on mains water use for certain non-potable water uses, such as irrigation of gardens and public open space. Some of the larger stormwater harvesting schemes in SA were encouraged through the availability of Commonwealth Government funding that was made available as part of the drought response. Population growth and the likely impacts of climate change are expected to exacerbate pressures on traditional water supply catchments. The adoption of alternative water sources, such as stormwater harvesting, as part of a WSUD strategy, provided local governments with an alternative water source to maintain public open space and street trees. While, the adoption of rainwater tanks provided households with a local water source that mitigated the impact of water restrictions on garden maintenance.

The type of WSUD features adopted has been influenced by multiple factors, including (i) physical constraints, such as restrictions the availability of open space and physical conditions (suitable geology, slope) (e.g. for ASR); (ii) the technical capacity and expertise of proponents and (iii) policy (local government policy or State and Federal government policies, regulations and incentives).

The current inventory showed that WSUD uptake has been driven by councils, with a few exceptions. This partly reflects the composition of the practitioners sampled, which was predominantly comprised of local government officials. However, it also reflects that stormwater management and flood risk mitigation is a core responsibility and function of local government, which meant they have the opportunity to incorporate WSUD principles in planning for stormwater management. The limited WSUD implementation by private developers (residential and commercial) was perceived by local government to be due to a lack of incentives and interest by this sector to adopt WSUD practices unless required by local government regulations (Myers et al 2013). The level of commitment to WSUD was also seen to differ among local governments, with some placing a greater emphasis on adherence to WSUD targets through their development approval processes.

Part III Mapping of SA WSUD stakeholders and legislative review

4 WSUD institutional and legislative arrangements in South Australia

This chapter provides an introduction to the institutional and legislative context of WSUD implementation in South Australia. The chapter:

- Summarises the current legislative and policy framework relevant to WSUD in South Australia;
- Characterises the institutional framework and maps the major stakeholders; and
- Briefly compares the institutional set-up for WSUD in South Australia with other Australian states.

More detailed assessments of the legislation and policy in SA and the WSUD context in other Australian States/territories are provided respectively in Appendices **C** and **D**.

4.1 The South Australian Context

On the 1st November 2013, the SA Government released the policy paper *Water sensitive urban design – creating more liveable and water sensitive cities in South Australia* (Government of South Australia, 2013). The paper for the first time outlined a clear State Government policy and commitment to WSUD. The paper states the desire for transitioning SA into a water sensitive State, established State-wide minimum performance targets for stormwater run-off quantity and quality for new developments and guiding principles for government action that will lead to a pathway for WSUD implementation. However, as of December 2013, there was still limited formal legislation specifically addressing WSUD at the State Government level (Myers et al., 2013).

Historically, water quantity, flood management and water conservation have been the main focus of policy and code development, with lesser emphasis given to water quality management and the adoption of local stormwater management features, such as local infiltration devices. Consequently in SA policy is fragmented across different aspects of the water cycle management, and there is a lack of integration between catchment management and WSUD.

In regards to environmental protection, the *South Australia Environment Protection (Water Quality) Policy 2003* (WQEPP), under the *Environment Protection Act 1993* was designed to protect aquatic environments in South Australia, setting requirements to prevent the contamination of aquifers and adherence to the water quality criteria of surface waters; however the WQEPP does not apply to the discharge of clean stormwater from a public stormwater system.

The need to manage the stormwater quality was emphasised in the *Adelaide Coastal Water Quality Improvement plan (ACWQIP)* (McDowell and Pfennig 2013). The ACWQIP highlighted the need to reduce nitrogen loads by 600 tonnes per year, sediment loads to 50% from 2003 levels and to reduce coloured dissolved organic matter (CDOM) to halt the loss of seagrass and allow its recovery as a long-term strategy for improving the water quality of Adelaide's coastal waters. Stormwater is the main source of suspended solids and CDOM reaching coastal waters.

Legislation indirectly relevant to WSUD was found in a range of associated areas such as natural resources management, environmental protection, planning and development, flood and stormwater management and regulation of alternative water supplies, which are discussed in Appendix **C**. Each of those areas covers a particular aspect of the water cycle, but a key gap in legislation is that environmental and water management objectives are not integrated into the State planning and development legislation. This is despite many agencies and local government areas expressing their support for WSUD objectives. At State government level, agencies have very specific roles and scope of responsibilities based on their portfolios, and even agencies which in principle could facilitate for councils to develop and adopt stormwater management objectives, e.g. the Stormwater Management Authority, are restricted in their capacity to assist due to resource constraints.

In South Australia, water is a state owned good and the *Natural Resources Management Act 2004 (NRM Act*) sets the right to use water through water allocation permits for use and transfer of water from prescribed water resources across the State. Under the NRM Act, DEWNR and NRM boards can issue *water licences and allocations* for selected activities including irrigation, industrial, commercial, stock and domestic use and managed aquifer recharge. In addition, DEWNR administers *Water permits* for groundwater activities, such as drilling, operating and sealing a well, draining or discharging water directly into a well, use of imported water or effluent for the carrying of a business. NRM boards administer activities related to dams, draining and discharge into water courses, floodplains or lakes.

Non-prescribed water resources, such as surface water run-off in a catchment, can in principle be lawfully accessed and used by any landholders in the catchment. This means that stormwater captured and stored in council infrastructure is 'owned' by council and that rainwater captured by a householder in his/her property or rainwater tank is 'owned' by the householder.

The management of stormwater drainage infrastructure assets and natural features (creeks and waterways) is distributed across multiple agencies and levels of government (DEWNR, EPA, local government, Commonwealth), with the jurisdiction and responsibilities defined based on the traditional management of the water cycle. Natural features in particular have the added complexity of passing through private land (see Appendix C for more details). However, the roles and responsibility at interfaces between agencies' jurisdictions are not well defined. In particular, the interdependency and coordination between upstream and downstream impacts and liabilities across catchments and jurisdictions are not yet fully defined. For instance, under the current legislation there is limited inter-agency coordination in the management of the River Torrens (Kelly 2007). SA Water has powers to dam the River Torrens, subject to the exercise of powers by the regional NRM Board (NRM Act), and to impound water from streams and lakes (Waterworks Act 1932) and (b) the Adelaide City council is responsible for the care and management of the River Torrens weir, the waters held in the dam and adjacent sheds, boat houses and landings, (Kelly 2007). However, there is no clarity on the mechanisms for (a) The release of excess water from water reservoirs managed by SA Water and the potential impact from sudden flooding to local government areas downstream; (b) Implications of stormwater capture in urban areas to environmental flows for prescribed water streams, such as the River Torrens. Under the NRM Act the River Torrens catchment is under the jurisdiction of the NRM Board planning process, but there is no legal mechanism that ensures that councils comply with the NRM Board plans (Kelly 2007).

Stormwater management plans (SMPs) prepared by local councils at catchment scale may be facilitated and supported by the Stormwater Management Authority (SMA), an entity established by Local and State Government. Such plans, which are expected to comply with SMA-issued guidelines, are usually prepared with advice from staff of the relevant council/s of the catchment, the relevant regional NRMB, and DPTI Transport (hydrological/technical expertise). Once prepared, SMPs are submitted to the SMA for its consideration for approval. Once approved, they may form the basis for councils applying for SMA funding to support their implementation.

SMPs can focus on the "management of flooding risk, opportunities for stormwater beneficial use, desirable planning outcomes associated with open space and environmental enhancement of ecosystems" (Local Government Act 1999), but historically the focus has been on the first two objectives. SMPs do not specify local stormwater objectives nor WSUD implementation strategies as they focus on objectives for large scale catchments (over 40 hectares), whereas WSUD measures are typically developed at much later stages in the planning process and often applied within sub-catchments. However, the setting of overall directives and the development of SMPs establish the initial step for the development of a local government stormwater strategy, which may include WSUD principles and objectives at later stages, but these are not compulsory.

WSUD objectives and their implementation can be set in individual local government areas' development plans (DPs). Local councils have the option of adopting selected modules from the *South Australia State Planning Policy Library* (SPPL) into their local development plans. The SPPL has a section, in its natural resources module, with overarching WSUD principles for developments. However, the module does not specify performance based targets: 'Development should be designed to maximise conservation, minimise consumption and encourage reuse of water resources' (Government of SA 2011). Amendments to the local government development planning process are subject to the approval of the planning minister through the Development. A more detailed explanation of the role of local government as set in the *Local Government Act* is provided in Appendix C.

The *Development Act 1993* specifies the provision of public infrastructure and of 'drainage' in general terms, but it makes no mention of stormwater management or WSUD. It also does not make clear how to manage and pay for private infrastructure in developed easements. Thus, whilst environmental and ecological sustainability is stated as an in-principle intention in the *Development Act 1993,* the Act is vague regarding the requirements and the means for implementation of such principles. Thus, under the Local Government Act the powers of councils regarding stormwater are restricted to roadwork drainage, with no powers regarding management of rivers, creeks or infrastructure in private property. Neither do councils have the powers to maintain or interfere with permanent infrastructure on private property without the land owners consent (Kelly 2007), which would apply to rainwater tanks and on-site stormwater detention systems.

Therefore in practice the development and implementation of WSUD objectives are left to local councils' discretion. In principle, this framework gives local government the freedom to develop their DPs and to include WSUD objectives and policies, provided they align with relevant State legislation and policies. Stormwater treatment objectives to date have been subject to the initiative of individual local government, except for prescribed areas/sinks, which have water quality targets requirements set by the SA EPA (Myers et al, 2013). At the time of writing, only the City of Onkaparinga and the City of Salisbury had implemented WSUD targets for TSS, TP and TN for runoff quality as a requirement for new developments. However, in the absence of a consistent State directive for WSUD, local council objectives could also be vulnerable to challenges in court by development proponents, which has served as a disincentive for local government areas to pursue WSUD targets (Myers et al, 2013).

Furthermore, the ability of individual councils to develop and implement their own WSUD objectives varies markedly depending on their financial resources, and capacity and ongoing commitment to WSUD initiatives.

Among the councils interviewed, the majority had engineering or asset management departments where a few staff had responsibility for managing wide asset portfolios (footpaths, roads, vegetation, flooding, etc.) and very few had dedicated stormwater specialists with expertise on WSUD, thus presenting resourcing challenges (Myers et al, 2013). Operating costs for WSUD needs are not currently specified in local government operating budgets and there are also no set funding mechanisms for it (Meyers et al 2013).

Aside from stormwater, the legislative and political framework on other alternative water supplies was more defined. The *South Australian Recycled Water Guidelines* (Government of South Australia, 2012a) outlines the key legislation, agencies and the approval processes required for implementation of any schemes that adopt stormwater extraction, drainage and storage to aquifers, greywater use and treated sewage or mixed source waters.

The assessment of alternative water sources is based on a risk management approach. State agencies, such as the Department of Environment, Water and Natural Resources (DEWNR), the Department of Health, the EPA and SA Water had well defined roles for activities such as the approvals and validation of schemes and roles and responsibilities for agencies in pre-development evaluation of schemes involving recycled water schemes. However, there were also a number of areas where roles and responsibilities are not yet clearly defined, which required cooperation between agencies. For example, the DHA does not give advice on the use of stormwater and rainwater unless requested by a relevant referring authority (e.g. a council).

The process for verifying the performance and ongoing management of WSUD schemes after implementation is also not clearly defined. Depending on the disposal location and water use, stormwater recovery and recycled water schemes may require the submission of monitoring reports to relevant agencies, such as EPA and DEWNR (see Appendix C for a more detailed explanation). The EPA licenses the discharge of stormwater to aquifers in metropolitan Adelaide and Mount Gambier when the contributing catchment is larger than one hectare (EPA 2012, Ruth Ward personal communication). DEWNR licenses stormwater allocation in prescribed areas, including the extraction of groundwater from a well in a prescribed area. Hence, large-scale schemes that inject into aquifers are required to provide monitoring reports in compliance with EPA requirements. Monitoring and information on the performance of other type of stormwater related schemes require no formal reporting.

To achieve integrated urban water management, the planning and funding structures need to account for the linkages between elements in the water cycle and to consider the benefits and risks associated with both quantity and quality of water streams across the wider ecosystem. These at present are still underdeveloped in the current water management framework. The existing mechanisms for the coordination between portfolios and for the implementation of an integrated stormwater management plan at a city-wide catchment scale are limited.

4.2 Comparison with other Australian states

Across Australia WSUD uptake at the state level has progressed with different focuses and at various paces. Queensland and Victoria are seen as pioneer States in the development of WSUD policy and implementation. However, Western Australia, Tasmania and the ACT have also made significant progress in the integration of WSUD into planning. A detailed analysis of the WSUD policy for each state is provided in Appendix D**.**

Queensland, Victoria, Tasmania, Western Australia and the ACT have WSUD water quality targets that are incorporated in the planning and development processes both at the state and local government levels. In addition, those jurisdictions have also focused on improving the alignment of water management and land use planning, to improve the implementation of WSUD into the development planning and approvals process.

In Queensland the *Healthy Waterways program* established a framework, assessment targets and the policy basis for the valuation of the environmental health of waterways and was instrumental for the promotion of WSUD in the State. Recent reviews had highlighted the importance of more coordination and collaboration between State and local government at promoting compliance in industry and the need to address uncertainty regarding WSUD management responsibilities (Jones *et al.* 2012). However, recent changes to State Planning Policy (Oct. 2013) increased the emphasis of aligning state objectives and priorities to regional and local development planning.

In Victoria many of the policy and programs addressing stormwater management were initiated by Melbourne Water (bulk water supplier and also caretaker of waterways health). WSUD principles were applied in these programs to integrate the management of stormwater quantity and quality to protect the health of receiving waters under the coordination of Melbourne Water. Mandatory stormwater management requirements are integrated in planning legislation and apply to the residential, commercial and industrial developments. Also, significant emphasis was given to the developing local government capacity for planning and managing WSUD systems. This capacity building program includes improving understanding the O&M requirements of different WSUD features.

In Tasmania marked progress was observed after the State government's initiative to develop water quality targets. Support was made available to industry and local government to implement WSUD and secure funding opportunities. This has resulted in the delivery of various WSUD projects that integrate both stormwater quality and quantity management objectives and which were successful in securing federal funds.

In the Northern Territory the development of water management strategies for Darwin and other urban centres resulted in the development of supporting material for planning and implementation of WSUD systems, and a draft policy (2010) promoting the adoption of WSUD. Whilst the legislation has not been finalised, the implementation of the strategy has proceeded in the region informally, this was possible in large part because urban development is concentrated under a few key jurisdictions with well-established capacity, in particular the City of Darwin, Palmerston City Council and Alice Springs Town Council (K. Gardner, NTDPI, personal communication, 2012).

In New South Wales WSUD is not mandatory and implementation is progressing in a more fragmented manner, with a recent review highlighting current gaps that need to be addressed to facilitate greater WSUD uptake, including the revision of local government plans, development control plans and related codes for the promotion of WSUD objectives at local government level (SMCMA, 2012). However, across the Sydney drinking water catchment that supplies Greater Sydney, development is regulated under the *State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011* (SEPP) by the Sydney Catchment Authority (SCA). The SCA manages and protects the water quality and quantity of the catchments, the management of raw water supply and associated infrastructure, including dams, raw water provision to licensed operators, and the regulation of activities within the catchment and regulate certain activities within and also outside of catchment that might impact its water quality (see Appendix E), which has similarities with Melbourne Water's role. Under the SEPP, developments proposed under a council's local environment plan must have a neutral or beneficial effect (NorBE) on water quality, and should incorporate current recommended practices or performance standards endorsed or published by the Sydney Catchment Authority related to water quality. Under the SEPP it is mandatory for councils to use the NorBE assessment tool and undertake the NorBE assessments. Developments are classified into classes using a standard instrument, the Principal Local Environmental Plan, and then grouped into modules based on the development assessment process and the level of risk from the development. Assessment requirements are set based on the risk classification of a development, with more detailed assessment (e.g. requirements for MUSIC modelling of stormwater) as the potential risk increases. The tool also records the decision process and standardises the development assessment process increasing the transparency of the process. In addition, the SCA developed a model clause for councils to include in their development control plans, which describes the need for inclusion of a water cycle management study (including erosion control and sediment management during the construction phase), relevant reports and modelling for all developments based on the type and scale of the development proposal, as part of the assessment. The NorBe guideline also provides guidance on modelling and access to information sources tailored to the conditions of the catchment.

In Western Australia following the integration of land use and water planning in State and local planning policy, there has been significant investment in the development of local government capacity and resources for WSUD implementation. This WSUD program is being coordinated by State agencies, led by the Department of Water (Government of Western Australia, 2011; 2013). However, in practice there is a disconnect between land release planning and infrastructure service provision.

In the ACT, WSUD was integrated into planning through ACT Planning and Land Authority in 2010, with mandatory consideration of the water cycle and targets for all types of developments in planning legislation. The performance of the ACT Water strategy was recently reviewed and the draft Water strategy is now undergoing public consultation (ACT Government, 2013).

Table 4-1 provides a snapshot of the various policy components in each jurisdiction.

Overall, a distinct feature across the various Australian jurisdictions has been the pursuit of a water (and stormwater) management framework with greater integration of the total urban water cycle management and WSUD principles in environmental and land development policy and legislation. Each of the States has developed water quality and quantity objectives which are required for development. States with a longer history of WSUD institutionalisation, such as Victoria, Queensland, Northern Territory, ACT and areas in NSW (e.g. Sydney catchment) have also had the time to develop associated codes and legislation and to develop new tools to assist in the implementation process. In addition, in a number of those States, WSUD implementation, coordination and often enforcement are facilitated by a single entity, often in collaboration with LGAs. In the Sydney drinking water catchment area and in Melbourne, the stormwater management frameworks are respectively managed by the SCA and Melbourne Water, which have a stated mandate of protecting the health of receiving waters, and have legal authority and resources to enforce that mandate. In the NT, WSUD has not been enforced through legislation, however population and land development is concentrated in a much smaller area (e.g. City of Darwin and Darwin Harbour) compared to other State capitals, and the local government is able to enforce WSUD implementation in development in its practice. In Queensland the development of mandatory State and regional water quality objectives for receiving waters and their implementation through the Healthy Waterways program was essential to mandate WSUD.

In comparison the current legislative framework in SA is very fragmented in stormwater management.

Table 4-1. Examples of selected WSUD policy features across Australia.

Policy components	ACT	NSW	NT	SA	Qld	Tas	Vic	WA
WSUD targets	√	√	√ (selected areas)	√*	√	√	√	√
Integrated planning requirements	√				√		√	√
Local WSUD guidelines		√ (selected areas)	√	√	√	√	√	√
Legislated WSUD requirements for development	√	√ (selected areas)			√	√	√	√
Central coordination at State level	√				√	√	√	√
Capacity building programs	√	√	√ (limited progress since 2010)	In progress	√	√	√	√

*Note: SA targets as outlined in *Water sensitive urban design – creating more liveable and water sensitive cities in South Australia* (Government of South Australia, 2013)

5 Process of WSUD implementation

WSUD implementation should in principle be integrated in the planning and design process at development level. Figure 5-1 provides an overview of the process of WSUD implementation in SA:

(a) Policy: development of policy and legislation that guides WSUD;
(b) Planning of WSUD features in a development;
(c) Design;
(d) Verification of design and approvals by relevant authorities;
(e) Construction of development and features;
(f) Commission;
(g) Monitoring and evaluation (not always implemented);
(h) Handover of WSUD assets from developer to long-term operator;
(i) Maintenance and operation; and
(j) End-of life disposal or upgrade.

The process ideally would be cyclical with the improvement of the implementation process as lessons are learnt from on-going experience. This experience can develop WSUD knowledge and help refine system design. In addition, there are strong inter-dependencies between O&M and the design and construction stages. In practice the process for individual developments is often linear from steps (a) to (i), while steps (g) and (j) are often not conducted due to the focus on implementation alone. There is often a lack of resources for the verification process beyond handover (step (g)). Also, many WSUD features are relatively new so they have not yet reached their end-of life when step (j) occurs.

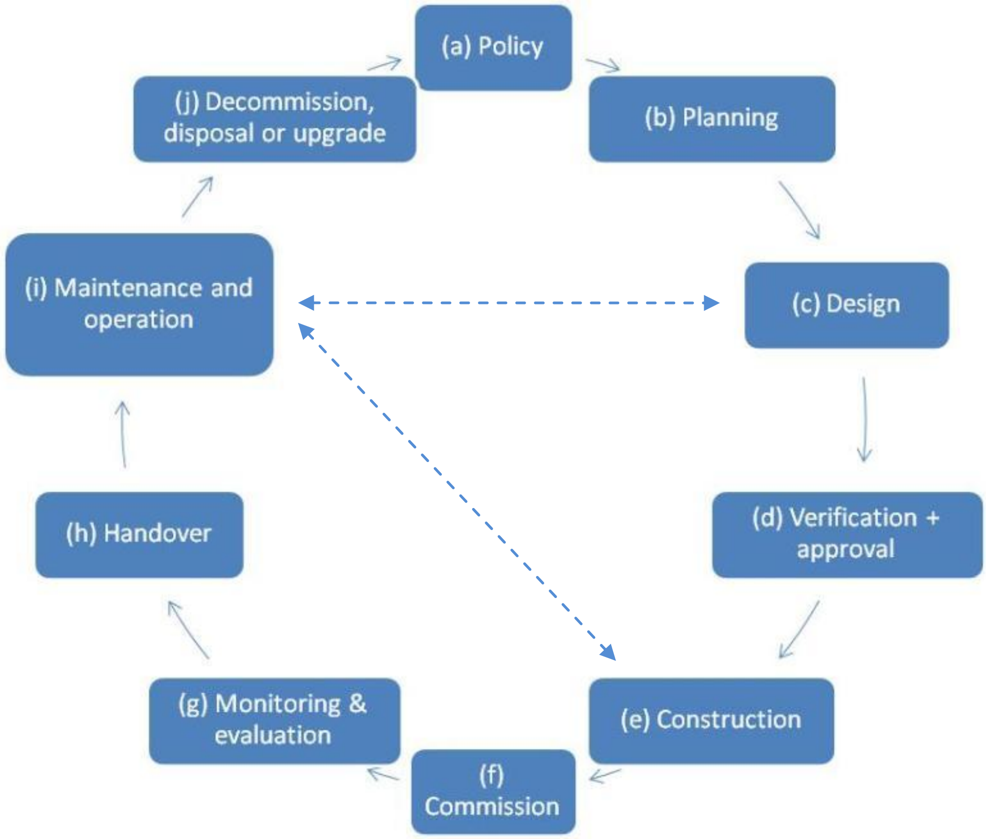


Figure 5-1. Process of WSUD implementation

The implementation stages are explained in the following paragraphs.

(a) Policy and legislation

Local government is currently responsible for establishing the WSUD requirements necessary for a development approval to be granted. The current mechanism for WSUD implementation relies on the appropriation of modules from the State Planning Library into Local Development plans and leaves the responsibility for WSUD implementation in the hands of local government. The criticism of this model is that the capacity for local government to assimilate the modules and to develop its own WSUD requirements is limited by each council's resources and priorities.

(b) Planning

WSUD should be integrated in the planning and design of a development. This ensures effective and consistent application of WSUD principles from the start of a development.

(c) Design

Typically the approvals process places the onus to demonstrate the effectiveness of proposed WSUD measures (if required by councils) on the development proponent. The design is contracted out to consultants who propose concept designs that are expected to fulfil the required targets or objectives set by local government. Standards, technical guidelines and supporting technical manuals can assist consultants in the design process. However, given the range of disciplines involved in WSUD features (engineering, landscaping, environmental science, etc.) practical experience is also valuable for ensuring effective design.

(d) Verification and approvals

Development design plans are submitted for verification and approval by local government. Developments larger than 50 lots also need to be submitted to the EPA for advice on environmental assessment, or to other relevant agencies, DHA or SA Water, if recycled water is proposed; usually at the conceptual design stage in the development approval application. NRM boards provide advice with respect to the assessment of various activities or proposals referred to the respective board and relevant to the management of natural resources within their respective regions, which includes compliance of any Development Plan with the objects of the *NRM Act*. Under the *NRM Act*, DEWNR and NRM boards can issue *water licences and allocations* for selected activities including irrigation, industrial, commercial, stock and domestic use and managed aquifer recharge. DEWNR administers *Water permits* which are issued for activities such as drilling, operating and sealing a well, draining or discharging water directly into a well, use of imported water or effluent for the carrying of a business. NRM boards administer activities related to dams, draining and discharge into water courses, floodplains or lakes.

In some cases, advice is sought from the Transport or Land Use coordination divisions of the DPTI, which may then refer the application to its Engineering division for comment on stormwater drainage. The agencies advice is provided to council, which has the discretion to accept the recommendations and proceed with the approval process or request changes to the development plan by the development proponent. The process does not require future consultation with the State advisory agencies, unless it refers to a licensed activity, such as injection of harvested stormwater into an aquifer. Councils can then approve or require modifications to the plans before development approval is granted.

(e) Construction

The development industry bodies, local government representatives and consultants interviewed highlighted that the fragmented approach of civil works by different contractors, who have differing levels of WSUD knowledge, can adversely impact the construction of WSUD features. A lack of understanding of WSUD concepts can be compounded by poor communication among the parties involved in the construction stage (landscapers, engineers and builders). Mistakes made during the construction stage can lead to poor WSUD performance, and potentially additional costs for rectifying faults. The construction process can also result in sediments being washed into existing downstream stormwater infrastructure if proper controls are not adopted. In addition, in the case of greenfield development, land parcels are typically developed on an ad hoc basis depending on the sales and timing of each land developer. This creates additional challenges for staging infrastructure implementation across a new area, particularly regarding stormwater quality and quantity management during the interim building period.

(f) Commission

Typically is conducted by the proponent or contracted to service providers hired by the proponent.

(g) Monitoring and evaluation

In large developments, following commission, developers are required to maintain and operate features located in public and open space areas (e.g. water bodies, etc.) for a pre-determined period before handover to council to establish the features and ensure that they operate as expected. However, stakeholders overall have reported that monitoring and evaluation of WSUD systems is not often undertaken beyond the establishment period. There are notable exceptions in SA, such as Lochiel Park, where funding of the sustainability features specified the need for independently monitoring and reporting of performance post-implementation.

(h) Handover

Following the construction of community infrastructure and the establishment of open space features by developers, it is typical for the council to take over the ownership and maintenance of these features. The handover process and timing is typically specified in the initial stages of the development application process, but is typically around two years.

(i) Maintenance and operation

On-going O&M is required to ensure that WSUD assets continue to function effectively and their service life is maximised. WSUD features based on natural systems have different requirements compared to *hard* infrastructure systems. O&M is reported as the least understood aspect of WSUD by councils, consultants, developers and other agencies. The O&M requirements for WSUD features can vary depending upon the service objectives and the standards of the managing organisation.

(j) Decommission, disposal and upgrade

These tasks are essential for life cycle analysis and costing of any infrastructure project. However, for WSUD there has been scarce information available. The Planning Industry Association has expressed concern that end of life requirements may not always be properly accounted during design. For example, the disposal of sediments from de-sludging wetlands and detention basins may pose a problem. The sediment removed can be classified as trade waste due to contaminant concentrations, which can then incur high disposal costs that were not considered in the original assessment.

6 Stakeholder mapping

Stakeholders are individuals, institutions, communities or social groups that have a vested interest in WSUD or can affect the outcome of the WSUD implementation process.

A large array of stakeholder groups can be impacted by and can impact the implementation of WSUD in SA. Understanding the stakeholder groups, their vested interests and interdependencies, can aid in developing strategies for improving the uptake of WSUD. There is also the need to understand how different stakeholders engage with the decision-making and implementation process.

6.1 Stakeholder segmentation by formal roles

Although the WSUD philosophy aims at integrated water cycle management, the current legislative set-up is based on individual water cycle streams: rainwater, stormwater, managed aquifer recharge and recycled water. Figure 6-1 shows the formal roles and the major stakeholder groups for WSUD implementation, based on their role in each water cycle stream.

Legislation and policy setting

State legislation and policy provide the overarching framework for the set-up of development plans at local government level. State government is comprised of elected representatives, officials and State agencies. State agencies are responsible for the overarching policy and legislation that could impact development and planning, influence the set-up of local Development Plans and which in principle should provide guidance on the interpretation of policy.

The roles of the various agencies are segmented into discrete portfolios based on their responsibilities. The EPA is the responsible authority for water quality in the environment, while the DHA has jurisdiction over public health. DEWNR, NRM Boards and DPTI cover water and natural resources management and land use, road transport infrastructure and planning respectively, these mandates allow them the scope to consider mandating WSUD implementation. SA Water is the main provider of wastewater services, however some local governments operate Community Wastewater Management Systems (CWMS). SA Water is also responsible providing mains water supply to more than 1.5 million South Australians, hence it has responsibility for maintaining safe, affordable and reliable water supply to its customers in any interface of the mains water system with alternative water schemes. It is however, the Planning division that is perceived to have the largest potential for exerting influence on WSUD implementation.

Development proponents

Development proponents can include home owners, developers, councils or any other private entity that is responsible for the decision to adopt WSUD. In addition, selected infrastructure assets are proposed, owned and managed by State agencies, e.g. major stormwater and transport assets.

Home owners can act as proponents in decisions impacting their immediate property only. The exercise of such function is limited and the most common example is the decision to retrofit a rainwater tank or to adopt water efficient appliances. However, in many instances, home owners don't commit to such decisions when it comes to new housing. In addition, the awareness of home owners on WSUD is typically low (Leonard et al., 2013) and so is their willingness to pay for environmental features varies.

Developers are one of the two the largest stakeholder group to act as proponents and implementers of WSUD in land planning and construction. The other group is local government. The development industry has a vast and diverse range of segments including land development, housing construction, consulting, state and local government etc., covering greenfield, brownfield, residential, commercial and industrial development. Developers range in size and typology and encompass private companies of various sizes, ASX listed companies and government (e.g. Renewal SA, the State government land development agency).

Land and property development requires a significant upfront capital investment, thus unexpected costs and delays, if significant, can pose a risk to the financial viability of a development. This can deter some developers from going beyond the minimum development requirements stipulated by council.

Local government is the main group to act as proponent of WSUD in South Australia. It is also a diverse group with different levels of resources, goals and capacity.

Designers and consultants

Proponents engage consultants and contractors to design and construct WSUD features. Consultants have limited power in the brief setting and final selection of the features implemented, however they are able to influence the design process through their design concepts and technical recommendations.

Approvers or advisors

The development plans are subject to approval by approval authorities (typically a council). Large schemes such as managed aquifer recharge, recycled water or large stormwater schemes typically can be referred for comment to state agencies (DEWNR, EPA, DHA, NRMBs and DPTI) during planning and also for approvals, however smaller and localised WSUD in developments at sub-division or individual properties (e.g. rainwater tanks, infiltration features, ponds) are assessed and approved by local government (or their consultants) and advice from State agencies such as the EPA, the DPTI Transport or the DHA is not mandatory, but can be requested by council. State agencies have no mechanisms to verify if their recommendations are considered in the plans by a council.

Implementers

The implementation of a WSUD feature can be conducted by a property owner (an individual or company), local government or contractors hired by the land owner or government agency, which often depends on the type of feature and the type of project. Often the implementation process is fragmented and multiple contractors are engaged for the delivery of specifically assigned tasks.

Operators or end users

A range of actors (private citizens, incorporate entities/body corporate, service contractors and local government agencies) can be classified as operators of WSUD schemes depending on the scheme type and governance model. Local government tends to be the major owner and operator of WSUD features located on public open space and also associated with stormwater management and drainage, and is responsible for their management, including features constructed by developers after handover.

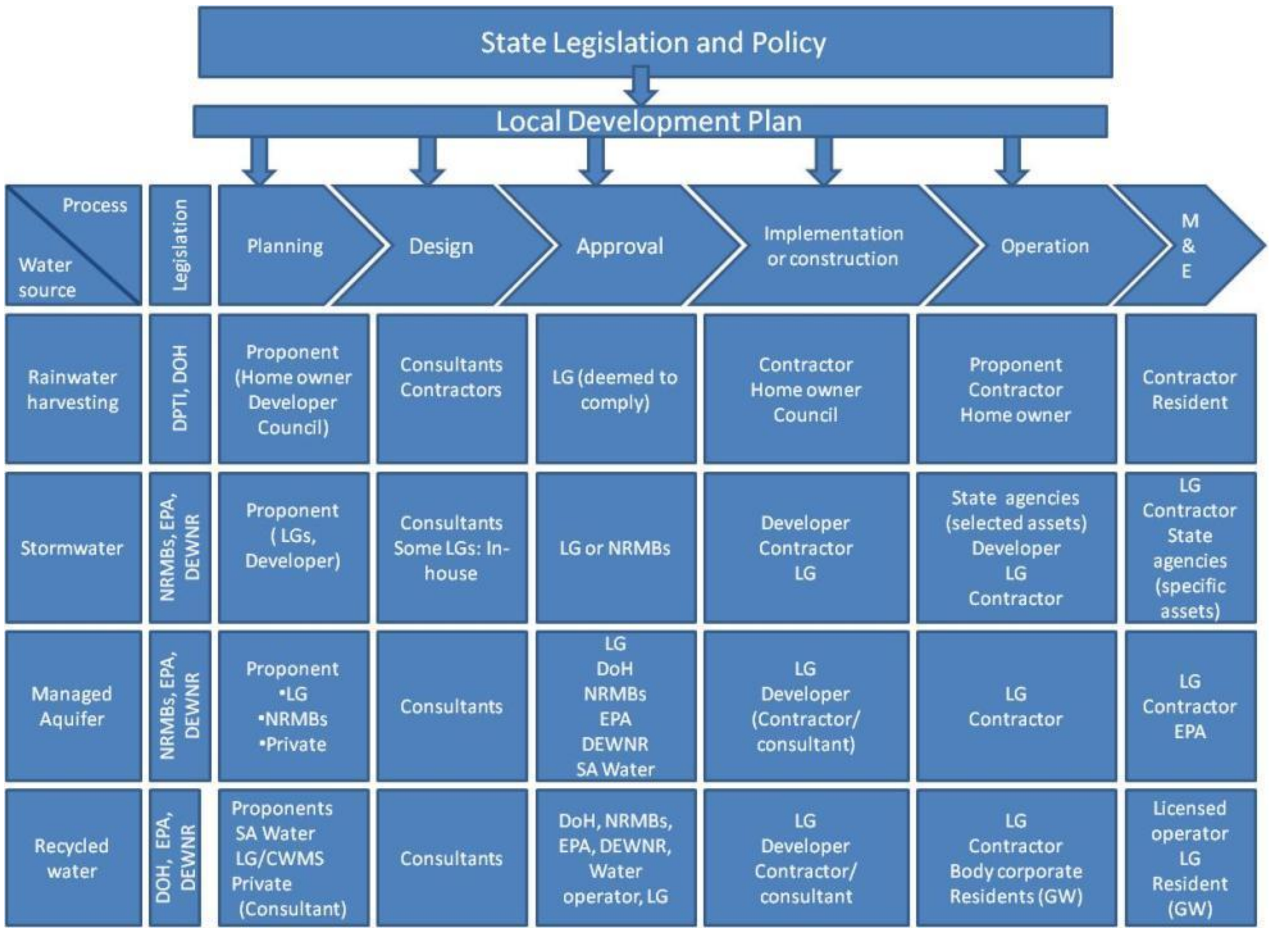


Figure 6-1. Major stakeholders involved in WSUD implementation according to formal stakeholder map.

Note: *Agencies responsible for specific legislation requirements.

Legend: CWMS (Community wastewater management scheme), DoH (Department of Health and Ageing), EPA (Environment Protection Authority South Australia), GW (Greywater), LG (Local government), NRMBs (Natural Resources Management Boards), SMA (Stormwater Management Authority).

In addition to those stakeholder groups that have a formal role, there are other stakeholder groups that influence WSUD implementation indirectly and need to be included in the stakeholder map.

6.2 Stakeholder segmentation by influence on WSUD implementation

The diagram in Figure 6-2 provides an overview of the major stakeholder groups based on their level of influence on WSUD adoption: (a) Primary stakeholders: directly influence the decision process or are directly impacted by it, (b) Secondary stakeholders: can influence the decision-process but may not directly be involved in the decision-making process, (c) tertiary stakeholders: can influence the decision-process or benefit from it, but their influence on decision-making occurs via indirect or complex influence channels. This classification was based on the interviews with stakeholders and their perceptions of the various links between various stakeholders.

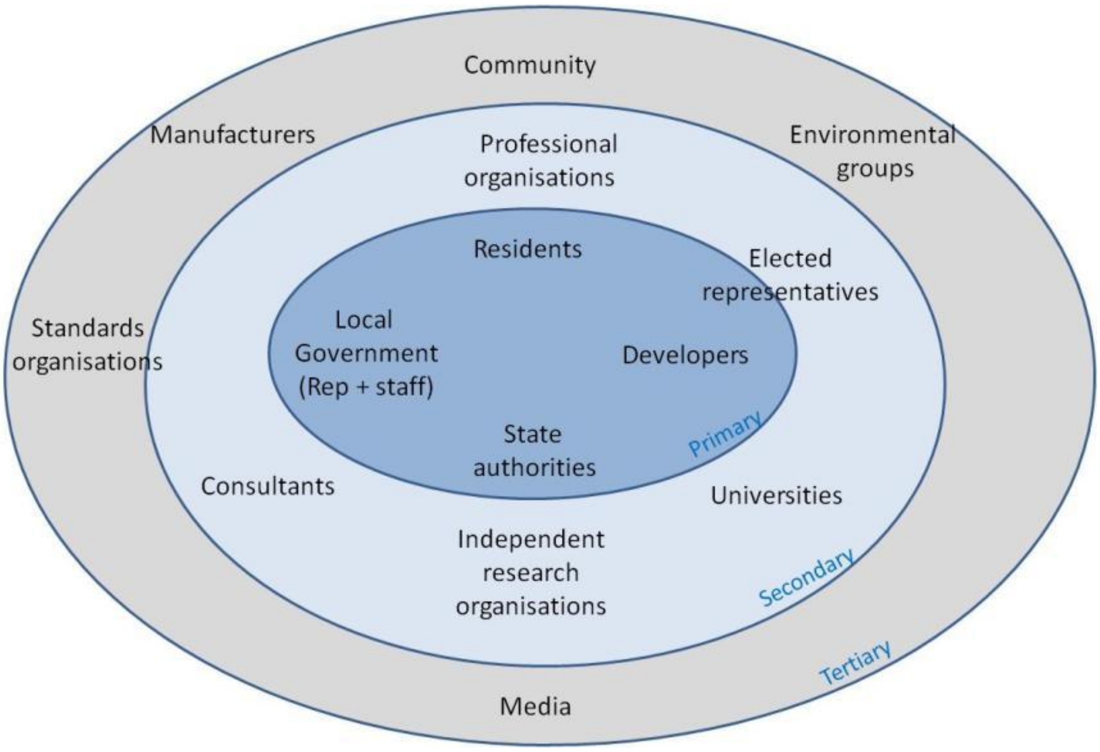


Figure 6-2. Stakeholders influence levels on WSUD

Figure 6-2 outlines how three of the major primary stakeholder groups (State agencies, local government and development industry) perceive the distribution of influence among the primary stakeholders.

Primary influencers

In WSUD primary stakeholders include local government, development proponents, state authorities (minister and departments) and residents. Within this group the role and level of influence of residents will vary with the type of WSUD feature adopted. The implementation of some features such as stormwater features in public land may occur with limited awareness of residents, whilst the retrofit installation of a rain garden next to a private property may require the cooperation of residents.

Local government is perceived by other stakeholder groups to have considerable influence in the decision-making process for WSUD implementation. Their influence is due to their control of the development approvals process and the DPs. The next most significant group influencing WSUD implementation is the project proponents (most often developers or councils, but can include SA Water for recycled water, and home owners for lot retrofit). The proponents make decisions on the way that WSUD will be implemented. State authorities have various degrees of influence, depending on the strength of WSUD legislation.

Residents or communities were mostly perceived as lacking awareness and interest in WSUD systems, which was seen to limit their influence on WSUD outcomes.

Perceptions differ among the primary stakeholders of which groups have the highest influence on the decision-making for WSUD implementation (e.g. Figure 7-1). Local government agencies see developers and State government (including the Ministers), in particular the Planning minister and the DPTI Planning division, as the most influential. State agencies see local governments and the ministers for Planning and Environment as highly influential regarding WSUD, but often perceive local government to be poorly resourced. Developers see local governments as the most influential.

Secondary influencers

Secondary stakeholders include consultants, independent research organisations (Universities, CSIRO, CRC for Water Sensitive Cities, Goyder Institute), professional associations (Stormwater Industry Association, Australian Water Association, Local Government Association, Institute of Public Works Engineering Australasia, Institute of Engineers, Planning Institute of Australia, UDIA, Master Builders, Plumbing Industry Association of SA, etc). There are also other professional organisations (e.g. Australian Institute of Landscape Architects, Parks and Leisure Australia, Royal Australian Institute of Architects, Hydrological Society, etc.) that can have a potential impact on WSUD particularly regarding capacity building, but which are not as closely associated with it, examples are provided in Appendix **G** (Alluvium and Kate Black Consulting, 2012).

Consultants directly influence WSUD implementation through contracts with developers and local government to deliver concepts and engineering designs. However, their actual influence on successful WSUD uptake is dependent on their expertise and familiarity with WSUD and their ability to deliver a WSUD system that fulfils the development plan requirements.

Universities and professional organisations provide expertise on all aspects of WSUD. They can build capacity for WSUD design and planning among students and professionals, and advocate for improved practices for WSUD implementation. Research agencies and universities also contribute by addressing WSUD research gaps and improving technical guidelines. These institutions are perceived as independent so they can act as trusted advisors to other stakeholder groups.

The development industry is diverse and is represented by a number of organisations (UDIA, MBA SA, HIA, PC, GBCA). The level of interest from developers for WSUD will depend on the legislative requirements, location, development type and the customers being targeted for the development. However, one common characteristic of this group is that their business model is characterised by significant capital outlay up-front before revenue is generated from land/dwelling sales and hence economic factors (costs, project duration, timing and certainty) are highly important for the industry.

Elected representatives at local and State level were classified as secondary stakeholders due to their influence on local and state policy. Whilst they can have strong influence and political awareness, their interest in WSUD has typically been low in SA, with a few exceptions.

Tertiary influencers

Tertiary stakeholders include actors that can influence WSUD implementation, but who may not be directly linked to the decision–making process. Therefore, they tend to exert influence on WSUD indirectly by deliberately or unknowingly influencing the actions from other actors.

For example, environmental groups may focus on the preservation of local receiving waters or the bay, which places a greater emphasis on the need for source control of stormwater quality. Local residents may object to the construction of a rain garden if they dislike the feature aesthetics and exert pressure on their local councillors to stop the implementation. Whilst, if the wider community values the environmental benefits of receiving waters they can lobby elected representatives to strengthen policies for improving stormwater quality through WSUD.

The influence of these groups on WSUD uptake is dependent upon their awareness of the link between WSUD measures and improved environmental outcomes. Local residents in proximity of a WSUD feature, e.g. a raingarden, may benefit directly from the amenity created and reduced run-off peaks, whilst downstream in the catchment the overall community benefits with the improved stormwater quality of discharges to receiving waters and the associated ecosystem health due to installation of multiple rain gardens. However, downstream or inter-catchment benefits are often not recognised or understood by the wider community.

Manufacturers of WSUD devices and technology were also considered as tertiary stakeholders, as whilst they are interested in the uptake of WSUD as technology providers, they cannot directly influence WSUD adoption.

6.3 Stakeholder roles

Table 6-1 provides a summary of the main roles exerted by both the formal and informal WSUD stakeholders in South Australia. A detailed analysis of the formal roles, knowledge and influence of the major institutional agencies on WSUD in South Australia is provided in Table 6-2 and a more detailed assessment in the Appendix **F**. Some institutions, such as local government, can perform multiple WSUD functions.

Decision-makers are the entities or actors that decide on the implementation of WSUD. This role is fulfilled by councils for council-driven WSUD initiatives, private and government developers (e.g. Renewal SA) and NRM boards in regional areas.

Influencers are entities that influence the WSUD implementation process, either via formal or informal roles, legislative requirements, ability for capacity building, etc.

Gatekeepers are entities that have the power to approve or reject proposed WSUD systems. Gatekeeper organisations include local government and NRM boards. While for some WSUD systems SA Water, EPA and DHA can determine if a WSUD system goes ahead. For example, the DHA has the power to close down any water schemes that it deems a threat to public health.

Operators manage and maintain the WSUD features. Typically WSUD schemes in public space will fall under local government control, but WSUD features in private land (e.g. rainwater tanks, rain gardens, etc.) are retained by the land owner and managed by either the land owner or his / her service contractor. In addition, the DPTI Transport, NRM Boards and SA Water also manage some WSUD infrastructure. For example, in the case of SA Water they manage recycled water treatment plants and reticulation networks.

Table 6-1. Formal functions of various agencies in the WSUD implementation process in South Australia

Decision-makers	**Influencers**	**Gatekeepers**	**Operators**	**Other**
Local government NRM Boards	DEWNR	Local government	LG (departments of asset management, roads and landscape, parks and gardens)	Commonwealth
Private developers	DPTI (Planning)	NRM Board	SA Water	State Treasury
	NRM Board	SA Water	Contractors	Office of technical regulator
Renewal SA	Community	EPA	Licensed service provider	Plumbing Industry Association
	Independent advisors	DHA (public health scope)		
	Universities	Planning minister DPTI		
	CSIRO , CRC			
	Consultants			
	Individual Champions			
	Professional organisations			
	Planning SA, SIA, AWA, IE, AILA, LGA SA, IPWEA, Plumbing SA			
	Development industry bodies			
	UDIA/GBCA/MBA /HIA/PC			

Legend: Australian Water Association (AWA), Australian Institute of Landscape Architects (AILA), Department of Environment, Water and Natural Resources (DEWNR), Department of Planning Transport and Infrastructure (DPTI) (includes Planning and Transport divisions) , Environment Protection Authority (EPA), Green Building Council of Australia (GBCA), Housing Industry Association (HIA), Institute of Engineers (IE), Institute of Public Works Engineering Australasia (IPWEA), Local Government Association South Australia (LGA SA), Master Builders Association SA (MBA SA), Planning Institute of Australia SA chapter (Planning SA), Plumbing Industry Association of South Australia (Plumbing SA); Property Council of Australia (PC), Stormwater Industry Association (SIA), Urban Development Industry Association (UDIA).

Table 6-2 Major stakeholders' characteristics, WSUD knowledge and formal levels of influence in WSUD in SA

Stakeholder	Classification (based on influence)	Characteristics	WSUD knowledge	Influence
Local government	Primary	Local government is comprised of a mix of councils responsible for areas of various sizes (small to large), with various levels of resources and priorities. LG receives a regular source of income from rate payers and is responsible for delivery of local services including roads, stormwater management, solid waste management and recreation and open spaces.	Members' awareness of WSUD varies significantly across the spectrum. Varies from poor to good, but highly dependent in individuals within local government. Knowledge and awareness can also vary between staff and elected representatives. Understanding of WSUD varies within council departments and across councils. Assessment of WSUD features may take place in-house or be referred to State agencies for larger and more complex projects.	High. In the current institutional and regulatory context LG are responsible for the setting of local development requirements and plans and for development approvals. However, their actual influence varies due to limitations in local government resources and capacity in WSUD.
Development industry	Primary	A mix of various service providers represented by various bodies (UDIA, MBA, PC, HIA). Members include builders, developers and other professionals involved in the development of properties ranging from single lot to large developments in residential, commercial and industrial applications. Cost is an important factor for the development industry, given the capital outlay required for construction.	Members' awareness of WSUD varies significantly across the spectrum. Relevance of WSUD to members also varies depending on development characteristics and proponent knowledge. Consultants are often hired to develop infrastructure plans including WSUD.	Medium to High. However, varies with the type of development. Individual developers are subject to local government requirements and regulations for development and constrained by financial resources and ability.
DPTI	Primary	Department combines various disciplines which deal with typically operate separately on various aspects of infrastructure	Varies among sections. The level of knowledge in engineering (Infrastructure and transport) and the planning divisions varies with the relevant discipline. Planning whilst responsible for development as a discipline is not traditionally strong in WSUD expertise which requires engineering/water/landscaping know-how.	Medium to High. It has potential for high power given the potential to influence planning legislation. However, current influence is low to medium given the current legislation, fragmented advisory roles and the role of advisory body for local government on large infrastructure projects. DPTI Transport division also takes part in SMA reference committee for SMPs.

Stakeholder	Classification (based on influence)	Characteristics	WSUD knowledge	Influence
EPA	Primary to Secondary	State agency responsible for protection, restoration and enhancement of the quality of the environment. Provides advice and guidance, partnering with other organisations, education and regulation.	Good. The focus of EPA is on water quality and health of the environment.	Low to Medium. EPA has influence on regional water quality targets and guidelines, in prescribed areas, but not directly on the implementation within developments, which is under jurisdiction of local government. EPA has the power to set up targets and requirements for stormwater and other discharges to prescribed surface waters and groundwater which can include large stormwater conveyance infrastructure.
DEWNR	Primary to Secondary	Manage environmental and natural resources to achieve productive and balanced use of natural resources; Help improve condition and resilience of natural systems. Traditionally the focus has been on water allocation and quantity.	Good.	Medium to High. Responsible for Development of overarching State policy approach and targets for WSUD; Expected to ensure an integrated water management approach to infrastructure planning/design and implementation especially in new development areas; Coordinates activity across Government to ensure a consistent approach to WSUD activity and support.
SMA	Secondary	Prioritizes stormwater planning and infrastructure projects on a catchment wide basis throughout the State and manages available funds.	Good. But not directly involved in WSUD implementation, but highly influential on catchment management.	Medium. Currently it focuses on large catchment flood management mostly, but could have potential to assist in better integration if better resourced.
Consultants	Secondary	Conduct engineering design as required by councils.	Varies from basic to good depending on the firms skill set and freedom in project brief.	Medium to high. Varies with knowledge base
Community	Tertiary	End beneficiary and voter.	Low	Low. This group has low understanding and concern for WSUD and its benefits. But the community could be more influential if they are more engaged.

7 Stakeholders' perceptions

This chapter analyses the perception of the various stakeholders on WSUD in South Australia.

The data sources used included interviews with the organisations shown in Table 7-1, the input from practitioners belonging to the various stakeholder groups from the survey conducted by Alluvium and Kate Black Consulting (2012) and interviews with developers. Detailed analysis of this data is provided in the appendices (Appendix **G** provides the analysis of the survey data from Alluvium and Kate Black Consulting (2012), Appendix **H** provides the analysis of the developers input and Appendix **I** provides a summary of local government perceptions).

Table 7-1. Stakeholders contacted for interviews

State Government	Local Government	Development Industry	Professionals/Consultants
DEWNR	Individual councils (26)*	GBCA	Planning SA
DPTI[#]	LGA SA	HIA	SIA
EPA		MBA SA	
DHA			Tonkin Consulting
NRMB		UDIA	Design Flow
SA Water		Renewal SA	KBR Ltd
SMA		Selected developers	Plumbing SA

Legend: Department of Environment, Water and Natural Resources (DEWNR), Department of Planning Transport and Infrastructure (DPTI) (includes Planning and Transport divisions) , Environment Protection Authority (EPA), Green Building Council of Australia (GBCA), Housing Industry Association (HIA), Local Government Association South Australia (LGA SA), Master Builders Association SA (MBA SA), Planning Institute of Australia (Planning SA), Plumbing Industry Association (Plumbing SA), Stormwater Industry Association (SIA), Stormwater Management Authority (SMA), Urban Development Industry Association (UDIA).

Note: *Myers et al 2013; # Planning and Transport divisions.

7.1 Perceptions of influence on decision-making

Interviews with the stakeholder groups shown in Table 7-1 have confirmed that State government, local government and developers are perceived to be the three primary decision-makers regarding WSUD implementation among stakeholder groups. However, the three primary stakeholder groups differ in their perceptions of the group which has the most power for WSUD implementation, as shown in Figure 7-1.

7.1.1 Local government perception

The DPTI Planning division was perceived as the key agency to hold the power to influence WSUD implementation across SA (Figure 7-1a), whether actively (through policy and legislation) or by lack of action. There was a general perception that the development industry uptake of WSUD was slow.

However, councils also recognised that limitations in their powers, capacity and resourcing for WSUD implementation. They saw the need for State support mechanisms to allow a more consistent WSUD implementation and its long-term viability across SA.

7.1.2 Developers perception

In the opinion of developers, local government exerts the greatest influence on WSUD uptake (Figure 7-1b). Such influence is exerted through the council requirements in the development approvals process, or site caveats in special land release projects.

The developers perceived that awareness of WSUD in the development sector was increasing due to technological development and improvement in standards relevant to WSUD. Among interviewees there was a general consensus that the application WSUD principles was beneficial to society overall.

A number of developers believe that the development industry has a responsibility to provide leadership in the achievement of more sustainable development. This could be achieved by improving the overall design and living standards through adoption of more sustainable practices, for which WSUD can be one aspect. However, to the majority of developers, investment in WSUD was not perceived to generate an economic return unless it resulted in a local water feature or aesthetics improvement. The main drivers for WSUD were perceived to be: (a) compliance with requirements from local council or land release caveat, (b) compliance with the company's own ESD charter, or an altruistic action. There was often a perception of disincentives by local government.

WSUD systems initiated by developers were less common due to perceived disincentives, which included: (a) Home buyers unwillingness to pay for environmental features, (b) Uncertainty associated with WSUD approvals, (c) Lack of clarity of many councils on their WSUD requirements, and (d) perceived lack of understanding by councils of WSUD features, their performance and cost implications for construction and long-term O&M, which contributed to (b) and (c) and often led to risk aversion towards innovation in WSUD.

Regarding the greater adoption of WSUD, developers acknowledged three key aspects that need addressing:

1. Recognition by state and local governments that land and property development requires a significant upfront capital investment that can deter developers from going beyond the minimum development requirements stipulated by council. Whilst costs known at the onset of a project can be dealt with by developers, unexpected costs and delays, if significant, pose a risk to the financial viability of a development;
2. There is disincentive to propose leading-edge examples of WSUD due to uncertainties in the local government approval process. The additional time and costs required to develop novel WSUD designs, which are then rejected by council approvals, was seen as risky and an avoidable cost.
3. There was also a general perception that the level of expertise and understanding of WSUD varies markedly among councils and often within departments of a council. This variability in capacity contributes to the lack of clarity and certainty in the approval process in selected councils. In addition, some developers felt that WSUD requirements requested by some councils can be ineffective and represent token gestures for improving the environmental sustainability of developments. Yet developers prefer to submit to those conditions than to create further delays in the development approvals process.

Developers acknowledged that capacity for WSUD implementation is influenced by the scale of the developer. Large scale developers had a greater ability to absorb the costs and effort associated with the implementation of WSUD features, and the approvals process. While it is possible for smaller scale developers to implement WSUD, the process is eased when clear directions are set through a master plan and/or guidelines. Clear council requirements for WSUD enable small-scale developers to estimate costs and identify the requirements associated with the approval processes. On the other hand, land development requirements and minimum associated infrastructure or open space requirements have in some cases been jointly pre-determined based on the determination of land use zoning as part of the land release and development approval process. This practice can accelerate the development approval process, however it limits the ability of local government to influence WSUD outcomes on a holistic basis.

There were mixed views from developers on the approaches needed to encourage greater adoption of WSUD. While developers felt that there is a role for councils and State government regulation to advance WSUD uptake, there was a concern that practical issues associated with successful implementation would be neglected. This includes consideration of cost sharing among the community when the benefits of the WSUD measure extend beyond the development, instead of automatically allocating the cost burden to developers. There was also a concern that mandatory WSUD measures could be over prescriptive.

Development industry bodies also felt that the development industry could contribute its practical knowledge to the WSUD debate, if further engagement between government and industry was procured.

Suggestions of incentives to developers to implement WSUD included collaborative agreements to share open space works/tasks between council and developer, dispensation or tax rebates for implementation of WSUD features (Appendix H).

7.1.3 State agencies' perception

State agencies recognised that local government was the key group for leading WSUD implementation (Figure 7-1c), but that they required some assistance from State agencies and a focus on developing capacity in local government. Among the various State agencies there was a general consensus that leadership from State government was necessary to coordinate the WSUD implementation process and to set targets. State agencies identified DEWNR and DPTI as the two agencies most suited to take the role, DPTI Planning division for its influence on planning and DEWNR for its knowledge in the domain of water resource management.

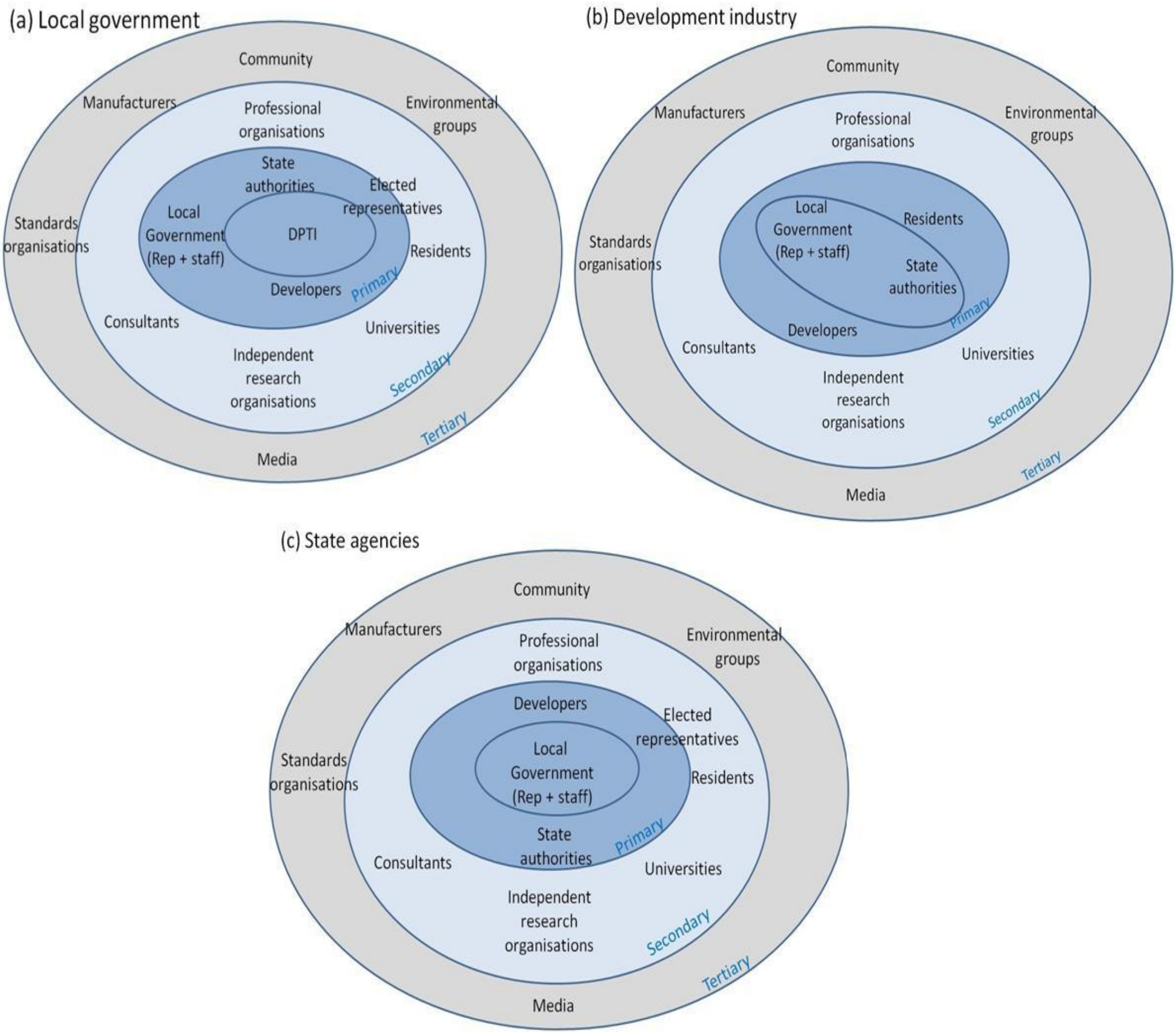


Figure 7-1. Perception of influence on WSUD decision-making by stakeholders: (a)Local government perspective, (b) Development industry perspective, (c) State agencies perspectives.

7.2 Stakeholder perceptions of the status of WSUD

There was a general consensus among stakeholders that WSUD implementation in SA has been fragmented, informally driven by local champions, and that the quality of WSUD projects can vary depending on the skills and resources from proponents. Queensland, Victoria and Northern Territory were mentioned as good examples of coordinated WSUD implementation by consultants, State agencies and the GBCA.

There is agreement that SA provides nation leading practice in large-scale WSUD schemes, in particular large-scale stormwater capture and managed aquifer recharge and recovery schemes. However, small-scale WSUD features were considered to be less understood and “experimental” in SA compared to other States, such as Victoria. In view of the 2030 strategy and the location of aquifers across Adelaide, there is limited potential for development of new large scale stormwater harvesting and MAR schemes in the prospective infill growth area, where majority of the future development is expected to occur and which will be constrained by high density living and limited open space restricting the type of WSUD options that can be adopted.

Government agencies (EPA, SMA), government owned water utility (SA Water), professional associations (SIA, Planning SA), councils and developers agreed that the focus of WSUD historically has been primarily on water quantity and flood management, with water quality and overall integrated water management a lower priority. The use of alternative water supply sources gained in importance during the drought given the availability of funding and the need to reduce mains water demand, but the ending of the drought reduced the perceived importance of these measures (Myers et al., 2013).

The ability of local government to promote and maintain WSUD features has been shown to be highly dependent on individual council capacity and history. There are a number of councils that showcase good implementation practices and could be used as examples for further learning and knowledge sharing (Myers et al., 2013). However, councils overall expressed concern about the lack of frameworks and supporting mechanisms to allow a more consistent WSUD implementation and long-term viability. In particular, capacity limitations, unfamiliarity with WSUD (by council staff, consultants, elected representatives and the public) and lack of resources for on-going maintenance, and a perception of uncertainty of cost-benefits for proposed WSUD features were seen to contribute to the perception of risk for WSUD.

Professional organisations, such as Planning SA and SIA, recognise that WSUD as concept has been in existence for many years, often recurring as a topic for professional seminars among practitioners. However, Planning SA sees uptake of WSUD in mainstream planning and in the development industry as slow. State agencies and councils also perceived low uptake by developers in WSUD implementation.

On the other hand, the development industry believed that their members were embracing the WSUD philosophy and principles. However, the development industry (UDIA, MBA SA and GBCA) acknowledged that their members are comprised a diverse range of individuals and organisations with various levels of understanding, disposition for WSUD and willingness for innovation uptake. This view is also supported by agencies such as the EPA and DPTI Transport division which are involved in the assessment of development plans, and have reported a marked disparity in the level of understanding on WSUD observed in development applications. Interestingly, developers also feel a lack of supporting mechanisms and incentives for WSUD implementation.

Developers interviewed were in principle supportive of WSUD provided the features adopted were effective and had a clear purpose. Development industry representatives (MBA SA and UDIA) perceived that local government and selected State approval agencies were often prescriptive and risk adverse. This tended to discourage innovation in development servicing, even in demonstration projects.

Other stakeholders such as Plumbing SA and DHA have a selective scope of involvement with WSUD. Plumbing SA members are professional plumbers involved mostly with the installation of alternative water sources at the dwelling level. Similarly the DHA's involvement has been mostly related to recycled water schemes.

7.3 Understanding of WSUD

The representatives of the stakeholder agencies interviewed demonstrated a common understanding of the principles and scope for WSUD (See Table 7-2). However, the stakeholders were also aware that the level of understanding and knowledge on WSUD varied across their institutions and members. This variation was likely to be due to the multiple disciplines involved with WSUD, and the roles and experiences of individual members.

Overall, the stakeholders interviewed perceived that the communities living within areas that are serviced by WSUD features had limited or no knowledge about the WSUD functions of landscape features.

Leonard et al (2013) established that 'WSUD features that improved aesthetics, greenscape, recreational amenity, and increased resident control over their own water supply had instant appeal. Installations that had less visible outcomes, such as improving water quality or flood mitigation, were often overlooked by the community. Such views agree with the overall perceptions from the stakeholder groups interviewed.

Developers reported that the majority of home buyers were not concerned with environmental features and this was reflected in their willingness to pay and in the selection of options in new dwellings. As stated by a developer "Home buyers prefer a more expensive kitchen bench-top over solar energy panels."

7.4 Support for WSUD implementation

All stakeholders groups interviewed supported the implementation of WSUD in SA and believed that it would bring environmental and economic benefits to the State improving the overall sustainability of urban development. WSUD is perceived as necessary given water resource limitations, population growth, the increase in urbanisation and impervious surfaces, the trend for climate extremes, limitations of existing infrastructure capacity, the need to counter urban heat island effects, and the population's desire for amenity and liveability.

Two of the stakeholder groups highlighted the need for a common terminology among stakeholders when discussing WSUD. This was exemplified in two opposing views considered to be prevalent: the understanding of WSUD as referring to large scale projects versus the understanding of WSUD as mostly small street- scale projects.

The stakeholders interviewed recognised the existence of both and the difference in WSUD needs and approaches relevant for greenfield and infill developments given space restrictions. There was also recognition of the need to investigate the potential of catchment or precinct scale approaches in the planning of WSUD, particularly given the projections for infill development in Adelaide.

Table 7-2. Stakeholder definitions for WSUD

Stakeholder group	WSUD definition
Local government	"It encompasses from small plot size good planning outcomes to large scale wetlands, for example. It encompasses from planning, engineering, operations with the outcome to putting water to high value uses, from reduction of flooding threat and to infiltration, MAR, trade and resale."
Professional organisations	"Incorporating holistic water planning in the design and construction of landscapes. Looking into building or renewal of an area to better incorporate the uses of water and the collection, reuse, discharge of stormwater/wastewater, is there capacity to do more in a holistic approach." "How you manage run-off at source in a locality to give it a productive use or to minimise its impact downstream." "How water comes in and goes out of a system" "WSUD is a sensible way to go. There are 240GL of stormwater rushing to sea every year; there is a huge cost implication. The infrastructure just managing to cope, even with only 1 in 5 year flood management, growing number of extreme events, urban growth, amenity issues, retaining water in environment, depleting aquifers, large urban areas, increasing impervious surfaces, in suburbs and cities. Heat island issue and people like to live in nice places."
State agencies	"WSUD is a key to improve water quality in receiving waters. … is very strong on water quality component tools and also recognizes the environmental flow component and the frequent flow component as part of the natural water cycle. It is about stopping the frequent flow events to improve the water quality at receiving streams." "Any initiative/design for landscape, construction, building for domestic residential, commercial for landscape and environmental outcomes to assure it accounts for water use, conservation and reuse. Design on all aspects of water capture, preservation and use." "Is about maximizing water resources and ensuring water security and wellbeing via

	use of multiple water sources, including rainwater and stormwater reuse. Strong stormwater reuse focus for non-potable.”
Development industry	“is part of good planning and good construction design. Good planning, good development includes WSUD and it is inconspicuous – public should expect good results/performance, but does not necessarily need the details to be promoted or need to be informed. Good practice and its evolution needs to be an on-going practice of councils and developers.“ “all about not taking away from the built environment and natural environment so that it actually makes for the sustainable use of water resources, i.e. water.” “A way of managing water in a way that mimics natural systems, with less engineered solutions, less pipe and engineering solutions and treating and managing water in a more natural way. “

7.5 Enablers

Stakeholders recognised the need for increasing the practical support and facilitation for WSUD implementation in SA.

Consultants, the development industry and councils perceived a lack of incentives for those practicing good WSUD. Yet there was also recognition that incentives alone have limited impact on implementation and a balance of incentives and legislation or minimum standards is required to promote change of practice.

Since the development of the WSUD Technical Guidelines in 2010, there was a general perception of limited activity in WSUD policy in SA. The major policy challenge identified by stakeholders was the failure to translate broad policy into principles that can be adopted on the ground. All stakeholders have expressed frustration at the lack of action: “much talk and reports, no action or concrete implementation afterwards” – was a view shared by State agencies, local government, professional organisations and the development industry.

All stakeholders, except DPTI Planning, recognised the policy in WSUD up to November 2012, lacked certainty or implementation clarity. UDIA highlighted that the application of policy and requirements at local government level was often inconsistently applied and extremely onerous to developers.

Developers preferred a more collaborative process for WSUD implementation than prescriptive legislation. LGA SA, councils and DPTI Planning also expressed a preference for policy that allowed flexibility in technology selection and implementation based on development needs.

The UDIA in particular expressed disappointment by the lack of interest of government to obtain greater industry participation in policy discussion and expressed desire for developing better collaboration between industry and government if that would lead to implementation activities: “initiatives are often just driven by government only committees, without input from the development industry who has to pay for the costs associated with any initiative at development implementation” (UDIA 2013, personal communication). MBA SA was hopeful that WSUD uptake would increase in the future if local government could improve their understanding of WSUD alternatives. MBA perceived as beneficial the deregulation of water services through the Water Industry Act and changes to the Plumbing Code, which it expected would increase the flexibility of service options for developers.

Legislation, such as in the setting of flow and quality targets, was perceived as an important enabler that set minimum standards and assisted to legitimise WSUD in the eyes of consultants, government agencies, the stormwater professional organisations and some developers. However, there is the need for further clarification in the legislation (e.g. the Local Government Act) on local governments’ role in supporting WSUD implementation and enforcement.

Local government representatives highlighted the challenges from limited capacity and resources. Local government practitioners were supportive of further investigation of the concept of a developer levy, based on the experience from other States (e.g. Victoria) and selected examples in SA (Myers, 2013). Local government practitioners voiced that if WSUD was made mandatory in the planning phase of the project, with the support of appropriate guidelines, it would help reduce the internal barriers in the uptake of small scale systems, and as such, this would assist in embedding WSUD at local government practice. Some representatives suggested improving the development assessment process with a series of steps where WSUD is flagged based on the type of development proposal being considered. Practitioners would also like to see recognition of small scale options for WSUD in planning requirements because these are the only available solutions for infill development scenarios (Myers et al 2013).

All groups recognised capacity building as a key priority for furthering the development of WSUD, particularly within local government.

7.6 Barriers to uptake

This section explores the perceptions of the 21 stakeholder organisations interviewed. The barriers mentioned by the stakeholders were classified into common themes and summarised in Table 7-3, which shows the ranking of the barrier based on the number of mentions and the stakeholder groups that specifically mentioned that barrier. The feedback from individual councils was previously described in Myers et al., (2013) and hence will not be used for institutional analysis, but the outcomes will be used for a qualitative comparison.

Table 7-3. Perception of Barriers to WSUD uptake

Rank	**Issue**	**Mentions (% sample) (Total number of responses 21)**	**Mentioned by stakeholder groups**				
			C	**D**	**S**	**L***	**P**
1	Capacity	92.9	■	■	■	■	■
2	Perception of cost-benefit	78.6	■	■	■	■	■
3	Understanding of O&M needs	71.4	■	■	■	■	■
4	Lack of target/benchmarks	57.1	■	■	■	■	■
5	Policy	50	■		■	■	■
6	Developer uptake	42.9			■	■	■
7	Lack of leadership	35.7			■		■
8	Design approach/ Guidelines translation into ground works	35.7	■				■
9	Approval issues	28.6	■	■	■		■
10	Uncertainty in WSUD tailoring to locals conditions	28.6	■	■	■		■
11	Financial resources	28.6	■		■	■	
12	Poor community awareness	28.6	■	■	■	■	■
13	Inadequate construction	21.4	■	■	■	■	■
14	Lack of support to practitioners	21.4	■				■

Legend: Consultants (C) – (n=3), Development industry (D) – (n=5), State government (S) – (n=9), professional organisations (P) – (n=4), and Local government (L).

*only included for comparison, see Myers et al. (2013) for details on local government perceptions.

All stakeholders recognised that multiple barriers affect WSUD uptake as listed below:

- Inadequate understanding of WSUD;
- Capacity limitation issues;
- Uncertainty in operation and maintenance knowledge;
- Lack of understanding of cost-benefit of WSUD and perception of cost;
- Lack of political will;
- Lack of clarity and consistency in legislation and policy;
- Lack of targets/benchmarks;
- Approval process issues;
- Fragmented approach to WSUD implementation; and,
- Poor community awareness and lack of support.

The top three barriers identified were: capacity limitations, lack of understanding of WSUD cost-benefits and inadequate understanding of O&M needs. Each of these barriers was mentioned by more than 71% of respondents (Table 7-3). Inadequate understanding of WSUD and lack of resources were the most commonly identified barriers.

Table 7-4 ranks the priority for self-improvement needs as perceived by individuals belonging to each stakeholder segment. This is based on Alluvium and Kate Black Consulting (2012), in which the responses of professionals were aggregated based on their employment sectors into State Agencies (57), EPA (9), Local government (101), contractors/consultants (50), researchers (10) and NGOs (6). Appendix **G** shows the detailed analysis. Note that developers were not represented in the survey. For example, 64.9% of respondents that work in State agencies consider that improving their knowledge on the monitoring and evaluation of WSUD systems would enable them to better understand WSUD.

Table 7-4. Priority areas for self-improvement by stakeholder group*

Stakeholder group	Priorities (% agreement)
State agencies (n = 57)	1. Monitoring and evaluation (64.9%) 2. Policy (60%)
EPA (n = 9)	1. Engineering design (77.8%) 2. Costings (both capital and operational expenditure) (77.8%) 3. Community engagement (77.8%)
Local government (n = 101)	1. Costings (both capital and operational expenditure) (74.3%) 2. Monitoring and evaluation (73.3%) 3. Landscape design (65%)
Contractors/consultants (n = 50)	1. Costings (both capital and operational expenditure) (72.9%) 2. Regulation and approval (66.0%) 3. Construction (61.2%) and Monitoring and evaluation (61.2%)
Researchers (n = 10)	1. Policy (90%) 2. Engineering design (70%), landscape design (70%) and regulation and approval (70%) 3. Cost (both capital and operational expenditure)(66.7%)
NGOs (n = 6)	1. Landscape design (100%), community engagement (100%), Monitoring and evaluation (100%), working with stakeholders (100%)

*The agreements between responses is shown as percentage of respondents in the sector sample (n%).

7.6.1 Capacity constraints

All stakeholders acknowledged that WSUD in SA is led by individuals and informal professional networks. These groups were perceived as often operating in isolation and faced with a lack of mechanisms and financial resources for knowledge sharing. This results in poor capturing and dissemination of WSUD knowledge. There was also a common recognition that State government agencies had limited capacity due to loss of experienced staff and increasing work load.

The lack of understanding of WSUD was one of the main barriers identified by all stakeholder groups and was perceived as an underlying contributor to many of the other barriers (Box 1). The lack of understanding of WSUD is particularly apparent in:

- Local government: (a) planners can have difficulty in assessing development plans against WSUD objectives, resulting in complex requirements and lengthy development approval processes (UDIA and local government perception); local government often demonstrates a preference for well-known and traditional engineering solutions over WSUD; there can be a lack of inter-departmental consultation by planners with engineers, landscapers and maintenance staff during planning approvals; (b) oversight of practical aspects and maintenance needs and unfamiliarity with maintenance of WSUD by maintenance staff, can result in mistakes in design, implementation and inadequate maintenance after handover; (c) Lack of clear guidance to developers on WSUD objectives, resulting in inconsistent and variable policies and subjective interpretation of policy across councils; as perceived by local government, professional associations, development industry.
- Development industry: (a) inclusion of WSUD plan in late stages of development instead of in the early planning stage; (b) Incorrect interpretation and implementation of WSUD design by contractors (concern from consultants); (c) Preference for least cost solution and lack of understanding of cost of WSUD – perception by local government, State agencies, professional associations. At the same time EPA and DPTI Transport (assessors) have also commented on examples where development applications submitted for comment showed a lack of understanding of WSUD, with WSUD seen as an add-on instead of being integrated into the planning process. However, developers have also often expressed frustration with inadequate/conflicting/unclear requirements from councils.
- State agencies: there is the perception among developers that limited familiarity with WSUD has contributed to a risk adverse position by agencies, in overall planning policy and to conflicting requirements from different assessment agencies. On the other hand, a number of State agencies reported their willingness to provide advice and work collaboratively if consulted during the early stages of development planning.

It was noteworthy that the perception of individuals had of the capacity of their organisation differed from how their capacity was perceived by other stakeholders.

The development industry perceived that the engineering consultancy industry had a good knowledge of WSUD, but saw the major barrier as lack of experience of local government engineers and planners resulting in onerous approval requirements, over-regulation, delays for approval and compliance verification, thus increasing the cost of the development approval process.

On the other hand, the consultants and professional associations acknowledged that even among consultants and engineers the depth of knowledge varies, particularly regarding more complex WSUD projects, and was often linked to the practical experience from individual professionals.

Box 1.

"People need to understand you cannot expect everything out of WSUD – there is often lack of clarity on what WSUD objectives we are trying to achieve." - Practitioner

The local government sector was aware of the disparity of knowledge and constraints within its sector, which depended on the councils' individual staff knowledge, financial resources and priorities. Whilst a number of councils had the desire to improve their WSUD knowledge, there was also recognition that the ability of individual councils to provide the necessary training and education varied. The lack of firm state directives on WSUD and in particular on water quality was seen as a hindrance to councils. State government also signalled that the level of understanding observed in development proposals varied. Even for individuals that had some awareness of WSUD, there were differences in depth of knowledge and the absence of benchmarks or mechanisms to assess the know-how compounds the problem.

The lack of practical experience in WSUD in councils and also in parts of the development industry was seen to contribute to the perception of a high cost for WSUD in developments and the perception of risk/uncertainty in performance associated with WSUD features. However, as commented by LGA SA: "*the uncertainty is likely to decrease as more WSUD projects are developed and the collective experience increases*".

7.6.2 Understanding of O&M needs

One of the consequences of the lack of familiarity with WSUD was the lack of consideration for or misunderstanding of operation and maintenance (O&M) needs for WSUD features. Thus resulting in:

(a) Inadequate consideration for O&M (see Box 2), e.g. no replanting of vegetation or inadequate vegetation maintenance,
(b) Lack of scheduled O&M activities, which impact the WSUD performance, requiring more extensive repairs and feeds the misconception of higher costs or inconvenience, and
(c) The lack of resources allocation for O&M during budgeting in councils or by asset owners.

Box 2.

"The design had failed to consider the space for heavy equipment to access the wetland for sediment removal." - Consultant

Multiple perceptions are held by different groups regarding the O&M of WSUD features, with perceptions ranging from "more expensive than conventional infrastructure", "fear of O&M" and reported "ignorance of the appropriate O&M ". Uncertainty has also been reported among structural engineers regarding the impact and the risk to road infrastructure from infiltration features. Lack of consultation with various disciplines involved in WSUD from design to operation has also been highlighted as a cause of misconceptions in this area.

The perception of a lack of O&M understanding is attributed mostly to local government and was a view shared by the EPA, consultants and the development industry. The development industry mentioned that "*some developers delayed the handover of WSUD features to council for fear of improper O&M by council and deterioration of amenity which might impact sales*".

Consultants have also expressed the need to develop SA specific knowledge to address technical gaps that can impact the design, maintenance and the life of WSUD features:

- Lack of technical data on filter media for biofilter for SA conditions;
- Lack of design/implementation data for SA specific climatic conditions;
- Lack of data on plant species tailored for SA climate and soils for use in WSUD;
- Accounting for saline groundwater and clay soils;
- Lack of MUSIC calibration parameters for SA; and,
- Lack of documentation on the impacts of infiltration devices on traditional road infrastructure and footings.

7.6.3 Perception of WSUD cost-benefit, the business case, O&M and lifecycle costing

The justification of costs and benefits of WSUD through a business case was considered critical for stakeholders to persuade their organisations to adopt WSUD.

In the development industry, the UDIA and the MBA highlighted that showing cost neutrality or proving cost-benefit for development of a business case can validate WSUD and convince their members to invest in WSUD.

Professional organisations and council practitioners also recognised a strong business case as an important tool to promote WSUD to decision-makers and elected officials in government.

Developers, consultants, professionals, state agencies and some of the councils acknowledge that WSUD when implemented properly is cost effective and more sustainable than traditional infrastructure. The MBA SA reported that in industry there are various examples and data on the life costs associated with WSUD, that demonstrate a higher costs of stormwater drainage associated with traditional kerb and pipe infrastructure compared to infiltration systems.

However, stakeholders also reported that a common perception that prevails is that WSUD is "more expensive" or "risky" and that "costs and benefits are poorly characterised". Issues raised include:

- The lack of life cycle cost analysis for WSUD;
- Lack of local information on maintenance requirements and costs given the diversity of WSUD features, particularly for street scale WSUD features;
- Equitable distribution of costs among various stakeholders and gather funds for O&M across council areas given the diversity of features, various costs and feature locations; and,
- Need for consideration of the opportunities and mechanisms to allow the integration and coordination of WSUD across precincts and or across catchments/councils boundaries.

In summary, transparency and availability of data on lifecycle costs for developments would allow better budgeting, resource allocation and planning and would also be a more persuasive tool to assess WSUD value in all sectors. Whilst it is perceived that the cost data may already exist, there is the perception that it is held by individual project owners.

7.6.4 Targets and benchmarks

Consultants, Planning SA, SIA, and development industry organisations were asked to comment on the current WSUD guidelines for SA. The general consensus is that the WSUD guidelines provide a good general overview. However, the two consultants interviewed used the technical guidelines from Victoria and Queensland for their detailed design. Planning SA agreed that the current SA WSUD guidelines were general and that there was a lack of information on how to implement the features. However, consultants and industry associations also believed that the gaps can be addressed by referring to other existing documents and by adapting them to SA requirements. Developers also believed sufficient technical information was available when guidelines and documentation from other States were considered.

The development industry favours performance based guidelines for WSUD. Local government perceived the lack of defined targets and priorities to contribute to the difficulty in WSUD implementation (It has to be noted that the survey of local government was conducted prior to the release of the WSUD policy (November 2013)). The concerns noted included:

- Need for targets or trigger mechanisms in planning. There was a lack of clarity on objectives defined by councils, including nutrient removal, suspended solids, flood, peak flows, water conservation, etc. On November 2013, a State policy specifying targets was released, but the mechanisms for their implementation are still to be developed;
- Uncertainty on WSUD performance;
- Necessity to focus on the assessment of wider catchment and 'big picture solutions" – particularly as more infill will be expected in the future. Considerations include: treatment location, scale and impact, e.g. determining the benefit of treating upstream stormwater versus having treatment downstream; the impact of stormwater diversion on environmental base flows and the cumulative impact of WSUD on the larger catchment.

Defining targets and benchmarks provides consultants, designers and developers greater certainty regarding the objectives they aim to achieve and allows them the flexibility to design a suitable treatment train. Yet consideration needs to be given to the implications to the wider catchment, to ensure that the targets allow enough flexibility for the implementation of optimal sustainable service options.

7.6.5 The role of policy, political will and leadership

Lack of political will and interest in WSUD by decision-makers was signalled as the major cause of inaction in WSUD in SA according to State agencies, professional and development industry organisations. The perception of lack of political will by State and local government is perceived by most stakeholders but varies between stakeholder groups.

Whilst the policy on WSUD provided in principle support for WSUD, it did not provide the necessary guidance on how to interpret policy and legislation in order to implement WSUD on the ground. Local government also wanted stronger support from state policy to legitimise WSUD requirements in local development plans. State agencies and developers also expressed frustration given the long history of initiatives and reports that were not translated into practical on-the ground outcomes.

UDIA perceived an over-emphasis on regulation and under-emphasis on incentive, consumer education, promotion of best practices and benchmarks. The development industry recognised the limitations of adopting self-certification alone to promote WSUD, and acknowledged the role that legislation could have to raise minimum standards. For example UDIA's EnviroDevelopment tool (www.envirodevelopment.com.au) served primarily an education tool being adopted by many of its members, who were following the steps but not paying for the final certification (UDIA personal communication 2013); and the GBCA recognised that most of their sustainability rating tools were adopted by building developers in the commercial sector where certification was seen to add value to the commercial property, but not in the residential sector.

At the same time, the development industry feared the introduction of legislation that was too prescriptive and which constrained the flexibility of developers to determine solutions suited for the specific needs of their developments based on the development characteristics and local context; i.e. the proponent has the onus to demonstrate that the solution will achieve the required objectives. Local government, the DPTI and consultants also agreed that WSUD is better specified in policy than in regulation to allow the uptake of innovation and greater flexibility of adoption, provide adequate support tools to assist implementation.

The Building code rainwater tank minimum size of 1kL was cited as an example of overly prescriptive legislation by the development industry, that did not consider the specific water needs of individual dwellings or the overall sustainability of the measure to the development.

State agencies and professional organisations highlighted that currently there was a vacuum in the WSUD ownership and leadership at State level. Given the legislation and state of affairs, the agencies highlighted that it was important to identify a government agency to lead WSUD. Stakeholders saw DEWNR and DPTI (through the Planning division) as the two most suited agencies to lead WSUD. DEWNR because of their portfolio and expertise, while DPTI was seen as suited to lead WSUD implementation through influencing planning and determining development requirements. However, the Planning division in DPTI perceived that they did not have the depth of knowledge and resources to promote WSUD, but they were willing to support DEWNR. The EPA was also willing to assist DEWNR in aspects related to water quality to the receiving environment. In addition, analysis of the current legislation regarding the powers and duties of various agencies, including councils, in regards to stormwater management has also highlighted the fragmentation of roles, the lack of mechanisms for coordination among various agencies, public and private land holders and also limitations in the powers that are granted to councils which can restrict their ability to implement integrated water cycle principles and WSUD (Kelly 2007, 2008).

7.6.6 Developer uptake of WSUD

Councils and State agencies had a general perception that developers tended not to adopt WSUD as it was not mandatory, with a few exceptions such as Renewal SA and selected developers which were seen as leaders in the field.

The development industry acknowledged that the level of uptake varied among members, but expressed the perception that increasingly the industry was adopting the WSUD philosophy in development design; and perceived local government and selected State agencies to often lack the willingness to collaborate with the industry in the development of innovative approaches (UDIA and MBA SA).

Consultants were seen as able to provide the know-how to increase WSUD uptake in the development industry, but they were perceived by councils to be restricted by the vested interests of the company that hired them in the design of developments. In addition, implementation of WSUD in the commercial, industrial and infill sectors were seen as areas of limited expertise in SA.

See Box 3 for the suggestions from the development industry on how to promote WSUD uptake in the development industry.

Box 3 – Suggestion from developers for improving WSUD uptake

- Consistency and clarity in WSUD guidelines and council requirements.
- Transparency in the approval process for WSUD systems, including a consistent approach from all tiers of government.
- Capacity building across local council departments, including planning approvals. Capacity building should also target civil engineers, as those professionals are responsible for infrastructure design and adhere to legal and ethical principles that guide the profession.
- Link the approval of WSUD systems for a development to a broader local government strategy. One suggestion was for councils to link WSUD requirements to their SMP. Greater freedom for local government to set its Local Development strategy.
- Quantify benefits of WSUD in monetary values. This would enable improved cost benefit comparisons between traditional and WSUD techniques and provide evidence of the actual cost-benefit of WSUD. The benefits to be quantified should also extend to environmental benefits.
- Better dissemination and sharing of WSUD information.
- Firmer action from State planning in terms of targets, but flexibility on the selection of WSUD methods to meet targets.
- Create incentives for developers to adopt WSUD, in lieu of penalties only. Suggestions include:
    - Dispensation: a developer implements certain design features, and gets dispensation in other areas.
    - Collaboration between developer and local government on open space works: e.g. A developer grants a parcel of land to local government and in exchange the local government develops the open space and conducts civil work as per council design and requirements. This would avoid much of the typical back and forth between developer and council that occurs during the design stage.
    - A discount on state or local council fees or taxes to offset additional developer costs of installing a WSUD feature.

7.6.7 Design and implementation

The lack of familiarity with WSUD among contractors in the development industry and councils; and the typical process of development implementation and management, which is characterised by fragmentation of tasks and execution by individual contractors, has contributed to errors in execution of WSUD features, according to the consultants interviewed. The absence of consolidation and consultation with the original designers during project execution contributed to errors in the execution, which has distorted the performance of the WSUD features and created misconceptions about the validity of WSUD

7.7 Discussion

The strategic policy directions in SA water resource management aims to adopt the principles of WSUD for: better resource management, maximisation of multiple benefits, community well-being, environmental protection and enhancement. However, the current policy and legislation for development and planning impedes greater application of WSUD principles.

The current SA planning policy aims to provide guidance and to be non-prescriptive, providing general directions and giving flexibility to local government to tailor policy implementation, (e.g. Planning modules library). Likewise the development of SMP targets at catchment scale, which require the development of strategies by each council or group of councils for incorporation into their relevant development plans, also aims to provide individual councils or groups of councils in a same catchment to have flexibility in the development of their SMPs and infrastructure solutions.

However, the strength of the policy differs according to different WSUD streams, when it comes to facilitating implementation:

- Water conservation – is clearly delineated in the building code with specific targets required at State level, whilst allowing home owners to select the mode of achieving the prescribed water savings;
- Alternative water supplies – have had their requirements tightened and specified, with harmonisation in the National Plumbing code facilitating the implementation process both at State and local level;
- Stormwater management – is handled in a fragmented manner. The legislation has a strong emphasis on control of flood and quantity management through SMP requirements, however less emphasis is placed on water quality and the implementation of stormwater management measures at the local level is not specified. In this area, WSUD would have potential to assist in the integration of both quality and quantity, however the legislation does not demand the follow-up of WSUD principles, nor does it provide clear guidance regarding implementation responsibility and assessment at local level for local government and practitioners. Nor does it address the need for a holistic approach to stormwater management.

The legislation does not explicitly refer to WSUD (except for the planning library), but refers to a range of objectives that are part of WSUD strategies. However they fail to address the integrated nature of the WSUD philosophy.

Policy direction regarding mains demand reduction is clearly outlined in legislation and in supporting codes and standards, such as the Building Code and Plumbing Code. Legislation such as the mandated water targets for new dwellings support the adoption of water efficient fittings and alternative water sources, whilst still granting freedom to builders and other stakeholders on the pathway for selection to achieve those targets. There are defined rules and regulations and institutional roles for approvals and management of recycled water schemes and MAR, however for stormwater management of smaller schemes the legislation is not as clear. For small schemes, such as on a lot or street scale, the responsibility of the property owner or council is to deem to comply with local council regulation and to do no harm in the management of the water resources on their property.

In the absence of a blueprint or another policy instrument, currently the responsibility for translating the State policy into more specific directives for implementation on the ground falls upon local government.

Whilst local government has a high degree of influence and importance when it comes to the implementation of WSUD, the feedback from local government is that:

(a) without a clear or strong state directive, many local councils feel that they lack a clear mandate to enforce WSUD;
(b) a number of local councils also feel that they lack the capacity and know how to properly implement and enforce WSUD requirements (Myers et al., 2013);
(c) There is a general perception that WSUD is more costly and/or more difficult to maintain particularly among local government; and,
(d) The Planning library alone does not facilitate the integration of WSUD into local planning.

There is also recognition that SA soil typology and rainfall conditions can vary markedly and need to be considered in the determination of WSUD objectives and treatment options.

The interviews with stakeholders have shown that there are significant gaps in knowledge and capacity at various levels. This applies particularly to local government, who is expected to be the main implementing agent for WSUD in SA, but given the lack of capacity and resources local government is not always able to push WSUD implementation. Limitations in experience and capacity prevent local councils from incorporating requirements and developing their own targets to incorporate WSUD into their development plans. Hence assistance from State government is required for councils to improve their knowledge and capacity and to change policy into proper implementation codes. The experience from other States, such as VIC, QLD, WA and TAS, has shown the impact of strong state directives, supported though the legislative framework and coordination had on the development of a proper framework for WSUD uptake and its contribution to the education of other stakeholder groups.

However, resources and leadership are also required to enable the capacity development. Among the trappings of current legislation, the fragmented nature of water management across agencies further dissuades the coordination of WSUD. Hence, in the absence of political will, there is the need for an agency to coordinate policy and the WSUD implementation initiative, preferably with support from other agencies, and in addition the enforcement of WSUD. Currently NRM board is developing the capacity building initiative.

Consolidation of information and centralisation of data is also recommended similar to the model of centralised information portals or knowledge hubs adopted in other States to facilitate data access.

7.7.1 The way forward and prioritisation of needs

A number of enablers were identified by stakeholders that can contribute to the advancement of WSUD:

(a) Examples of good WSUD are available in local government and industry, although they are not widely known or disseminated;
(b) A small group of passionate and enthusiastic WSUD practitioners exists across various agencies: local and state government, consultants, academia and development industry;
(c) All stakeholder agencies interviewed expressed the desire to collaborate in improving WSUD uptake, yet they also recognised that achieving such objective will require collaboration between multiple sectors and agencies – including government at all levels, development industry, professionals and researchers and require coordination; and,
(d) The completion of the business case for WSUD Capacity Building (Alluvium and Kate Black Consulting, 2012) and the current implementation of the Capacity building program funded by the AMLR NRMB. The capacity building case report released in December 2012 undertook extensive consultation with major stakeholders and industry organisations to identify capacity building requirements and to develop a business case for WSUD capacity building for the State. Stakeholders were classified based on their level of influence and degree of support for the capacity building business case. The stakeholders who participated in that process included professionals (engineers, landscape architects, planners, asset managers, CEOs, NRM, operations and maintenance personnel, architects, landscapers, NGOs and manufacturers) representing mostly State and local government respondents: State (30.2%), Local government (36.9%), Consultants/contractors

(18.1%), Researchers (4.5%), NGOs (2.1%) and others (7.6%). The sample population had an absence of developers, but 8 people out of 331 respondents were UDIA members.

The priorities identified by stakeholders focus on three major aspects:

(a) Capacity building;
(b) Knowledge sharing and dissemination – particularly for the business case;
(c) Leadership; and,
(d) Policy interpretation and facilitation.

7.7.2 Capacity building implementation strategy

The key priority identified by all stakeholders was *capacity building,* which is required at all levels, but particularly for local government. Hence findings from this report further support the earlier capacity building initiative (Alluvium and Kate Black Consulting, 2012), which will focus on the development and identification of strategies for WSUD capacity building in SA. The AMLR NRM Board is hosting the initiative and should continue to do so.

On the other hand, stakeholders have also highlighted that capacity building alone may not lead to WSUD uptake. Instead investing in capacity building in conjunction with stronger policy or legislation to legitimise the need for WSUD and focused on practical implementation, i.e. environmental objectives or targets based on scientific evidence, would support councils and encourage councils to upgrade their skills. Given that legislation and policy take a few years to be gazetted, the build-up of capacity prior to introduction of the legislation/policy is also required. Caution is also needed to avoid unnecessary and inflexible over-regulation – yet allowing sufficient flexibility for industry to demonstrate how to achieve the pre-determined targets.

7.7.3 Leadership

In the absence of strong political will, and given the fragmented nature of water assets ownership and management and the need for better integration, it is necessary that a State agency assumes the ownership of WSUD policy and coordination to ensure the alignment and interpretation of the various policies relevant to WSUD, but dispersed across multiple sectors (planning, NRM, environment, etc), preferably in collaboration with and support of the other agencies.

The feedback from interviews (with State agencies, local government and professional bodies) identified two agencies, DPTI and DEWNR, as potential leaders for WSUD coordination. However, DPTI Planning has expressed concerns about its current staff resources and limited expertise given its planning mandate and has recommended DEWNR. Hence the suggestion is for DEWNR to coordinate the policy on WSUD, with the support and assistance of the EPA, NRM Boards, DPTI and DHA.

The implementation models from WA, TA, QLD and VIC provide examples of integrated frameworks for WSUD integration into planning.

7.7.4 Improving the business case, O&M and lifecycle costing

Given the current financial resource and funding constraints, and the need to educate politicians, council members, the community, developers and other decision-makers, the development of a business case for WSUD and the gathering of data and tools that can assist in this exercise are of extreme importance.

To decision-makers this means the business case for WSUD implementation. To the community this means linking benefits and externalities from WSUD in catchments to the receiving waters health.

The *Business case for WSUD Capacity-Building* (Alluvium and Kate Black Consulting 2012) highlighted the need and importance of capacity building for the development of WSUD in SA. The business case also mapped the major stakeholders that could contribute to capacity development.

The low hanging fruit of this exercise is to collect existing data, provide wider access to and promote existing case studies, showcase the available developments and features in a format that is readily accessible for key stakeholders. For such purpose, it would be useful to gather information from councils' projects, the development industry; and hence the recommendation is for collaboration among various stakeholders from the private industry, professional and government sector in the data gathering and dissemination process.

7.7.5 Communication, education and collaboration – the role of stakeholders

Finally, to overcome the fragmentation of knowledge and the creation of knowledge silos and to facilitate the dissemination it is important to develop an easily accessible central data repository or hub for housing links to information, news and events to allow greater interaction between stakeholders and to promote cross-sectoral sharing. Similar models can be found in other States, where a central website hub is used to serve as a portal for WSUD contextual information and provides links to relevant websites on policy, legislation, guidelines, technical information, events, professional associations, case studies from the state.

Table 7-5. Needs identified by stakeholder interviews

Need	Suggestions by stakeholders
Training	Provide training to assessors, asset management groups in councils, approvers.
Communication	Improve communication cross-sectoral- partnership
Knowledge sharing	Case studies, Showcases, Cost data Examples of construction, commercial attractiveness, principles to adopt, management strategies, typical situations where some strategies, management/schemes work best, cost effective ways
Understanding WSUD needs and costs	O&M plans prior to construction based on existing site conditions and underground services Develop WSUD targets Develop performance based guidelines and controls
Regulations	Allow flexibility in design and approval process that allows developer to prove it

7.8 Challenges and needs ahead

This report explored some of the implementation challenges for WSUD, including the role of policy and incentives, benefits, challenges and gaps identified by stakeholders in relation to capacity development. These are further supported by previous findings from local government in Myers et al. (2013) and Alluvium and Kate Black Consulting (2012).

Table 7-6. Summary of stakeholder perceptions on WSUD implementation gaps and barriers

Perception of gaps	Perception of needs	Perception of enablers
Limited WSUD exemplars for further learning	Working with stakeholders	
Lack of understanding of costs (Capex and Opex) for WSUD (LCC)	Insufficient budgeted resources for O&M	Potential to adapt BMPs and guidelines from other states to local conditions.
Limited performance monitoring and evaluation data	Need to know if WSUD features work and are cost effective	Data is available, but needs to be assembled.

Lack of knowledge within local government departments regarding WSUD, particularly planners and the other sectors responsible for WSUD implementation and on-going operation (engineering, landscaping).	Less red tape for developers	All stakeholders support capacity building program/investment.
Lack of political will or lack of strong state policy to drive WSUD	More consistent local development controls, with flexibility in development approvals. Not all parties agree with mandated targets and new regulation.	Stakeholders including development industry are willing to collaborate and assist to advance WSUD.
Lack of inter-agency capacity (or frameworks) for collaboration on WSUD	Consolidation of WSUD capacity, information and training to reduce fragmentation and ease cross-collaboration and learning.	
Lack of funding	Any initiative requires financial backing. The State government has not shown willingness to fund implementation.	

Source: Alluvium and Kate Black, 2012

7.9 Summary

A consultation process was established by which key institutional stakeholders shared their views through semi-structured interviews and in addition a web-based survey was established to attempt to gain further insight from selected groups. The key stakeholder groups invited to participate included: State government agencies, local government, consultants and professional associations and development industry organisations.

Analysis of the current legislation on WSUD and the stakeholder map of SA revealed that implementation hinges on the capacity and willingness of local government to adopt WSUD and develop local government policy and strategies that will promote the implementation of WSUD by developers. However, current State legislation addresses singular water cycle streams and functions (water supply, flood management, alternative water supply, discharge to aquifers and receiving waters) separately, whilst WSUD requires the integration of multiple objectives and water functions.

The problem of such approach is that the resources, knowledge base, the needs and capacity of local governments on WSUD vary markedly. Consequently, the pace and extent of translating State policy into local development policy has been slow and markedly variable. In addition, WSUD is not a mainstream engineering practice and hence not all professionals have the level of experience, expertise and confidence to assess the suitability and quality of WSUD projects. Consequently, this also creates uncertainty in the requirements for local development, due to absence of targets that are required (only two councils have stormwater quality targets), approval processes that are lengthy and onerous and thus act as a disincentive to WSUD proponents and the development industry. There is also a general perception that the knowledge generated from existing WSUD projects is not being disseminated more widely across sectors and to the community (with the exception of a few large examples, e.g. Salisbury) due to the lack of coordination and mechanisms.

This is in contrast with the experience in some other States, where State government policy, was further supported by the evolution of supplementary legislation in planning, building codes and auxiliary material to facilitate the implementation of policy and to assist in translation into local applications. Every single jurisdiction with the exception of the Northern Territory and South Australia has a central website that serves as a hub to collate information or provide direction to web links on WSUD relevant legislation, policy, case studies, initiatives and technical materials available at within the State and best practices from other jurisdictions. Good examples are available across Australia of various strategies that can be adopted to assist in the development of capacity and enabling legislation to support uptake, e.g. WA, TAS, VIC, South East Queensland and the ACT. The literature has also shown marked differences in the pace of WSUD uptake by private industry in States that promoted WSUD through legislation and also developed enabling environments to implementation and capacity building, compared to States where WSUD was voluntary. Another lesson is that States that had good uptake also targeted capacity building efforts and education at various societal sectors: local government, development industry and professionals. The examples of WA, TAS, QLD, ACT and VIC showed significant efforts at creating clarity in the interpretation of legislation, e.g. through the targets, local guidelines and their integration into local planning.

The overall perception among stakeholders is that the lack of capacity and the lack of political will to support WSUD are the main barriers to WSUD implementation. These two factors compound the perception of uncertainty associated with WSUD performance across the State.

Whilst all stakeholders groups interviewed perceived WSUD to be beneficial and cost effective if constructed and applied properly they also noted the need for greater dissemination of data and experiences related to previous WSUD projects. This would require more openness from companies to share information on projects.

A number of specific gaps were also highlighted in the process, in particular regarding the need for locally based calibration data and information for design and use with existing modelling tools.

In addition, there was recognition that the community in general had no awareness of the benefits of WSUD and were not necessarily able to associate the health of the receiving waters with strategies within catchments.

All stakeholders were aware of the needs and expressed a willingness to assist in furthering the uptake of WSUD and also a desire for its proper implementation and for greater collaboration between government, development industry, professional organisations and other stakeholders. However, this requires leadership and coordination of the various agencies to proceed towards a more integrated and holistic policy on WSUD. State agencies saw as potential leaders for WSUD DEWNR or DPTI. However, DPTI prefers DEWNR to take on the coordination role.

Stakeholders also suggested the priorities for improving WSUD uptake based on their perception of needs.

The experience from other States shows that capacity development is an area that requires continuous investment and that the capacity development needs will change over time. However, much can be achieved from the lessons from other jurisdictions and from collaboration among the key sectors interested in WSUD in SA.

The key priorities identified were:

- Need for leadership and coordination;
- Support for the capacity building initiative.
- Increased focus on improving the implementation of WSUD, through the development of support mechanisms and adequate resourcing (including funding) for the previously suggested items ;
- Consolidation of existing knowledge, including documentation of cost-benefits of WSUD case studies. A central repository or portal could facilitate access to existing know-how. Consultation with key technical agencies/organisations on how to bring this together; and
- Strengthen current WSUD guidelines by adopting references to guidelines and other material already available in different States. Consultation with Planning SA, SIA and key practitioners and industry for assistance.

Part IV Post-implementation assessment of selected WSUD developments

8 Post implementation assessment - Developments with WSUD features in South Australia

8.1 Introduction

Seven of the WSUD sites identified through the inventory of WSUD sites in SA (Myers et al., 2013) were selected for detailed post-implementation assessment. The detailed post-implementation assessment, summarised in this section was undertaken to obtain a greater understanding of the impediments that have been faced in implementing WSUD systems in the South Australian context.

Table 8-1 provides an outline of the sites that were selected, which was finalised in consultation with the Project Reference Group formed for this project. Table 2-1 provides the criteria that were used to select these WSUD developments, while Figure 8-1 shows the location of the WSUD sites across Greater Adelaide.

The detailed post implementation assessment of case studies can be found in **Appendix J**. This Appendix includes the technical details of the assessment, including modelling studies undertaken and the references used to understand the case studies. This section presents a summary that highlights the key impediments faced in implementing the WSUD approaches and the potential implications for the greater adoption of WSUD in South Australia.

Table 8-1. List of sites for detailed investigation

Site details	Council	Rainfall zone (mm)	Year of construction	WSUD feature	Reason for selection
City of Burn side 'B-pods'	City of Burnside	600-800	ongoing	Infiltration(OSR pods)	An innovative simple and cost effective technology, developed in house for flow management.
Harbrow Grove Reserve	City of Marion	400-600	2011	Flow, reuse, pond	Availability of data
Mile End-Streetscape	City of West Torrens	400-600	2012	Bio-retention	Numerous street scale systems and data available
Mawson Lakes	City of Salisbury	400-600	ongoing	Reuse (ASR+WW)	One of the major water management projects in South Australia with post maintenance issues.
Christie Walk	Adelaide City Council	400-600	2006	Stormwater harvesting and reuse and green-roof	Demonstration of WSUD implementation at high-density Brownfield residential development
Lochiel Park	Campbell town	400-600	2013	Bio retention, wetland ASR	Infill development. Good example for the issues with post implementation of WSUD features
Springbank Waters	City of Salisbury	400-600	2007	ASR	Part of the larger Salisbury stormwater harvesting scheme

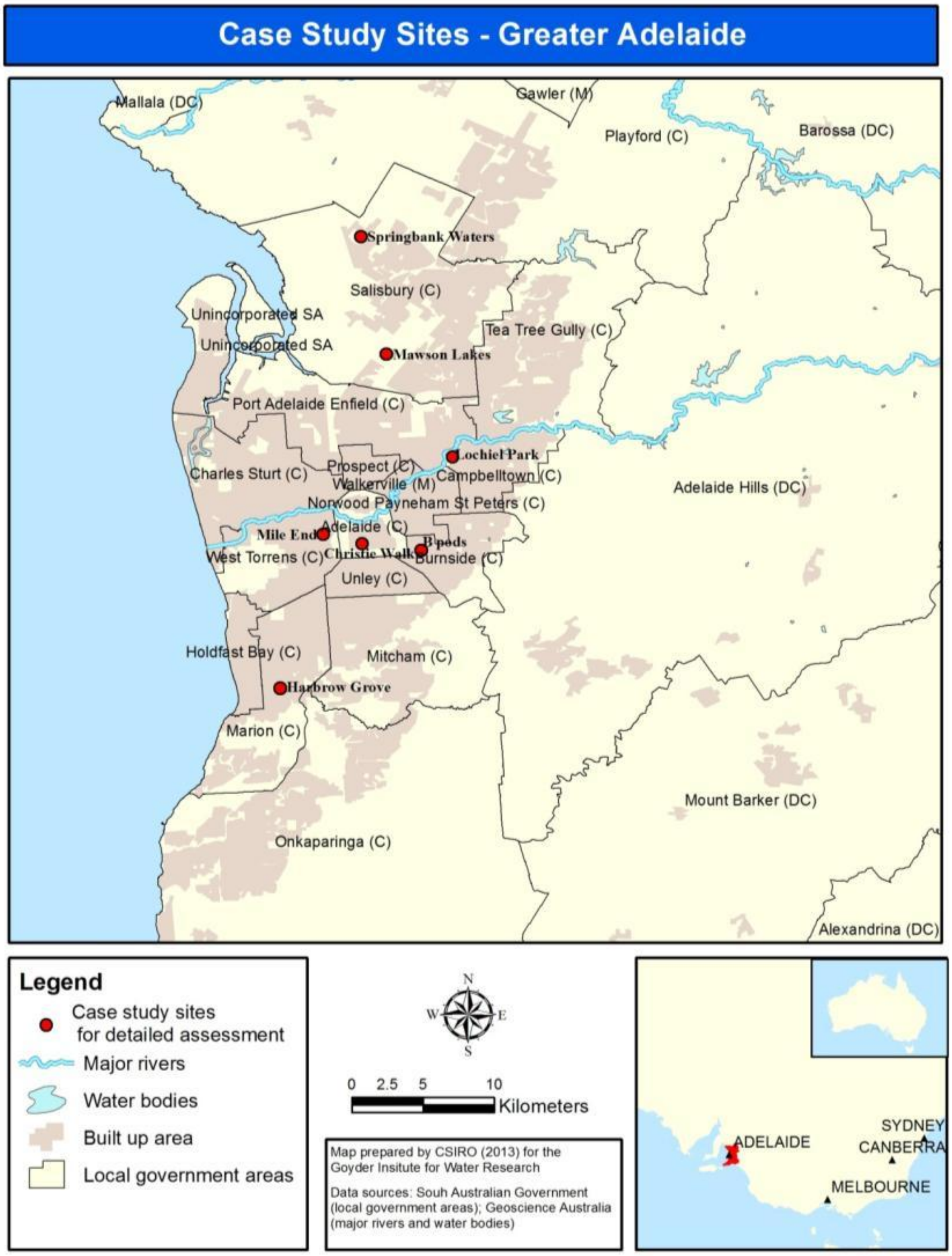


Figure 8-1. Location sites selected for WSUD post-implementation assessment

8.2 Burnside pods (B-pods)

8.2.1 Overview

B-pods are small detention systems developed by the City of Burnside with the aim of developing an alternative water management strategy for maintaining the tree health within the council. The adoption of the B-pods was driven by the need to protect the health of newly planted street trees, while reducing the costs and water demand associated with the council's tree watering program.

The system was designed to act as a source control device and capture the first flush of roof runoff following a rainfall event. The installation of the B-pods took advantage of routine road and drainage upgrading works, which reduced the costs of civil works.

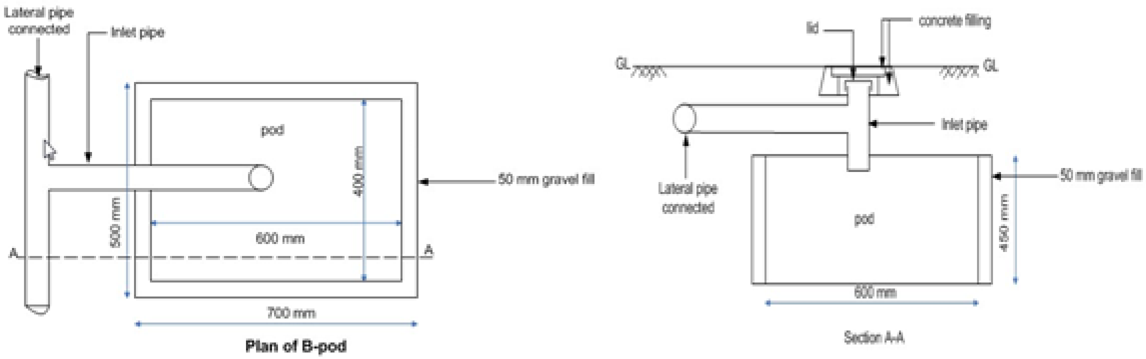


Figure 8-2- Plan and cross-section of B-pod

The B-pod system consists of downpipes that convey roof runoff to the pods via a series of lateral pipes. The pods are small plastic crates with concrete lining and a lid under the grassed area of the kerb) near the younger trees (Figure 8-2). Currently the council has established nearly 150 pods along six streets in Burnside.

8.2.2 Main impediments faced in WSUD implementation

There is a lack of onsite monitoring data that validates the performance of the B-pods on stormwater runoff reduction and stormwater quality improvement. This lack of data also limited the validation of a MUSIC model simulation of B-pods, which was undertaken for this project. However, despite the limited data the simulation results indicated the unsuitability of B-pod systems as flow management devices in heavy clayey soils, which are predominant in Burnside council. The MUSIC model results did indicate the effectiveness of the B-pods as a passive irrigation system. More details of the modelling undertaken for the B-pods can be found in **Appendix J.**

8.2.3 Successful aspects of WSUD implementation

The B-pods were implemented as part of strategy to ensure the health of recently planted street trees in the council. Anecdotal evidence suggests that the young trees have thrived during hot and dry periods, when compared to the street trees that do not have the B-pods installed near them. The project has also assisted the council to reduce the costs associated with the existing tree watering program.

8.2.4 Implications for the greater uptake of WSUD in SA

The exfiltration rate simulation of B-pods using MUSIC indicated the suitability of such systems as flow retention units, where soil properties allow infiltration to occur. This suggests that the B-pods could be an effective flow management device in some of the coastal councils where sandy soils are more prevalent.

Greater uptake of devices like the B-Pods in South Australia requires validation of their performance in different contexts as a WSUD measure. The assessment of the B-pods, based on modelled simulations, indicated that they can provide useful approach to passively irrigate street trees. However, there is some uncertainty about their impact on managing the quantity and quality of urban runoff. This knowledge gap could be addressed through monitoring studies, which would then enable improved model calibration to understand the potential significance of greater implementation of B-pods in managing stormwater in an urban catchment.

8.3 Harbrow Grove Reserve

8.3.1 Overview

Harbrow Grove Reserve in the City of Marion which was redeveloped in 2011 as part of the council's 'Open space and recreation strategy'. The purpose of the redevelopment of the reserve at Harbrow Grove was to alleviate risk of local flooding, reduce mains water usage for open space irrigation, and to provide a green space that would enhance the amenity of the area and provide for community recreation. The multifunctional WSUD system implemented at Harbrow Grove consisted of a swale, sedimentation pond, bioretention basin, detention basins and an underground rain water tank for storing the treated runoff (Figure 8-3). These features were incorporated into the landscaping of the reserve, which included an ornamental pond that was to receive top-up from the rainwater vault.

Phase 1 and 2 of the project received an open space grant from the South Australian Government. This provided financial assistance to the City of Marion, to plan and develop the Reserve. The project commenced in the 2009 and was completed in 2011. The total cost of the project was estimated to be about $ 1.1 Million.

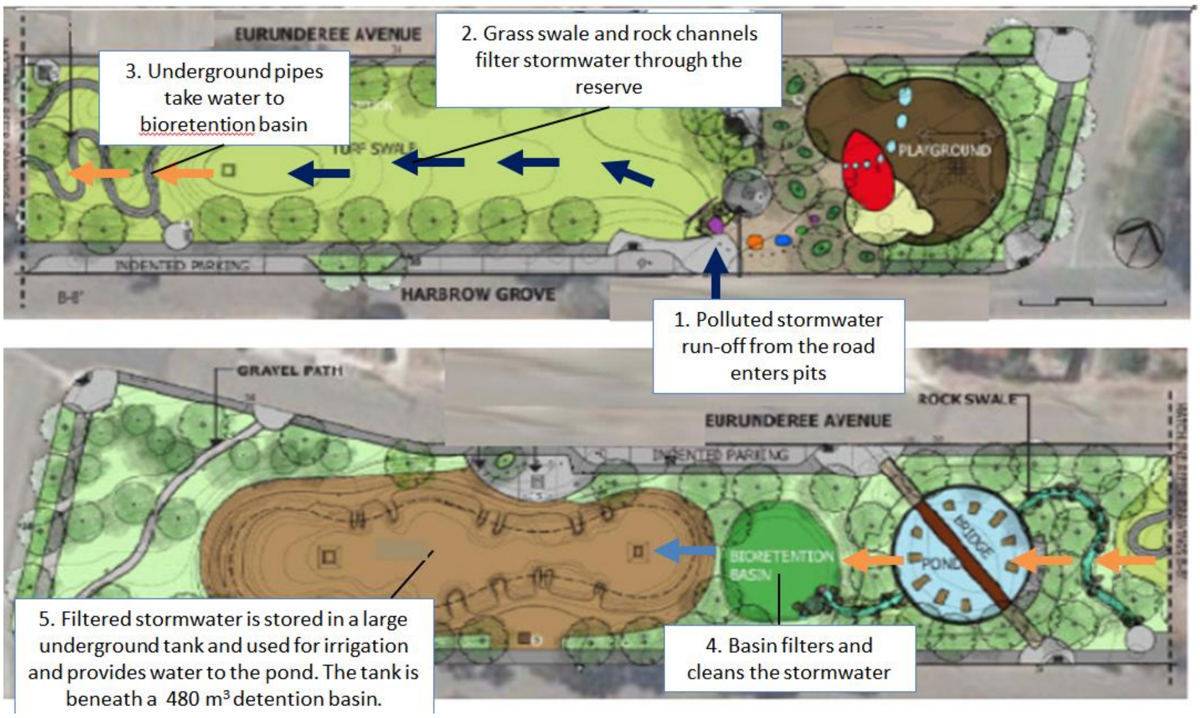


Figure 8-3- WSUD elements at Harbrow Grove Reserve

Source: City of Marion (2009)

8.3.2 Main impediments faced in WSUD implementation

There were problems faced in the commissioning of the WSUD system at Harbrow Grove. The main problem faced was that the ornamental pond installed as part of the WSUD system leaked. It was thought that this was due to poor installation by the contractor, who may have been unfamiliar with the installation of WSUD systems. This highlights the need for effective collaboration between the designer of the system and the different contractors involved in constructing a WSUD system. The maintenance costs associated with the WSUD features was initially considered an impediment by the local council. This was because regular tasks required to maintain the WSUD system at Harbrow Grove were not adequately funded. This impediment is being addressed by the City of Marion by developing an understanding of the life cycle costs of small scale WSUD systems, such as Harbrow Grove, and then ensuring these costs are incorporated in the long term financial plan. Detailed analysis of Harbrow Grove WSUD initiatives can be found in **Appendix J.**

8.3.3 Successful aspects of WSUD implementation

Harbrow Grove Reserve provides a good example of how a WSUD scheme can be incorporated into the redevelopment of a small public reserve. The Harbrow Grove WSUD system effectively manages the quality of stormwater runoff from the neighbouring urban catchment, while also providing an alternative water source for irrigating the reserve that reduces mains water use. The greening and landscape features associated with the WSUD system have also improved the amenity of the local area and provide for recreation. The project has helped the council to devise a whole life cycle cost analysis for managing such small scale systems, which enables these costs to be included in the council's long term financial plan.

8.3.4 Implications for the greater uptake of WSUD in SA

The problem faced in the construction of the WSUD features at Harbrow Grove has demonstrated the importance for capacity building in the sector, particularly for contractors who may not be familiar with these approaches. A possible control is to ensure that one expert maintains oversight of the WSUD system through the development process. This expert input would not only cover the construction phase, but would also be important in the initial stages of operation to ensure there is an understanding of required maintenance, and to help to assist in designing a suitable maintenance schedule and management entity.

The problems faced in the commissioning of the ornamental pond, where it was leaking, led to community complaints. Ornamental ponds in the South Australian climate require top-up to maintain water levels during the dry summer months, and also can face water quality issues due to pest infestation, such as carp, and algal blooms due to high nutrient levels. This raises the question of are ornamental ponds aligned with principles of WSUD? There may be the need to develop community understanding and acceptance of WSUD features that seasonally dry-out.

8.4 Mile End Raingardens

8.4.1 Overview

The City of West Torrens identified opportunities to incrementally improve their streetscapes and manage the stormwater runoff by retrofitting raingarden systems (Figure 8-4) opportunistically along road verges during civil work constructions associated with road and drainage systems. The council has installed more than 90 individual raingardens over the last four years which have been designed to collect, store and treat the stormwater runoff from lots and streets. The raingarden design consisted of a shallow trench with a vegetation zone, a filter media and permanent water well beneath to support the vegetation.

Figure 8-4- Rain-garden system at Mile End

8.4.2 Main impediments faced in WSUD implementation

There was uncertainty in the selection of the appropriate plant species for these rain-gardens, which needed to be resilient to the local conditions while also providing for optimal treatment performance. This is an area that requires further research in the South Australian context. Clogging of the inlet from leaf litter often impedes the growth of rain-garden shrubs located near street trees. There was a lack of any monitoring data that limited the project team from validating the simulation results obtained for the rain-gardens. The need for routine maintenance of the rain-garden vegetation , regular replacement of the top soil to avoid the clogging issues, difficulty in quantifying direct economic returns and the perceived maintenance burden on the local councils are the dominant factors that are locally impeding the wide spread adoption of raingardens .

8.4.3 Successful aspects of WSUD implementation

The flexible and the generic design and construction aspects of the rain-gardens helped the contractors in familiarising and effectively transferring the key features on to the ground. The installation of rain gardens has helped the council to assess the overall costs which assisted them to develop budgets for similar proposals. The local council and the community perceive that the rain-gardens have alleviated the flooding issues to some extent.

The conceptual performance of the Mile End Raingardens was analysed using MUSIC software. Details of the modelling study undertaken for six Raingardens can be found in **Appendix J**. In summary, this modelling indicated that the Raingardens would only have a very marginal impact on annual flow volumes, but could reduce the loads of total suspended solids (TSS) by 90% and total phosphorous and total nitrogen by 30% and 55% respectively. However, these modelling results are not validated with field monitoring studies on actual performance of the Raingardens. The reduction in TSS loads indicates the likely efficiency of these raingardens in capturing sediment. However, this also highlights the need to undertake regular maintenance to prevent clogging from the sediments. It was found that MUSIC was unable to accurately estimate the impact of the raingardens on peak stormwater flows from the catchment. There is the need identify an appropriate model to estimate the impact of the raingardens on peak stormwater flows.

8.4.4 Implications for the greater uptake of WSUD in SA

Retrofitting WSUD approaches to established urban areas is a significant challenge, so the completion of the raingarden scheme at Mile End (up to 40 % of the rain-gardens have already been installed) can provide a valuable example to other local governments, both in South Australia and nationally, on approaches to retrofit WSUD into existing developments as well as integrating such source control mechanisms into the wider built environment.

There is the need for greater validation of raingardens through monitoring and modelling studies. This information is important to understand their treatment efficiency to improve local water quality, and to develop knowledge of design parameters such as vegetation type and soils on performance in the South Australian context. There is also the need for assessment of in-flow and outflow rate and quantity during rainfall events to determine the potential impact on peak flows for a catchment retrofitted with raingardens.

8.5 Mawson Lakes

8.5.1 Overview

Mawson Lakes is a mixed urban residential and commercial development, in the City of Salisbury, characterised by distinctive water features like wetlands and ornamental Lakes (Figure 8-5) as well as large areas of irrigated open space. The development houses a resident population of nearly 10,000 people. WSUD was implemented in Mawson Lakes with the reticulated supply of recycled water for non-potable demands, and WSUD landscape features (lakes and open spaces).

The local runoff from the development is diverted to the Greenfields wetlands to the west. Prior to the entry into the wetlands the runoff is pre-treated by passing it through a series of upstream GPTs allowing for the removal of suspended solids, litter and oil. The cleansed runoff is injected into the MAR scheme in the Greenfields wetlands (brackish in nature) which is used to generate 'injection credits' in the brackish T1 aquifer. Some of these credits are used for extraction of T1 ground water from bores at Mawson Lakes for topping up the ornamental lakes.

Parafield ASR scheme, upstream of Mawson Lakes, harvests low salinity water, which is used for storage and extraction in T2 aquifer. Highly saline treated wastewater from Bolivar is diverted to the Greenfields mixing tank where it is mixed with Parafield ASR scheme harvested water to mitigate the salinity impacts prior to supply to Mawson Lakes. The T1 and T2 aquifers are both confined, so they are not directly recharged from rainfall at Mawson Lakes. The main source of recharge is the Mount Lofty Ranges, where rainfall events recharge the fractured rock system (Department of Environment, Water and Natural Resources, 2012). However, groundwater levels may decline in dry years due to increased pumping for irrigation. Therefore, MAR can be used as one approach to ensure sustainable yields from groundwater reserves.

Figure 8-5. Ornamental Lake in Mawson Lakes Boulevard

8.5.2 Main impediments faced in WSUD implementation

Mawson Lakes was one of the first large-scale developments to implement a dual reticulation water supply system with potable and non-potable supply. This meant there were barriers faced in the initial stages of the development due to the lack of knowledge of contractors on dual pipe systems. These barriers were overcome by initiatives such as 'green star plumbers' who are accredited for working with alternative water systems. Also, homeowners were not familiar with recycled water use, which led to inappropriate uses, such as the filling of pools. These implementation issues have now largely been addressed through education programs to develop community awareness of appropriate use of recycled water.

It was initially envisioned that Mawson Lakes would have onsite wastewater treatment and recycling. The existing infrastructure with spare capacity (sewer network connecting the development and the proximity of the Bolivar Treatment Plant) and the costs involved in installing a treatment facility meant the initial plan for onsite treatment and reuse of wastewater was not feasible. The reclaimed wastewater from Bolivar WWTP was mixed with recycled stormwater (Parafield Wetlands ASR system) to reduce the salinity of reclaimed wastewater to be further pumped into the purple pipe network.

A review of water billing data for Mawson Lakes revealed that households use significantly more water than other households in Adelaide when the demand for mains water is combined with recycled water (See: **Appendix J**). The reasons for this require further clarification, but it could be due to the fact that the use of recycled water is not restricted during droughts, while other households in Adelaide faced restrictions during the drought. However, it does highlight that assumptions around the mains water savings to be achieved from the implementation of an alternative water source could be overstated if this leads to more profligate use of water.

There have been issues associated with the costs of regularly removing sediments from wetlands. The council has developed an extensive upstream treatment train methodology. The council emphasise bank stabilisation options incorporating soft engineering concepts like vegetated banks which reduce the rate of sediment erosion into the water ways. However, it was noted by the council that there is a lack of adequate maintenance guidelines for green infrastructures, which increase the difficulty in effectively managing and maintaining these WSUD features.

8.5.3 Successful aspects of WSUD implementation

The Mawson Lakes development led the way in the provision of dual pipe water supply, with homes being plumbed for both potable and non-potable water supply. The recycled water scheme has provided insights to the industry on the appropriate risk controls for recycled water schemes, and has also developed community acceptance of recycled water supply. The supply of recycled water to the home is now a relatively common servicing approach in large-scale greenfield developments in Australian cities.

The landscape amenity of the water features and green public open space at Mawson Lakes is also be viewed as a successful aspect by the local community. In particular, the recycled water supply allows for this greening of the landscape, which is particularly noticeable in the drier summer months when compared to public open space in other suburbs of northern Adelaide.

8.5.4 Implications for the greater uptake of WSUD in SA

The Mawson Lakes development may have initiated a trend among the developers in South Australia for increased acceptance of 'ornamental lakes' in greenfield developments. However, these water features come with a long term maintenance burden as well as additional water demand to maintain a minimum water level in the lakes during drier months. This can bring in to question the sustainability of ornamental lakes in a climate such as Adelaide with dry summers, and the alignment of these approaches with the principles of WSUD. The high overall water demand at Mawson Lakes indicates the need to take an integrated approach for encouraging more sustainable water use through WSUD. This approach may require both supply side measures, such as provision of a local non-potable water supply, but may also need to encourage demand side measures. These demand side measures could include efficient appliances and fittings, and low water intensity landscaping, but perhaps even more importantly could include education and engagement aimed at encouraging behavioural change for more efficient water use.

8.6 Christie Walk

8.6.1 Overview

Christie Walk is a brownfield medium density residential development, located in Adelaide's central business district. The development was initiated in 1999 and completed in 2006. The development is situated on a 2,000 m^2 lot, which was formerly used as waste recycling depot and now contains 27 dwellings of varying types that house a population of 44 people. Christie Walk was designed and is now managed to demonstrate a sustainable approach to inner city, high-density, urban development. The water supply, wastewater and stormwater services at Christie Walk were designed to be water efficient, minimise environmental impacts, and enhance the local ecological processes and liveability of the development. In terms of WSUD initiatives the particular innovations explored at Christie Walk were:

- A green roof to provide amenity to residents as well as benefits to managing stormwater quality and quantity;
- A scheme to harvest stormwater and roof runoff, which is then reticulated back to residents for non-potable applications; and,
- Onsite wastewater treatment and recycling, which did not proceed.

8.6.2 Main impediments faced in WSUD implementation

In the case of the green roof there was uncertainty in the quality of the exfiltrating water. This uncertainly in water quality means that water in excess of evapo-transpiration rates and soil water holding capacity is discharged to sub-surface soakage instead of contributing to the stormwater harvesting scheme. The uncertainty in the quality of green roof runoff highlights the need to validate the likely quality and quantity of water being discharged from green roofs.

The initial implementation of the stormwater/rainwater harvesting scheme was later found to be faulty in that all of the downpipes were not connected to collection and storages. This was discovered during a post-implementation assessment by resident committees and meant that the not all potentially harvestable water was being captured. This may have been due to building and plumbing contractors not being familiar with these systems at the time, as water harvesting schemes have become more common over the last 6 years the skills and experience for implementing such systems is likely to have improved, but it does highlight the need for project designers and planners to have an ongoing involvement in the construction to ensure design intent is achieved. It also raises the need for post-implementation validation of WSUD schemes.

The difficulty of realising the onsite wastewater scheme at Christie Walk highlighted the challenges of commissioning these decentralised approaches to water recycling. The main challenge faced at Christie Walk was cost. Small-scale onsite wastewater treatment and recycling for urban infill developments are potentially costly and just as importantly impose a management and operating complexity that might not be justified by the reduced mains water demand. These management costs and complexity may be appropriate for larger scale schemes that have the oversight and direct involvement of local authorities and service a large number of households, but it may be difficult at smaller schemes that do not necessarily have access to the required skills needed to maintain and operate these schemes appropriately.

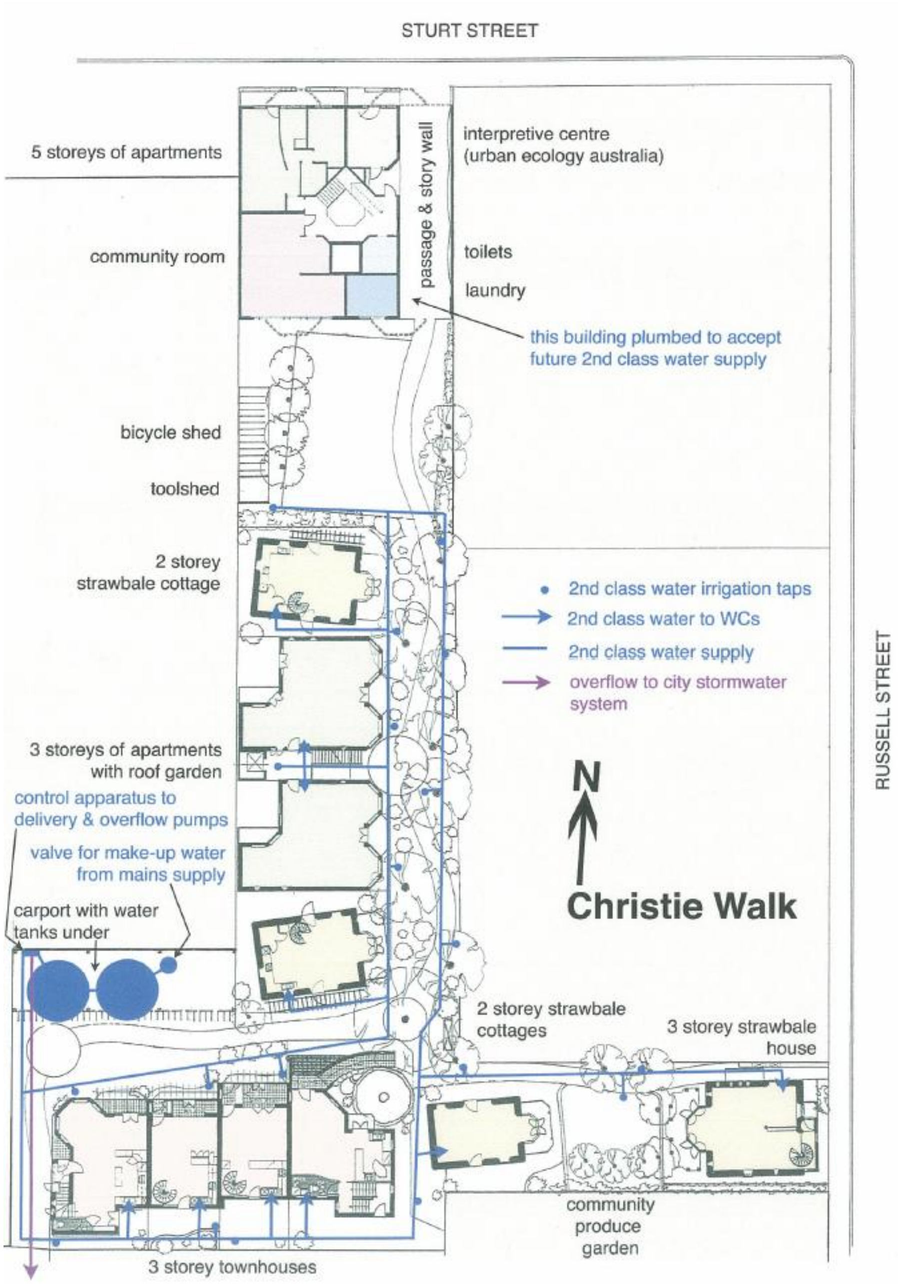


Figure 8-6: Christie Walk development

Source: Provided by - Christie Walk Community (2013)

8.6.3 Successful aspects of WSUD implementation

The analysis of the stormwater harvesting scheme at Christie Walk showed that the communal stormwater harvesting and reuse for meeting non-potable demand, in combination with water efficiency, has reduced mains water demand at Christie Walk by around 55% when compared to similar households in South Australia. In addition the capture and use of stormwater has significantly improved the retention of onsite stormwater. A modelling study was undertaken to determine the likely performance of the stormwater/rainwater harvesting scheme in reducing mains water demand and annual stormwater flows from the site (See **Appendix J** for details). This study estimated that the scheme could meet around two thirds of the demand for toilet flushing and garden irrigation, with the rest of the demand meet by mains water. The analysis showed that reliability could be improved through larger storage at Christie Walk, but that a decrease in the catchment area would only have a marginal impact on yield. The use of increased storage size in similar high density urban infill developments would need to be considered in respect to the feasibility given limited space and costs associated with putting storages underground.

The success of WSUD elements at Christie Walk have been due to the strong vision and commitment from the original project designers to delivering a sustainable high density urban development. This meant that the original design was progressive in exploring all feasible options to deliver sustainability objectives. The ongoing success has been due to the motivation and engagement of residents to participate in the community management of the development. In considering the broader applicability of a WSUD approach, such as that demonstrated by Christie Walk, to other urban infill developments in Greater Adelaide there is the need to consider if these approaches could be adopted as a mainstream development practice.

8.6.4 Implications for the greater uptake of WSUD in SA

The planning and implementation process for Christie Walk was atypical in that the purpose for the development was to push the boundaries of what could be achieved in terms of sustainable development for high density urban living. This meant that the development cooperative was willing to consider options that were not mainstream practice at the time, or even covered by the regulatory framework. The purpose of the Christie Walk development has implications when considering the potential for replicating the WSUD approaches more widely in urban infill developments across South Australia. The review has highlighted the need for further monitoring and validation of the WSUD measures implemented. This information is needed to understand the expected impact of stormwater harvesting on quality and quantity of runoff, and also the expected reliability as a non-potable water supply. This knowledge would help to inform the development of improved guidelines and provide the development sector with the evidence base that can be used to build more mainstream acceptance of the need to invest in these WSUD approaches.

8.7 Lochiel Park

8.7.1 Overview

Lochiel Park is a residential development on a 15 hectare site, which is located 8 kilometres from the Adelaide CBD. The master-planned development was designed to showcase sustainable living for medium-density urban development. The development had the specific goal of reducing mains water use by 80% when compared to the average for Adelaide households. To achieve this objective a range of initiatives have been implemented (See Appendix **J** for more details), which included:

- Demand management;
- Rainwater tanks for hot water supply; and,
- The use of harvested stormwater and ASR for non-potable uses.

Also, runoff from Lochiel Park is directed through streetscape bioretention systems. Bioretention pits and swales are used at Lochiel Park to both treat stormwater before it reaches the wetland, and also to provide a landscape feature.

A unique feature of Lochiel Park, when compared to other urban developments that are designed with WSUD approaches, is that there will be a focus on ongoing monitoring and evaluation to determine the actual performance. The comparison of performance in the field with that of estimated during conceptual design will provide a valuable knowledge base to refine WSUD design guidelines.

Figure 8-7. Lochiel Park streetscape

8.7.2 Main impediments faced in WSUD implementation

A problem faced in the delivery of WSUD at Lochiel Park was the installation of the Gross Pollutant Trap (GPT) was initially defective. The contractor responsible for the installation of the GPT did not align the inlet pipe correctly. This problem meant that there was a delay in Campbelltown City Council assuming responsibility for the GPT, as they needed to be satisfied the system was operating to specification. The harvested water is not yet being injected to the aquifer, which means the non-potable reticulation network is using mains drinking water supply at present. Also, there was some uncertainly on the fate of water to be injected to the aquifer as part of the ASR scheme, as the aquifer is a fractured rock. However, groundwater testing found that the Recovery Efficiency (the volume of the extracted water which is suitable for the intended use, expressed as a % of the water injected) was 55% (Australian Groundwater Technologies, 2006). At the time this review was finalised (September 2014) the GPT was operating to specification.

However, the system is about commence 12 months of validation to more accurately understand the likely sustainable yields from the ASR scheme. This includes more accurately understanding likely losses from the wetlands, including potential seepage losses, and also the recovery efficiency of water injected into the fractured rock aquifer.

8.7.3 Successful aspects of WSUD implementation

Lochiel Park has taken a comprehensive approach to achieving a more sustainable approach to urban development. In the case of water systems this has included both demand and supply side measures. A novel aspect of Lochiel Park is that households have in-home monitors that provide real-time feedback on water use and energy demand.

A review by Carrard et al. (2008) estimated that residents would use on average 75% less mains potable water supply than an average Adelaide household, when the recycled water scheme is operational. This was mostly as a result of replacing mains water with recycled stormwater for all non-potable uses. Also, the water bills for Lochiel Park residents are expected to be around 40% lower than the average for Adelaide homes, which was mostly attributed to demand management strategies, such as water efficient fittings and appliances. Appendix **J** contains more detailed assessment of Lochiel Park's WSUD initiatives.

8.7.4 Implications for the greater uptake of WSUD in SA

The problems faced in the commissioning of the GPT highlight the potential role for an overseeing organisation that can coordinate input from different consultancies to ensure the design intent is realised in the construction. Garnaut (2008) highlighted that a development such as Lochiel Park provides leadership to the development and construction industries on practical ways to deliver more ecologically sustainable developments. Also, the monitoring at Lochiel Park will provide an incubator for research that can assist in setting targets and guidelines for WSUD development, which will move urban development in South Australia beyond a business-as-usual approach (Garnaut, 2008).

8.8 Springbank Waters

8.8.1 Overview

The Springbank Waters residential development is located in the northern Adelaide suburb of Burton. The greenfield development is part of Adelaide's northern growth corridor in the City of Salisbury. Springbank Waters was developed in 2007 and is now largely completed.

Springbank Waters is located near the Kaurna Wetland, which forms part of the City of Salisbury stormwater harvesting scheme. Specifically, the Kaurna Wetland is part of the Helps Road Urban Stormwater Harvesting System. This system is a component of the Integrated Water Cycle Management Plan for the City of Salisbury, which includes the Salisbury Stormwater Harvesting Project. This project was initiated to deliver both environmental improvements and to provide a sustainable source of recycled water for non-potable uses in the community.

The stormwater harvesting scheme, which services public open space at Springbank Waters with non-potable water supply, was designed to achieve the following objectives:

- Reduce dependence on mains water;
- Enhance the amenity of public open space;
- Reduce the downstream environmental impact of stormwater discharge; and,
- Provide opportunity for increased harvesting of water for the Salisbury Stormwater Harvesting (SSH) Project.

Figure 8-8. Inlet to water pond at Springbank Waters

8.8.2 Main impediments faced in WSUD implementation

Discussions with stakeholders revealed there have been some problems with maintenance costs associated with the regular removal of sediments in the wetlands and ponds. There have been difficulties in securing the operational budget to effectively manage the wetland, particularly for the regular de-silting of the ponds. While, securing the capital investment needed for the scheme was often made possible by the availability of Federal and State government funding programs there is less certainty in how to secure the significant operational budget needed to adequately maintain the systems.

There is also community and political pressure to maintain water levels in Springbank Waters ponds and wetlands that would naturally dry up during the drier months. It is thought that not letting the ponds dry out can result in water quality issues due to wetlands turning anoxic and the proliferation of pest species such as carp. This issue highlights the tension when WSUD systems are managed for what can be competing objectives, which in the case of Springbank Waters where objectives included landscape amenity, water harvesting, flood mitigation and improvement in the quality of runoff.

The use of harvested water from the ASR scheme at Springbank Waters is limited to the irrigation of the school and public open space, with no reticulated supply to households for non-potable uses. Springbank Waters was developed prior to legislation required developers to provide an alternative water source, with individual rainwater tanks being the most commonly adopted source. However, it's likely for a development proximal to a recycled water scheme mains that servicing the development with a non-potable reticulation network may be more economical for a developer than installing a rainwater tank system at each household. Paton *et al.* (2014) compared water supply augmentation options (desalination, stormwater and rainwater) for a case study in southern Adelaide on the basis of discounted costs and supply security. This study found that rainwater was not the preferred option due to being too expensive compared with other augmentation options. A more detailed description of the Salisbury Scheme and Springbank Waters is contained in Appendix **J.**

8.8.3 Successful aspects of WSUD implementation

Springbank Waters has used stormwater harvested via the ASR scheme to reduce mains water demand for public open space irrigation. This irrigation, along with the WSUD landscape features such as ponds and wetlands, have enhanced the amenity of the development relative to similar developments in northern Adelaide.

8.8.4 Implications for the greater uptake of WSUD in SA

The Salisbury stormwater harvesting scheme was made possible due to the availability of land and the existence of drainage management features, such as wetlands and detention basins. The potential for this type of scheme in other areas of Greater Adelaide may be limited. At Springbank Waters the recycled water scheme has not been plumbed to the homes for non-potable uses, which has restricted the potential demand for the stormwater harvested in the ASR scheme. In future WSUD developments the objective of reducing mains water demand should be considered on a site specific basis that identifies the least cost option, while also reflecting stormwater management objectives and community acceptability. In developments such as Springbank Waters with proximity to a wetlands and ASR scheme it may be more efficient to reticulate a non-potable water supply than fit every household with a rainwater system.

8.9 Summary

A common finding from the case study assessments was that often there is a lack of a clear technical and economic justification for the implementation of the WSUD systems. This lack of a clear justification was in part due to the paucity of monitoring data that was available to actually ascertain the performance of the WSUD systems against their postulated objectives. A notable exception is Lochiel Park, where the sustainability features, including the rainwater supply and recycled water systems, are being comprehensively monitored. In cases such as Mile-end and the B-pods the implementation was seen as a way to improve the streetscapes through passive irrigation and improve amenity. The opportunistic installation of these types of WSUD features could be considered as 'no regret' option in that the actual contribution to improved management of stormwater quality and quantity is not yet known but they are still seen to deliver other important benefits. To encourage mainstream adoption of WSUD by local governments and developers requires a clear business case that identifies the net benefits of the scheme. There is the need to greater monitoring and validation of different WSUD approaches in a range of South Australian settings (climate, soil type, etc.). Knowledge gaps identified in the post-implementation assessment included: uncertainty of ongoing maintenance costs, impact of WSUD systems on stormwater quality and quantity, impact on environmental impact on local ecosystems and downstream receiving waters.

The burden of ongoing maintenance costs was highlighted by stakeholders as an impediment for greater adoption of WSUD systems. It was found that many of the systems implemented were partially funded through programs that provided the funds for investment in capital. In securing these funds there is also the need to consider the ongoing budget required to adequately manage and maintain these systems. The need to drain and de-silt wetlands was particularly highlighted as a maintenance item that needs to be accounted for in strategic setting of operational budgets.

Another common aspect to emerge from the review was that implementation issues were often the result of contractor oversight. These mistakes may have resulted contractors not being familiar with WSUD principles and approaches. It highlights the need for ongoing investment in capacity building through professional training and communication. However, in cases such as Mawson Lakes the WSUD approaches were well ahead of common practices at that time but now these approaches have become more common. Therefore, it could be expected that some of the issues faced with implementation would be less likely to occur now.

The post-implementation assessment also highlighted some of the issues associated with the scale of WSUD systems. Large scale systems, such as the ASR schemes, require significant areas of land but offer economies of scale for both infrastructure provision and maintenance. The view was put by some of the stakeholders interviewed as part of the post-implementation assessment that for small-scale systems the potential benefits may be outweighed by the costs. This was particularly for the ongoing maintenance for a large number of distributed assets. There is the need for improved understanding of the performance of small-scale features in reducing peak and annual stormwater flows, and improving water quality, when retro-fitted across a catchment. This improved understanding would assist in local councils to have the technical and economic justification for incorporating WSUD approaches in the development approvals process.

Part V Discussion and conclusions - Impediments and constraints for WSUD adoption in SA

9 Discussion and conclusions – Thematic analysis of impediments for the mainstream adoption of WSUD in South Australia

The following provides a thematic analysis of the primary impediments found for the greater adoption of WSUD in South Australia. The themes have emerged from the review of the current status of WSUD adoption in South Australia, evaluation of South Australian guidelines and legislative framework for WSUD, interviews and surveys with key sectors that have a stake in WSUD adoption (local government, developers, consultants, state agencies and water utility), detailed post-implementation assessment of South Australian developments with WSUD features, and community consultation.

WSUD uptake in SA has been characterised by the predominance of large stormwater harvesting schemes, including wetlands and managed aquifer recharge aimed at flow management and the provision of a non-potable water supply source. Such large schemes were mainly developed in the northern and western fringes of Adelaide and were made possible through land availability and government funding. A number of the large scale schemes were pioneered in SA, e. g. MAR, and reticulated recycled non-potable water supply at Mawson Lakes. In addition, there are examples of street and allotment scale initiatives across the Adelaide Metropolitan area, such as bioretention features.

The overall uptake of WSUD across SA has been ad hoc and fragmented, driven by the opportunities in LGAs and the passion of WSUD champions. This has been reflected in disparities of Councils in terms of the technical expertise for WSUD and the differences in the objectives of WSUD implementation across Adelaide.

SA's WSUD progress contrasts from states such as Victoria and Queensland, where the proliferation of WSUD has been driven strongly by State water quality targets that were developed on the basis of detailed monitoring studies that linked the health of receiving waters with runoff quality, e.g. Port Philip Bay and Moreton Bay. In such States and also in Tasmania, the water quality objectives have facilitated the creation of a WSUD strategy, which has been coordinated at state government level, and the development of institutional and legislative frameworks, which encouraged the development of WSUD capacity and implementation at local level.

In some of the inner city suburbs of Adelaide the receiving water bodies or streams do not have a high environmental value, so the purpose of WSUD measures may be less apparent to the responsible local government. This is also the case for urban areas where runoff is directed to wetlands prior to discharge to the coast, as it may be unclear of the need for WSUD upstream of the wetland. Yet, because there is interdependency between stormwater flows across catchments and because all stormwater ends in Adelaide's coastal waters the impact of WSUD impact needs to be examined at the wider catchment perspective.

9.1 Need for improved capacity for WSUD adoption and implementation

The concept of WSUD emerged in the 1990s as a way to better manage water flows and quality in an urbanised environment. The principle goal of WSUD was to maintain local water flow and quality close to the pre-development hydrology. Since that time the knowledge and capacity for planning and implementation of WSUD has increased markedly. In South Australia, there were a number of developments that provided internationally recognised leading edge examples of WSUD. This included the adoption of alternative water sources for meeting non-potable demand in the home (such as Mawson

Lakes). South Australia has also provided leadership in the stormwater management area, where the approach has evolved from one which considers stormwater as a nuisance to be rapidly conveyed from urban areas to receiving waters to stormwater being viewed as a resource. There are now many examples of progressive stormwater management in South Australia, such as the Salisbury stormwater harvesting network, where the management of stormwater goes beyond the conventional practice of alleviating flood risk to consider mitigating the environmental impact of urban runoff, while also recognising that stormwater can provide a valuable resource to reduce mains water demand, enhance local biodiversity, and improve landscape amenity and recreational space. The experiences and knowledge gained through these projects has developed South Australian capacity for WSUD implementation.

However, this project has found that there is still the need for further development of WSUD capacity in South Australia. In particular it was found that capacity for WSUD varies considerably. Local government has been identified through this research as specific target for further capacity building due to the importance of local government in translating State government policy into action through instruments such as the development approval process and stormwater management plans. WSUD capacity at local government level varies both within a local government and also among local governments. Internal local government capacity can vary among different departments. For example, there may be strong capacity for WSUD in areas such as environmental planning and water management but a lesser capacity for WSUD in those departments focussed on transport, asset management and civil engineering. The lack of capacity for WSUD in certain department(s) can constrain the adoption of WSUD. For example, the post-implementation case study assessments showed that certain type of scheduled road maintenance can provide for opportunistic retrofit of WSUD approaches. In addition, uncertainty regarding WSUD requirements was often associated with delays in development plan approvals, which served as a disincentive to developers. There was also found to be a marked difference in capacity for WSUD amongst different local governments. This could be related to urban growth patterns in Greater Adelaide, where there has been greater adoption of WSUD approaches on the urban fringe in new growth areas, as there is scope for implementing WSUD as part of the overall development process. In older, more established local government areas, there may be less emphasis on the development of capacity for WSUD, as it may not be considered a core activity because WSUD implementation in older established urban areas occurs on a more incremental basis through retrofit for urban renewal or infill development. Also, in these areas local waterways may be significantly modified and have little environmental value so the need for developing local government capacity for WSUD to mitigate environmental impact of runoff may be difficult to justify. The development of local government WSUD capacity is likely to be a higher order priority in areas with environmentally sensitive receiving waters.

It was also found that the capacity for WSUD varied in the urban development sector. Specifically, it was more likely that large-scale developers would have sufficient resources to develop WSUD capacity, while small-scale developers can often be limited in their ability to support or hire specialised WSUD skills. This has implications for the retrofit of WSUD in infill or Brownfield developments, as these are often undertaken by small developers, with limited access to (in-house or contracted) capacity for WSUD, and are likely to be subject to more stringent physical restrictions (e.g. allotment size, with lack of open space) which could increase the technical difficulty and cost of WSUD implementation compared to greenfield developments.

It was generally found that consultants offer the technical expertise needed to design and plan WSUD approaches, although developers expressed that the depth of knowledge on WSUD varies across the sector, between individuals and firms, and was often influenced by the previous WSUD design experience of individual engineers.

However, in the specific case studies reviewed it was often found that there was a poor translation of WSUD design intent in the built WSUD feature. In some cases this was due to a lack of WSUD experience and knowledge in sub-contractors that were tasked with constructing the WSUD feature. Sub-contractors were not always familiar with WSUD principles and approaches, which resulted in both sub-optimal installation of WSUD features and also inadequate operation and maintenance. Poor performance of WSUD approaches can lead to reluctance for mainstream adoption due to perceived problems but many of these issues could be addressed through a greater emphasis on capacity building.

9.2 Fragmented approach to WSUD implementation

The adoption of WSUD principles requires integration and coordination across traditional management boundaries. The mainstream adoption of WSUD in South Australia needs to cut across multiple sectors, which include: land use planning, environmental management, infrastructure and services, asset management, transport open space, recreation planning, and flood management. In many cases these sectors might consider aspects of WSUD in their planning and operations, but there is often a lack of coordination that can impede the achievement of WSUD objectives. The application of WSUD to a development is often multi-objective as it tries to achieve flood risk mitigation, reduced environmental impact of urban runoff, mains water conservation and improved landscape amenity. In some case studies it was found there was a need for trade-offs to occur amongst these objectives, but taking an integrated approach to the implementation of WSUD could ensure that these tradeoffs are explicitly considered. For example, if mains water reduction is the primary driver for the adoption of a WSUD approach, such as rainwater harvesting, the implications for stormwater quantity and quality management should still be considered.

Stormwater Management Plans (SMPs) in South Australia are required to be catchment based and prepared by local governments for areas of 40 hectares or larger if they are seeking funding from the Stormwater Management Fund (SMF). This means in many cases local governments will need to work together to develop a catchment-based SMP. The preparation of effective SMPs is likely to be more difficult in catchments where the relevant local governments have different organisational policies, capacity and immediate priorities. SMPs are subject to scrutiny by an advisory panel of key State agencies (DPTI Transport, NRM Boards, DEWNR). The EPA is not part of the advisory panel, but it can provide comment on specific plans as part of a consultation process upon requested by councils or SMA. SMPs can assist local governments to devise a stormwater management strategy for their area, which when considered in conjunction with other information and aligned with council priorities, can serve as a basis for the development of WSUD goals and strategies for sub-catchments. However, not all local government areas have SMPs in place and often this is associated with a lack of funds to develop and implement their SMPs. Feedback from stakeholders indicates that councils which have already developed and finalised their SMPs tend to display a clearer and more defined strategy in their development plans and often show greater integration of requirements for different departments within the council.

Developers noted that there is a need for consistency and clarity of WSUD requirements within local government. It is likely that the coordination of WSUD guidelines and policy needs to occur at the State government level and be applied at the local government and catchment level. A consistent application of WSUD across local government areas would provide developers and consultants with more certainty in planning for the implementation of WSUD. However it has to be noted that it is also important that policy is not prescriptive or fixed from a State perspective and that they allow local government the flexibility to tailor WSUD to their local strategy and requirements. On the other hand, the interconnectivity of catchments in Metropolitan Adelaide means that measures adopted upstream will also impact on downstream parts of the catchment, which may belong to different local government jurisdictions, and eventually Adelaide’s coastal waters. Thus such impacts also need to consider the most appropriate locations for WSUD measures across the wider catchment.

Adelaide’s Coastal Waters Quality Improvement Plan (McDowell and Pfennig, 2013) and the Catchment to Coast are endeavouring to ensure this connectivity is recognized and the cumulative impacts from all catchments are addressed. Infill development and existing development can contribute just as much if not more to poor water quality. To ensure a fair and equitable distribution of responsibility and cost all catchments should have to contribute to improved water health and if it not practical to do so then there should probably be a system that will allow for contributions elsewhere, such as the development off-set system used in Melbourne where funds collected were then adopted to fund other stormwater infrastructure investment across the catchment.

For example, a catchment with a demonstrated high environmental quality may have more stringent requirements at local level, while an existing catchment subject to infill development may not necessarily have flow quality controls, but focus on flow quantity control with quality control measures adopted at a downstream point of the catchment.

In the post-implementation assessment of WSUD case studies it was often found that there was a lack of coordination and oversight throughout the WSUD implementation process. In one case study the incorrect installation of a gross pollutant trap resulted in an extended delay to the commissioning of an ASR system for non-potable water supply.

9.3 Knowledge gaps on WSUD performance, externalities and O&M requirements

As previously identified, WSUD has been an emerging field over the last 20 years, but in many cases there still remains a paucity of reliable data on expected performance, externalities and operation and maintenance requirements that is specific to the South Australian context. The project revealed that many stakeholders considered the WSUD guidelines for South Australia to be too vague, and that there was a need to adapt more detailed technical data and guidelines from other states. The performance of WSUD approaches is often influenced by site-specific conditions such as climate, soil type and water demand. Therefore, there is a need for SA specific detailed guidelines for WSUD implementation. However, to deliver improved guidelines that address existing knowledge gaps would require a greater emphasis on post implementation validation and monitoring of WSUD approaches. The lack of a central repository to share and disseminate knowledge on WSUD performance was also identified as an impediment for greater understanding of expected performance amongst stakeholders.

The post-implementation assessment of selected WSUD developments found that in many cases there was very limited or no understanding of the actual WSUD performance. In the case of alternative water sources, this meant that there was no understanding of the actual level of mains water savings, and in the case of stormwater management there was a paucity of data on the actual impact of different WSUD approaches on stormwater quantity and quality. The knowledge gaps on the actual performance that can be expected from different WSUD approaches can impede the adoption of these approaches as it makes it difficult to clearly identify the business case for their adoption. Frustration was also expressed by the development industry, which at times confessed to implementing WSUD measures they considered ineffective, but at the request of local government, to avoid delays in the approval process.

A lack of understanding on the externalities associated with different WSUD approaches was identified as an impediment for greater mainstream adoption in SA. WSUD externalities relate to indirect costs and benefits associated with implementation. For example, a developer can implement an approach to collect and harvest stormwater with one of the postulated benefits being to avoid environmental impacts of stormwater discharge. However, in many cases it is difficult to quantify these externalities, such as the benefit to coastal waters or river ecosystems. WSUD externalities can occur at a range of scales and both upstream and downstream from a development. Some that may be considered, and that are as yet not well understood, include: biodiversity impact, community health and wellbeing, recreational opportunities, landscape amenity and micro-climate. This project also found that the aggregated impact of WSUD elements at a catchment or greater scale was poorly understood. For example, there is little information available which addresses the impact on peak flow following the incremental adoption of rainwater tanks retrofitted to an existing urban areas, on-site detention systems (Williams and Pezzaniti 2005) or rain gardens in urban infill developments. In addition, the responsibility and upkeep of on-site systems on private property typically residents with the land owners and no clear mechanisms are in place to safeguard their proper upkeep and operation. This lack of understanding could impede adoption of WSUD at the smaller scale, such as the opportunistic installation of street-scale bio-retention pits as part of routine road maintenance, as it is difficult to clearly identify the benefits at a larger scale. An improved understanding of these whole of society costs and benefits may assist in developing WSUD performance based targets for SA, and the lack of understanding is a disincentive for WSUD adoption by developers and local government.

A consistent theme to emerge from both stakeholder consultations and post-implementation assessment of WSUD sites was the need for an improved understanding of O&M requirements and the associated costs.

This issue was particularly pertinent for local government, who in most cases will assume the responsibility for ongoing management and O&M of WSUD elements. In the review of case studies, it was found that in some instances the burden of regular maintenance costs, such as de-silting of detention ponds, were a significant issue and a potential barrier for the greater adoption of these approaches. There was also a challenge associated with how to best manage WSUD features for multiple purposes including landscape amenity, flood mitigation, water harvesting and improvement in runoff quality. In some cases, development water features were perceived poorly in terms of performance against WSUD objectives as ornamental lakes required top-up during the drier months to maintain water levels and associated amenity value.

The uptake of WSUD by local councils is impeded by the limited understanding of their performance in managing stormwater flows and quality, enhancing the local environment and biodiversity, and reducing mains water demand. In addition, there are knowledge gaps on the appropriate management models and O&M costs. In the absence of any regulatory policy in the planning approval process, the knowledge gaps on WSUD makes it difficult local councils to develop a robust technical and economic justification for greater WSUD uptake.

9.4 Perceptions of risk and costs associated with WSUD adoption

The adoption of WSUD principles often requires a shift in the 'business as usual' approach to managing the urban water cycle. The business as usual approach is grounded in more than a century of practice so there is a good understanding of associated risks and life cycle costs. It was found through this research that some stakeholders can be reluctant to adopt WSUD principles due to uncertainty in associated risks and costs. Risks can include environmental and public health risk associated with alternative water sources, such as rainwater harvesting, on-site detention in private property or MAR systems. While the lack of understanding of the life cycle costs, particularly uncertainty around O&M costs can make local government reluctant to undertake broader adoption of WSUD.

In a number of the WSUD case studies reviewed the approach was initiated due to the availability of one-off grant or funding opportunities. For greater mainstream adoption of WSUD the availability of funding and in particular on-going funding for O&M has not been resolved. Local government can have concerns about the operational budget required to maintain WSUD initiatives, while developers can be reluctant to pay for any additional costs associated with WSUD implementation and management.

9.5 Poor policy coordination and a lack of mechanisms to implement WSUD targets

This research found that the policy in South Australia provides in principle support for WSUD, but it lacks clarity to allow the effective implementation of WSUD in practice. Formal legislation specifically addressing WSUD at the State government level is also lacking. For example, the policy paper *Water Sensitive urban design – creating more liveable and water sensitive cities in South Australia* (Government of SA 2013) states the desire for '*transitioning SA into a water sensitive state*', and recommended state-wide performance targets for stormwater run-off quality and quantity for new developments and guiding principles for government action. The paper represents the clearest intent of the State to pursue WSUD to date, however there are yet no defined mechanisms that support the recognition, implementation and enforcement of such targets.

Most stakeholders were in favour of the South Australian WSUD targets as a mechanism to encourage greater mainstream adoption. Stakeholders indicated a strong preference for performance-based targets rather than prescriptive regulations. The use of performance based targets enable flexible and innovative approaches for WSUD that is specific to the opportunities and limitations of particular development areas and suited to local council development policy.

Transparency in the development approvals process and clarity in WSUD objectives and requirements were identified as two key parameters that would aid WSUD implementation at the Local Government level.

Local governments and State agencies identified the need for a stronger directive from State Government to legitimise the incorporation of WSUD into local development planning. The *Development Act 1993* as it stands is very vague regarding the implementation of sustainable development and the protection of the environment.

There are also a number of areas where roles and responsibilities are not yet clearly defined, which at present are managed through cooperation between agencies. However, there is a need for greater coordination between State planning, natural resources management, water (flood prevention and water supply) and environmental management with a focus on WSUD implementation, given the integrative nature of WSUD. In particular, there is a need for stronger links between the planning section, which is responsible for planning policy but often lack the technical knowledge on WSUD, and the transport, infrastructure engineering section from the DPTI and DEWNR, which tend to have the technical know-how on WSUD.

In the absence of an urban water blueprint or another policy instrument, the responsibility for translating the State policy into more specific directives for implementation on the ground currently falls on local government. However, the capacity of local government to interpret policy and translate it into practical steps varies markedly, resulting in fragmented WSUD implementation and requirements. There was a perception from stakeholders that there is a lack of mechanisms, resources and coordination to assist individual councils to build their WSUD capacity, particularly regarding stormwater. The WSUD experience across Australia has shown that States that have adopted a coordinated approach and invested in the resourcing and up-skilling of councils' WSUD capacity, e.g. Queensland and Victoria, were able to produce a more consistent capacity baseline and create common platforms for knowledge dissemination and up-skilling.

9.6 Inadequate community understanding and acceptance of WSUD

Community acceptance of WSUD approaches is critical to ensure that WSUD is considered a legitimate approach for managing the urban water cycle.

In many cases WSUD features, such as infiltration swales, were integrated into the landscape. Local residents were often not aware of the function that these WSUD elements performed such as management of stormwater quality and quantity. In addition, the development industry remarked that majority of home buyers valued the aesthetics of open green spaces or water features, but have poor knowledge of WSUD and under the current climate (in the absence of water restrictions and in tougher economic times) a majority of home buyers were unwilling to pay extra for environmental features.

On the other hand, Leonard et al. (2013) verified that residents in localities with WSUD features were more receptive and positive about the features once they were provided with information about their function, operation and benefits.

9.7 Conclusions

The project found a number of common themes emerged when considering the impediments to the greater mainstream adoption of WSUD in South Australia. The following points highlight these themes based on findings from the project activities, and consider the implications for South Australia:

(1) *Consistent and coordinated application of WSUD in planning frameworks and development approvals processes.* WSUD as a practice cuts across many professional disciplines and traditional management and policy areas. Therefore, there is the need to consider how WSUD is integrated across sectors in a consistent way that achieves multiple objectives. The objectives of WSUD can include flood risk reduction, improved stormwater quality, mains water conservation, improvements to local ecosystems and enhancing landscape amenity. The planning of WSUD needs to consider how the design can best achieve these objectives, and make clear where there is a trade-off between objectives. There is the need to develop transparent and efficient processes for incorporating WSUD objectives in development planning and approvals. This includes ensuring that WSUD initiatives address broader flood management and water quality objectives for the local government area and catchment. It has been suggested that this could be achieved though linking development approvals to stormwater management plans.

(2) *The need for further developing local government capacity for WSUD implementation*. The project has found that capacity for WSUD varies both among local governments, and also among departments of a local government. Local governments play a vital role in the implementation of WSUD in South Australia through urban and landscape planning, development approvals and maintaining community infrastructure. A particular need identified was improving local government capacity to develop WSUD guidelines that are clear and appropriate to the local context. Local governments also need to develop the capacity to plan for WSUD that addresses broader catchment-level objectives, and understand where there are trade-offs between objectives so that local government priorities for WSUD can be established. This also needs to be supported by powers and mechanisms that allow local government to adequately resource and govern the implementation and operation of the systems.

(3) *Enabling WSUD adoption through state-level targets and policy*. It was found that South Australian policy provides in-principle support for WSUD, but further clarity in policy, objectives, institutional responsibilities and roles regarding WSUD is required that offers clear mechanisms to facilitate WSUD implementation. It was found that stakeholders preferred policies that specified performance-based WSUD targets over prescribed actions. This enables greater flexibility to adapt the WSUD approach to the local context. The recently released South Australian State policy on WSUD adopts performance based targets for managing water quality and stormwater flows.

(4) *Developing the knowledge-base for WSUD in the South Australian context*. The design and expected performance of WSUD features in South Australia was found to be frequently based on interstate guidelines and monitoring data. Also, detailed assessment of WSUD sites in Greater Adelaide revealed there was a lack of post-implementation monitoring studies to validate performance. The lack of data on WSUD performance that is specific to South Australian climates, soils and urban form can impede the development of improved guidelines for the design of WSUD systems. It was also found that local government can be reluctant to adopt WSUD approaches due to a lack of information on the ongoing costs for operation and maintenance. Monitoring and validation of WSUD systems and the collation of data and maintenance costs from existing projects would enable an improved understanding of life-cycle costs, externalities and management requirements in the South Australian context. This information is critical for the development of business cases that make clear the expected benefits and costs, including the ongoing costs. Uncertainty in WSUD costs and benefits is a major barrier to greater mainstream adoption of these approaches. In the absence of any regulatory policy in the planning approval process, addressing knowledge gaps would enable local council to develop robust technical and economic justification for greater WSUD implementation.

(5) *Improved understanding of how small-scale distributed WSUD systems can address catchment-level objectives*. Trends in Greater Adelaide for urban consolidation through infill development means there will be a need for more small-scale, distributed, implementation of WSUD. There is a need for improved understanding of how to select and design small-scale WSUD systems, which when aggregated, can assist in achieving catchment-level objectives for flood management and water quality. This would complement existing knowledge on large-scale system design and improve the understanding of appropriate WSUD treatment train options at various scales.

Part VI References and Appendices

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Appendix A. Interview guide for councils

Questionnaire

1. Development characteristics:
   Could you provide us with a brief background about the major WSUD developments, their locations and their key features, in your Council?
   Were you directly involved in any of those projects?

2. Drivers:
   Were there any specific/prominent drivers leading to the adoption of WSUD in those sites?
   Were there any barriers (internal/ external) to any of those WSUD sites in your council?

3. Implementation:
   What were the key criteria for the feature selection and implementation (sustainability, legislation, funding, etc)?
   How was the approval procedures conducted?
   Who were the key stake holders (even common) in those projects?
   Were the technical WSUD design aspects offloaded to an external agency?
   How were the technical reviews conducted?
   Could you mention the contractors involved?
   What were the technical/non technical challenges faced during the implementation of the WSUD features?
   Has the cost-benefit analysis been conducted for these WSUD?
   Do you use the SA WSUD guidelines?

4. Post-Implementation:
   Have these WSUD features been monitored?
   How could you rate their performance efficiency?
   Who conducts the ongoing maintenance of the WSUD features?
   Is there any significant improvement in the environmental quality and quantity, after the implementation of WSUD features, in the locality?
   Any appreciable community involvement/awareness reported in these developments?

5. Further steps ahead:
   Should WSUD be promoted?
   What do you think prevents the intake of WSUD features, in South Australia?
   Any suggestions/ thoughts to share?
   Would you like to participate in the future enquiries regarding this research project?

Thank you for your valuable time shared!!

Appendix B. Interview guide for institutional stakeholders

PARTICIPANT INFORMATION SHEET

Water Sensitive Urban Design: Stakeholder mapping

This project aims to find out about the main barriers to installing water sensitive urban design systems across Adelaide and South Australia. This information will be used to guide the planning and implementation of WSUD systems in the future. The project is being conducted by the CSIRO and University of South Australia. It is funded by the Goyder Institute for Water Research.

The semi-structured interview aims to gather information on the perspective of key institutional stakeholders on WSUD and its implementation in South Australia. It focuses on key areas:

- Institutional context and the role of the stakeholder in the urban planning, water and wider environmental management landscape;
- Perceptions of WSUD, including advantages and disadvantages;
- Major barriers and challenges for WSUD implementation;
- Addressing barriers and challenges

Research Questions

1. Definition of WSUD and the role of your organization in WSUD

    1.1. What is/How do you define/describe water sensitive urban design?

    1.2 What role does your organization play in WSUD implementation? What influence does your organization have on WSUD uptake? E.g. approvals, supply, O&M, etc.

    1.3 Which do you see as the key agencies when it comes to WSUD implementation? Which agencies do you interact with regarding WSUD (formally and informally)?

2. Perception of current status of WSUD uptake in SA

    2.1 What is you organization's view of WSUD?

    2.2 What is the current status of uptake of WSUD in SA in your view?

3. Major benefits/challenges/barriers

3.1 What do you see as the advantages from WSUD uptake?

3.2 What are the disadvantages?

3.2 What challenges/barriers does WSUD uptake experience particularly for Adelaide and SA?

3.3 What do you believe are the main barriers for the more widespread uptake of WSUD?

4. Major priorities for WSUD implementation

4.1 What in your view are the major priorities/issues that need to be addressed in WSUD implementation? E.g. Science, financing, capacity, transfer, legislation, etc.

4.2 What could be done to improve WSUD uptake? Who should be involved in it?

5. Which agencies do you believe are key to the progressing WSUD? Why

6. Would you like to provide any final comments or remarks?

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PARTICIPANT INFORMATION SHEET

Water Sensitive Urban Design: Stakeholder mapping

This project aims to find out about the main barriers to installing water sensitive urban design systems across Adelaide and South Australia. This information will be used to guide the planning and implementation of WSUD systems in the future. The project is being conducted by the CSIRO and University of South Australia. It is funded by the Goyder Institute for Water Research.

Why is this research important?
The need to manage water sustainably is becoming increasingly important as the population of Adelaide continues to grow, placing pressure on existing infrastructure and increasing the demand for new developments. Hence the project will investigate social and technical difficulties in implementing water sensitive urban design (WSUD) systems in South Australia by interviewing key institutional stakeholders associated with or potentially impacted by WSUD systems. This will help to understand the main advantages and disadvantages of these systems as experienced by key stakeholders and assist in informing DEWNR as they develop the State's Water Blueprint.

What is involved?
Your involvement in this research will be through participation in a 30 minute interview in which you will be asked a range of questions regarding your organisation's perspective on water sensitive urban design and its implementation in developments in South Australia. The interview will be recorded to allow for analysis provided you consent.

The interview focuses on the following areas:

- Institutional context and the role of the organisation in the urban planning and wider environmental landscape;
- Perceptions of WSUD, including advantages and disadvantages;
- Major barriers and challenges for WSUD implementation;
- Addressing barriers and challenges.

Participation and withdrawal
Participation in this study is completely voluntary and you are free to withdraw at any time without prejudice or penalty by informing the interviewer. If you do withdraw from the study, the information that you have provided up to that point can be removed and destroyed if requested and will not be included in the study unless you give us permission to use that information.

Risks
Participation in this study should involve no physical or mental discomfort, and no risks beyond those of everyday living. If, however, you should find any question or procedure to be invasive or offensive, you are free to omit answering that question. If you have any concerns about any aspects of the study, please contact Grace Tjandraatmadja (see overleaf for contact details).

Confidentiality

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Appendix C. Analysis of policy and legislation for WSUD in SA

This section provides a review of policy and legislation that is relevant to WSUD either directly or indirectly in South Australia.

Guidelines and Policies for WSUD in South Australia

In 2010 *The Water Sensitive Urban Design Technical Manual –Greater Adelaide Region* (Government of SA 2010) was released to serve as a guide for LGAs and planners in the design and development of WSUD features in new developments. The manual outlines a range of WSUD features, provides general guidance on their characteristics, indicative costs and references for further information follow-up. It was also the first major attempt at mainstreaming WSUD in South Australia. Feedback gathered from consultants and local government on the usefulness of the manual for guidance on WSUD varied, whilst the manual was seen as a good introduction into WSUD by some, a number of stakeholders believed that it was of a very general nature and lacked the required level of detail to allow implementation, and as such a number of interviewees often resorted to other documents and guidelines developed by other agencies interstate for detailed design guidance (Myers et al 2013).

The position paper *Water Sensitive urban design – creating more liveable and water sensitive cities in South Australia* (Government of SA, 2013), released in November 2013, was the first policy paper to set a stronger State commitment to a position on WSUD for urban development in SA. The paper outlined the desire for transitioning SA into a water sensitive state, and most importantly recommended state-wide performance targets for stormwater run-off quality (reductions of 80 percent total suspended solids, 60 percent total phosphorus, 45 percent total nitrogen and 90 percent for litter/gross pollutants) and quantity for new developments and guiding principles for government action.

Regarding alternative water supply as part of WSUD, such as recycled water, treatment and storage, The *South Australian Recycled Water Guidelines (*Government of South Australia 2012a) outlines the key legislation, agencies and the approval processes required for implementation of any schemes that adopt stormwater extraction, drainage and storage in aquifers, greywater use and treated sewage or mixed source waters. For such schemes a risk management approach forms the basis for approvals and validation of schemes and the roles and responsibilities for agencies in the pre-development evaluation of schemes are clearly outlined. Schemes that inject into or extract groundwater from prescribed areas and which import water or treated wastewater require approval from the Department of Environment, Water and Natural Resources (DEWNR), the Department of Health (DHA), the EPA or a combination of the three. However, there are also a number of areas where roles and responsibilities are not yet clearly defined, which at present are managed through the informal cooperation between agencies. For example the DHA is not involved in the delivery of advice on the use of stormwater and rainwater unless requested by a relevant referring authority.

Stormwater management and its infrastructure governance are distributed across multiple agencies (SMA, DEWNR, EPA, local government), with the jurisdiction and responsibilities defined based on the traditional disciplines and fragmented aspects of the water cycle. The multiple roles are at times not well defined, which poses challenges for integrated water cycle management and WSUD implementation. Planning involves NRMBs, SMA and local government. Stormwater assets are owned and managed by multiple agencies: in principle DPTI is responsible for large scale stormwater drainage infrastructure from roads to kerb in urban and rural areas (including highways, floodways, bridges); each local government is responsible for management of drainage infrastructure beyond the kerb within their jurisdiction; and NRM boards operate and manage infrastructure that they have constructed, such as sedimentation basins, stormwater outfalls and GPTs, where relevant. Under the Water Resources Act 1997, council powers in relation to drainage, stormwater, creeks etc are confined solely to drainage responsibilities arising from roads (Kelly (2007). The Stormwater Management Bill grants councils special powers to enter private land and to carry works and infrastructure in accordance with an approved and gazetted stormwater management plan , however this does not apply to work on permanent infrastructure on private land, in which case consent of the owner is required to maintain or access the infrastructure, or an easement needs to be purchased by council (Kelly 2007).

Planning for stormwater catchment management (Stormwater management plans) is in principle facilitated by the Stormwater Management Authority, undertaken by councils, with advice from a committee comprised of councils, NRMBs and the DPTI Transport for individual catchment areas (minimum area of 40 hectares). However efficacy is restricted by funding availability ($ 4million per year dedicated to the development of SMPs) and historically the focus of the SMPs has been on flood management.

To achieve integrated water management, planning and funding structures need to account for the linkages between elements in the water cycle, consider the benefits associated with both quantity and quality across the wider ecosystem. These at present are still underdeveloped in the current framework, and there are limited coordination mechanisms for the implementation of an integrated stormwater management plan.

The post-implementation and management of WSUD schemes and assets is another area that is unclear. MAR schemes have a defined governance arrangement, although the process could also be improved. DEWNR licenses stormwater allocation in prescribed areas, including the extraction of groundwater from a well. The EPA licenses the injection of stormwater to aquifers in metropolitan Adelaide and Mount Gambier (when the contributing catchment is larger than one hectare). Thus large scale schemes that inject into aquifers are required to provide water quality monitoring reports subject to the disposal location and water end use. Stormwater recovery and recycled water schemes may require the submission of multiple monitoring reports to relevant agencies, such as the EPA and DEWNR (mainly to NRMBs). Salisbury City Council, which has the longest operating MAR in Adelaide, indicated that for their MAR reporting process, different agencies often had similar data requirements, but they required different report formats, resulting in the preparation of multiple reports which was more time consuming, and thus any measures that streamline the reporting process could ease the cost burden associated with monitoring (e.g. a single data entry portal for government or a clearly defined process) (Salisbury Council 2013, pers. communication).

Information on the performance of other type of stormwater related WSUD schemes is scarce and no formal reporting is required.

The specific details of the various elements of legislation and policy are detailed in the following sections.

Natural Resources Management

Regional water planning legislation focuses on safeguarding water security (quantity) and environmental flow protection with a strong focus on water quantity. In South Australia, water is a state owned good and the *Natural Resources Management Act 2004 (NRM Act*) defines the right to use water through water allocation permits for use and transfer of water from prescribed water resources across the State. Non-prescribed water resources, such as surface water run-off in a catchment, can in principle be lawfully accessed and used by any landholders in the catchment. This means that stormwater captured and stored in council infrastructure is 'owned' by council and that rainwater captured by a householder in a rainwater tank is 'owned' by the householder.

Water supply and demand security for each of the eight NRM regions across SA is determined in Regional Water Demand and Supply statements (RDSS) (or Regional demand and supply plans under the *Water Act 2012*) designed to provide a high level 40 year overview of water security and outline of water resources (drinking and non-drinking), water demands and the timeframes for any possible supply and demand gaps. The RDSS are reviewed annually. The Natural Resources Management boards are responsible for the preparation of, review and amendment of water allocation plans (WAP's) for each regions' prescribed water resources under the NRM Act. RDSSs are considered in conjunction with other Long term plans, such as SA Water's Infrastructure plans, SA Planning Strategy and regional allocation plans. If a shortfall is identified the State initiates a planning process to address the shortfall.

NRM boards also provide advice with respect to the assessment of various activities or proposals referred to the board under the Act and relevant to the management of natural resources within their respective regions. This includes ensuring that any Development Plan under the *Development Act 1993* under each region abides by the objects of the NRM Act and to ensure cohesion between an NRM Board's regional plan objectives and any Development Plan under the *Development Act 1993* policies.

The *NRM Act* requires the inclusion of water needs for the environment in the determination of the quantity of water for consumptive use. The Act requires draft water allocation plans to be prepared by each NRM Board, with the support from DEWNR, and to be subject to community consultation. After such period the relevant minister adopts the water allocation plan and it becomes government policy. Under the NRM Act, DEWNR and NRM boards can issue *water licences and allocations* for selected activities including irrigation, industrial, commercial, stock and domestic use and managed aquifer recharge. DEWNR administers *Water permits* which are issued for activities such as drilling, operating and sealing a well, draining or discharging water directly into a well and the use of imported water or effluent for the carrying of a business. NRM boards administer activities related to dams, draining and discharge into water courses, floodplains or lakes (http://www.waterforgood.sa.gov.au/water-planning/water-licences-and-permits/).

Since 1 July 2009, water licences in SA were unbundled into water rights and responsibilities covering four areas: water access entitlement, water allocation, water resource works approvals and site use approval, each of which can be granted separately.

Stormwater management

Stormwater management planning is coordinated through an independent body, the Stormwater Management Authority (SMA) (*Local Government Act 1999*). Its functions are summarised in Box C1. The SMA issues general guidelines and objectives for the preparation of stormwater management plans (SMPs) on a catchment basis in alignment with the *Environment Protection Act 1993* and the *NRM Act 2004. The SMA* is invested with powers to force councils in a designated catchment area to prepare stormwater management plans, in consultation with the relevant NRM boards and in consultation with relevant agencies (e.g. DPTI). The designated catchment areas has to be 40 hectares or larger, and can often require multiple councils within the catchment to collaboratively develop the SMP. According to Kelly (2007) Councils are not legally bound by regional NRM plans, but must "have regard to" such plans. On the other hand, councils are required to take action if the SMA issues a coercive order (Kelly 2007).

Box C1 - SMA Functions include (*Local Government Act 1999*):

To formulate policies, provide information to councils in relation to stormwater management planning and to facilitate programs by councils promoting the use of stormwater (including policies, information and programs) to further environmental objectives and address issues of sustainability including the use of stormwater for human consumption, for the maintenance of biodiversity and other appropriate purposes):

- To administer the Stormwater Management Fund;
- To ensure that relevant public authorities co-operate in an appropriate fashion in relation to stormwater planning and the construction and maintenance of stormwater works,
- To undertake stormwater management works in circumstances provided by the Schedule,
- To provide advice to the minister in relation to the State stormwater management system.

The SMPs form the basis for cost assessment and funding distribution by the State across councils to fund structural and non-structural infrastructure development needs. SMPs focus on the management of flooding risk, opportunities for stormwater beneficial use, desirable planning outcomes associated with open space and environmental enhancement of ecosystems (Box C2) (Local Government Act 1999).

However, the SMA's action scope is limited by its operating budget of $4million per year. Therefore, whilst the SMA has in principle the power to force local government to develop SMPs, it has no influence on the execution of such plans, nor does it have the capacity to facilitate the implementation of SMPs nor provide any funding required to allow local government to further develop the SMPs. Local government is required to procure funds for implementation elsewhere, which can be challenging for less affluent areas.

It should also be noted that SMPs do not particularly specify local stormwater objectives nor WSUD implementation strategies as they focus instead on objectives for large scale catchments (over 40 hectares), whereas WSUD measures are typically developed at much later stages in the planning process and often applied within sub-catchments. However, the setting of overall directives and the development of SMPs set the initial step for the development of a local government strategy, which may include WSUD principles and objectives at later stages (these are not compulsory).

Box C2 - South Australian Urban Stormwater Management Policy goals:

- Adopt a risk management framework for hazards/flooding based on catchment characteristics;
- Facilitate the productive use of stormwater;
- Manage the environmental impacts of stormwater as a conveyor of pollution;
- Manage stormwater as part of the urban water cycle recognising natural water course and ecosystems where feasible;
- Responsible stormwater management locally by better use of the statutory development planning system;
- Gain innovative stormwater policy outcomes through effective funding and procurements arrangements.

Environmental protection

The South Australian Environment Protection Authority (EPA) administers the *Environment Protection Act 1993* (EP Act), to which the *South Australia Environment Protection (Water Quality) Policy 2003* (WQEPP) is subordinate. The WQEPP was established to protect aquatic environments in South Australia, but does not apply to the discharge of clean stormwater from a public stormwater system.

Management of a stormwater system by an authority is to be conducted in accordance with the *Stormwater Pollution Prevention General Code of Practice for Local, State and Federal Government* (Bolting and Bellette 1998). The WQEPP has obligations not to discharge or deposit listed pollutants into the stormwater system or onto land where it may enter the stormwater system, any stormwater discharged to the aquifer must not degrade the quality of the groundwater and must not contravene water quality criteria in waters.

The EPA has produced a series of stormwater code of practice documents for federal, state and local government entities (Botting and Bellette 1998), for the community in general (Bellette and Ockenden, 1997) and for the building and construction industry (Botting and Bellette 1999). The EPA has also implemented WSUD targets on a regional basis (Myers et al 2013)

Selected regional and local council areas have also developed their own guidelines. The *SA EPA Guidelines for Stormwater Management in Mt. Gambier* requires that development shall incorporate stormwater treatment systems that achieve a minimum standard for treatment. According to the guidelines, the ‘demonstration of “stormwater treatment system” performance will include the use of acceptable modelling methods, such as MUSIC by suitably qualified professionals’. However, there has been no MUSIC parameterization developed for SA local conditions.

The recently released *Adelaide Coastal Water Quality Improvement plan (ACWQIP)* (McDowell and Pfennig 2013) recommended a long-term strategy for water quality improvement of Adelaide’s coastal waters in view of the detrimental impact of pollution on coastal waters. The ACWQIP highlighted the need to reduce nitrogen loads by 600 tonnes per year, sediment loads to 50% from 2003 levels and further reduce coloured dissolved organic matter (CDOM) to halt the loss of seagrass and allow its recovery. Stormwater is the main source of suspended solids and CDOM reaching coastal waters.

The ACWQIP provided environmental values (EVs) and Water quality objectives (WQOs) for Adelaide coastal waters and recommended strategies for water quality improvement. Among which, it recommended as strategies for reduction of stormwater loads: the promotion of integrated use of wastewater and stormwater across Adelaide, targets for stormwater run-off and the recognition that “*the adoption of WSUD features into land development offers the opportunity to minimise the entry of further pollutants including nitrogen and sediment into Adelaide’s coastal waters if adopted for all new land developments and will support pollution load reductions if retro-fitted during urban consolidation.* “

The recent Goyder targets project (Goyder Institute of Water Research 2011) also provided recommendations for the development of suitable water quantity targets for SA, which are currently under Government consideration.

Under the current South Australian legislation, the *South Australia Planning Policy Library* sets in principle requirements for development controls for stormwater management and discharge to pre-development conditions with the aim to minimise harm to the receiving environment, and recommends the maximisation of stormwater harvesting and reuse through a range of stormwater management features, which can include the adoption of rainwater tanks and other WSUD features (Government of SA 2011). Although, the Planning Library serves as an overarching framework for development, the extent and timing of adoption of the various modules into the local government Development Plans is subject to the discretion (or resources) of each local council.

Consequently, the establishment of WSUD requirements at development level falls under the responsibility of local councils. Local councils assess development applications against the Council’s development plans (DP) and policies. Development plans and council policies are formulated according the needs, resources, capacity (or lack thereof) and strategies of each council. Stormwater treatment objectives are also subject to the same constraints, subject to initiative of individual local government, except for prescribed areas/sinks, which have water quality targets requirements set by the SA EPA (Myers et al 2013). At the time of writing, only the City of Onkaparinga and the City of Salisbury had implemented WSUD targets for TSS, TP and TN for runoff quality as a requirement for new developments.

The *Development Regulations 2008 Ministers Specification SA 78AA* contains ‘deem to comply’ requirements for the position of stormwater infiltration systems on a development site if directed to do so by the relevant authority responsible for authorization of the development.

Water Planning and Services Management

The *Water Industry Act 2012* (5 April 2012) sets a framework to reform and integrates the water industry legislation of South Australia and sets the roles and responsibilities for the management of the water sector. The Act opens the provision of water supply and sewerage services to competition by allowing third party access (besides SA Water). Bulk water supply infrastructure ownership remains with State Government. Currently SA Water is the only water supply and sewerage services provider.

Under the Act, the Essential Services Commission of South Australia (ESCOSA) becomes the single independent regulator for the urban and rural water and wastewater services provision, with the power to regulate the licensing, pricing and performance standards for water and sewerage services.

The Office of Technical Regulator provides independent advice on plumbing standards and practices beyond the meter. In addition, the roles of a Water industry Ombudsman, Consumer Advisory committee and a Consumer Advocacy and Research Fund were established to protect the interests of the community.

The Act's discussion papers outline a wide range of reforms, tasks, and the agencies and stakeholder groups responsible across the whole water sector. WSUD is mentioned specifically in two actions: the development of best regulatory approach for mandating WSUD in South Australia (action 67) and the development of targets for WSUD (action 68).

Alternative water supplies are also supported through supporting codes and guidelines. The *South Australian Recycled Water Guidelines* (Government of South Australia 2012a) outlines the key legislation, agencies and the approval processes required for implementation of alternative water schemes that adopt recycled water, stormwater extraction, drainage and storage to aquifers, greywater use and treated sewage or mixed source waters. For such large schemes a risk management approach is promoted as the basis for approvals and validation of schemes; and the roles and responsibilities for agencies in pre-development evaluation of schemes are outlined.

The South Australian Building Code rules require new dwellings, home extensions and alterations for class 1 buildings (of roof area > 50 m^2) to adopt an additional water supply to supplement mains water. The additional supply can be fulfilled via installation of an internally plumbed, rainwater tank, recycled water or a communal rainwater tank. If a rainwater tank is installed to fulfil the requirement a minimum capacity of 1000L is required (Government of SA 2006).

Groundwater

Under the *Environment Protection Act 1992* (EP Act) the EPA licenses discharges of treated effluent and stormwater to underground aquifers (injection), the latest applies to the discharge from a catchment area greater than 1 hectare and the stormwater drains to the aquifer from a stormwater drainage system in metropolitan Adelaide or in the city of Mount Gambier. Catchments smaller than 1ha do not require licensing from the EPA for stormwater discharges. Schemes that extract groundwater from prescribed areas and which import water or treated wastewater require approval from the Department of Environment, Water and Natural Resources (DEWNR).

Recycled water schemes intended for stock watering or pasture irrigation require approval from the Department of Primary Industries and Resources of South Australia (PIRSA). In addition, the Department of Health and Ageing (DHA) needs to be notified prior to the implementation of any recycled water schemes (including greywater or mixed source), and the water provider (most often SA Water) must be consulted for the development of a recycled water supply agreement (Government of South Australia 2012b).

Recycled water

Greywater schemes require approval from local government under the new Waste control regulation, and from SA Water or equivalent prior to installation if there is an interface with mains water supply. Prior to the WICA (until 2012), SA Water administered the *Sewerage Act 1929* in proclaimed drainage areas (where SA Water provides mains sewerage), whilst non- proclaimed areas were under the responsibility of local government and/or the DHA.

Recycled water schemes require approval from the DHA under the Public Health Act, including for the treatment process and the use of reclaimed water. Local government approves the planning and development of greywater schemes. SA Water approves any changes to plumbing and drainage that may affect the water supply or drainage system when a greywater system is installed. Under the *Water industry Act 2012*, supply of water and sewerage services and associated infrastructure, a service previously prescribed only to SA Water Corporation, can now be undertaken by licensed operators. In principle, this opens the right of water supply and sewage services to new entities besides SA Water, increasing competition. Although at present no other licensed agents have been appointed.

At present there are no requirements for the monitoring and verification of recycled water use and stormwater use on-site at a single property dwelling, unless specified by local government during the approval process.

Land planning

The *Development Act 1993* sets the legislative framework for planning and development in South Australia. The State government's planning strategy is outlined in the *30year Plan for Greater Adelaide* and in the plans for regional South Australia. The *Development Act 1993 requires the* planning strategy to be reviewed every 5 years and to ensure consistency with other major policy and strategies of the government. The role and responsibilities of councils in South Australia are outlined in the Local *Government Act 1999,* which also outlines the rates and charges set-up.

The *Development Act 1993* lists among its objectives: ' ...to provide for the creation of Development Plans – (i) to enhance the proper conservation, use, development and management of land and buildings; (ii) to facilitate sustainable development and the protection of the environment; and (iii) to encourage the management of the natural and constructed environment in an ecologically sustainable manner; and (iii) to advance the social and economic interests and goals of the community; ....(Part 1, section 3, item c). The *Development Act 1993* also mentions the provision of public infrastructure and the need for provision of 'drainage' in general terms, but it makes no mention of stormwater management or water sensitive urban design. Hence, whilst there is the in principle intention of achieving environmental and ecological sustainability the *Development Act 1993,* the Act is vague regarding the requirements and the means of implementation of such principles.

All councils in South Australia 'must align their development plans with the planning strategy volume that applies to their region' (*Development Act 1993)*. This is achieved through the development plan amendment (DPA) process. 'Development plans outline the policies, zones and maps that guide property owners and others on what can and cannot be done on a piece of land covered by the development plan. These zones, maps and policies provide the detailed criteria against which development applications are assessed. When a proposed development meets the criteria set in the development plan, a development plan consent is granted.' The DPTI Planning manages the *South Australia Planning Policy Library* (SAPPL), a series of standardised policy modules that can be adopted into the individual development plan by local councils (Government of South Australia 2011). The SPPL has a section on Water Sensitive Design (pg.79-80) in the Natural Resources module that provides overarching principles for developments, however the module does not include any specific performance based targets.

The Development Plan falls under the discretion of the minister for Planning. If a council or group of councils wants to amend its local development plan it needs to make a submission via the DPA process. An initial statement of intent is submitted to the minister of Planning, the minister consults with the Development Policy Advisory committee if applicable. Provided the council and the minister reach agreement, the council is then allowed to prepare a DPA proposal, demonstrating that the amendment complies with relevant policies, the planning strategy and legislation. The DPA proposal is then assessed using one of three processes pre-determined between the council and the minister during the Statement of Intent:

- DPA is evaluated by relevant government agencies and relevant bodies for comment, the minister considers the matter and comments and may then give approval for the release of the DPA or require the council to alter the DPA, after which the DPA is released for public consultation; or
- If required by the Minister, the council must first refer the DPA to the Minister for consideration, who may then request alterations to the DPA after consultation with council, after that the DPA is submitted to relevant government agencies for comment and then for public consultation; or
- DPA is referred to relevant government agencies for comments, after which the DPA is released for public consultation.

After public consultation, the council prepares a report on the outcomes of the consultation process for submission to the minister. The minister after obtaining advice from his/her Advisory committee decides on the alteration, denial or partial or full approval of the amendment (*Local Government Act 1993*). The minister also has powers to initiate a DPA as set under the *Local Government Act 1993*. Amendments approved by the minister are then referred to the Environment, Resources and Development Committee of the Parliament. The Committee can approve, object or request amendments to the Development Plan. In case of amendments, these are conducted by the minister either by himself or in consultation with the council (if relevant) before resubmission. If the Committee objects to an amendment, the submission is then sent to the two houses of Parliament for resolution.

Thus in summary, for a council to amend its local DP, the approval from the minister of Planning is required. As previously stated, the current planning legislation provides no clarity on the integration of water management into planning.

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Appendix D. Trends in WSUD uptake in other States

This section examines the existing legislation, guidelines and WSUD trends across the country investigated up to December 2013.

Since the National Water Initiative, the Commonwealth government aimed at the development of a national water strategy and enabling tools to support the implementation of integrated water management and WSUD. A number of resources have been developed which focus on the assessment and implementation of water recycling, managed aquifer recharge and water quality management topics, such as risk management guidelines for alternative water sources and other WSUD related topics (see Appendix E).

Across Australia WSUD uptake has progressed with different focuses and at various paces in each State. Queensland and Victoria are seen as pioneer States in the development of WSUD policy and implementation.

In Queensland the Healthy Waterways program established a framework, assessment targets and the policy basis for the valuation of the environmental health of waterways and was instrumental for the promotion of WSUD in the State. Recent reviews had highlighted the importance of more coordination and collaboration between State and local government to promote compliance with targets in industry and the need to address uncertainty regarding WSUD management responsibilities (Jones et al. 2012). Recent changes to State Planning Policy (Oct. 2013) increased the emphasis of aligning state objectives and priorities to regional and local development planning.

In Victoria policy and programs addressing stormwater management were developed through the coordination of Melbourne Water, with significant effort aimed at the integration of stormwater quantity and quality management through WSUD into planning and capacity building based on local government needs, particularly for O&M. Current efforts are now addressing the need for capacity building for O&M of WSUD and for expansion of stormwater management requirements into the commercial and industrial sectors.

In Tasmania, marked progress was observed after the State government's initiative to develop water quality targets, support industry and local government to implement and seek funding for WSUD. This has resulted in the delivery of various WSUD projects that integrate both stormwater quality and quantity management objectives and which were successful in securing federal funds.

In the Northern Territory development of a water management strategy for key areas such as the Darwin region resulted in the vigorous discussion and the development of supporting material and a draft policy for the promotion of WSUD during 2008 to 2010. Whilst a legislative approach has not been realised, the implementation of the strategy has proceeded in the Darwin Harbour region (NTDPI, personal communication 2012).

In NSW implementation is still progressing in a more fragmented manner, with a recent review highlighting current gaps that need to be addressed to facilitate WSUD uptake (SMCMA 2012a,b,c).

In WA following the integration of land use and water planning in the State, regional and local planning policy, there has been significant investment in the development of local government capacity and resources to facilitate WSUD implementation by industry and local government with coordination from State agencies, led by the Department of Water (Government of Western Australia, 2011b, 2013).

In the ACT WSUD has been integrated into planning through ACTPLA in 2010. The performance of the ACT Water strategy was recently reviewed and the draft Water strategy is now undergoing public consultation (ACT Government, 2013).

Australian Capital Territory (ACT)

The ACT government *Think water, act water strategy* established a plan and the targets for urban water management, including the implementation of WSUD for ACT (ACT Government, 2004 a,b). The follow-up *Water for the future –striking the balance - draft ACT Water Strategy 2013* is currently undergoing public consultation (ACT Government, 2013).

The ACT planning Strategy (ACT Government, 2012a) provides for the provision of water resources and water quality management setting broad direction, targets and objectives.

The *Waterways Water Sensitive Urban Design General Code* (ACT Government, 2009b) is a one stop reference document on WSUD for ACT. The code adopts total urban water cycle management principles for the management of water resources (demand reduction, stormwater and wastewater treatment and reuse) and aims to promote pre-development level stormwater export. The code sets mandatory targets for all new residential, commercial, institutional and industrial greenfield developments and redevelopments: a 40% reduction in mains water consumption (based on pre-2003 baseline) and stormwater quality and quantity targets. The code also outlines the legislative context, proposes measures that can be adopted to achieve targets, tools to demonstrate that targets are being met (BASIX, MUSIC, XP- RAFTS, DRAIBS(ILSAX), RORB, WBNM); and recommends a number of design references for further consultation. For each of the tools, a set of recommended calibration parameters based on Canberra conditions are also provided. Under the code, the onus for meeting water quality targets for a development or redevelopment lies with the developer, but regional and catchment-wide targets are the responsibility of Government (Goyder Institute for Water Research, 2011). In case a developer is unable to meet the WSUD requirements, the authority has the discretion to allow the payment of a developer contribution scheme for off-site control measures (ACT Government, 2009b).

The stormwater network at the ACT is under the responsibility of the following agencies: (i) ACT Planning and Land Authority (ACTPLA) is responsible for the master planning and development of new stormwater networks at subdivision level; (b) Roads ACT is responsible for planning and maintaining roads and kerbs as part of the stormwater system (including also sumps, stormwater pipes, channels, cut off drains, retarding basins, GPTs, dams and weirs); and (c) Conservation, Parks and Lands is responsible for the maintenance of natural systems (e.g. grassed floodways, urban lakes, water bodies, etc) in the stormwater network (ACT Government, 2014). Private land developers are required to construct the stormwater network within suburbs as per standards set by Roads ACT.

To aid developers, the *Guidelines for the Preparation for Estate Development Plans* (ACT Government, 2009a) specify the pre-application processes requirements, timelines and minimum documentation required for an *Estate Development Plan* (EDP) in compliance with the *Planning and Development Act 2007*. Each submission has to include a WSUD outcomes plan demonstrating how the 40% mains reduction and the stormwater management features will be used to achieve stormwater quality targets. Requirements include a stormwater masterplan and a WSUD outcomes plan (in accordance with the *Waterways: Water Sensitive Urban Design General Code* of the Territory plan (ACT Government, 2009b). A review of the effectiveness of the WSUD guidelines in meeting objectives has been recommended in the 2012 Strategy review (ACT Government, 2012a).

Regarding alternative water sources, ACT specific guidelines and regulations have been developed to address specific streams of the urban water cycle: rainwater, wastewater reuse, greywater (see appendix E). Amendments to the *Water and Sewerage Regulations 2001* were made to allow the separation of greywater pipes in domestic premises to the edge of the floor slab and for the installation of 'provisional' water pipes to toilets and washing machines and an external point to facilitate connection to either rainwater or greywater in the future (ACT government 2012b). In addition the *Rainwater tanks: Guidelines for residential properties* which outlines the rainwater requirements for residential developments, initially released in 2006 were also updated in 2010 (ACT Government, 2010a). Opportunities for sewer mining and effluent reuse should be followed with ACTEW.

Details of the guidelines that aim to support the WSUD strategy are available at the *Think water* website (http://www.thinkwater.act.gov.au/) and are also listed in Appendix E.

The Environment and Sustainable Development Directorate manages strategic water policy, including local implementation of water reform, national issues related to water access, pricing and trading, regulation of water resources and monitoring and report of water quality in ACT.

The Water Utility ACTEW Corporation Limited owns ACTEW Retail Limited and ACTEW Distribution Limited, which manage water and sewerage business assets, and is 50% owner of ActewAGL (Power and gas). From 1 July 2012, ACTEW Water was established to run the management, maintenance, operations and maintenance of ACT's water and sewerage.

ACT Health regulates water quality under Public Health Act 1997, in accordance with Australian Drinking Water Guidelines 2004.

New South Wales

The *2010 Metropolitan Water Plan* outlines the water strategy for the greater Sydney (Sydney, Illawarra and the Blue Mountains area) region with an emphasis on water security via dams, recycling, desalination and water efficiency (State of New South Wales 2010). Water and energy conservation requirements for new dwellings are embedded in planning through the BASIX Certificate (Building Sustainability Index) (NSW Government, 2014). In line with the strategy for increased competition in water and wastewater service provision, amendments to the *Water industry Competition Act 2006* (WIC Act) allow licensed private entities to provide drinking water, recycled water, sewer mining and infrastructure services under the regulation of the IPART (Appendix E). Licenses for stormwater harvesting and reuse are granted by the Minister for Water and assessed against Australian guidelines for water recycling (AGWR): stormwater harvesting and reuse, AGWR guidelines. Local councils are exempt from WIC Act, but still require compliance with AGWR Guidelines. At the time of writing, the regulatory arrangements governing the third party access were being revised (see Appendix E for further details).

Stormwater recycling is one of the tools promoted by the Strategy to save drinking water, however developing the impetus for the implementation of stormwater harvesting and reuse schemes has been a slow process.

In New South Wales, the *Environmental Planning and Assessment Act 1*979 and the *Local Government Act 1993* set the framework within which planning and local government operate. State Environment Protection Policies and Regional Environmental Plans set the objectives, policies and requirements for developments, guiding the establishment of local planning schemes. Local Councils are responsible for the development of local plans and for establishing objectives and targets for stormwater quality through development control plans or local environmental plans, similarly to SA. The Catchment Management Authorities (CMA)s are responsible for promoting improved natural resources management at catchment level and also to promote capacity building, coordinate resources and facilitate networking to support agencies (such as councils) that conduct the implementation and ground work (NSW Government 2013).

Flood management policy is overseen by Department of Environment and Heritage (DEH). The DEH is also responsible for the development of stormwater management objectives. Protection of water quality is shared between local, state, catchment management authorities and federal government.

Up to 2009, the development of WSUD programs and stormwater management was occurring in an ad hoc basis, where a number of individual councils in NSW, such as Tweed Shire Council and Ku-Ring-Gai, had developed local guidelines and objectives for stormwater management. Through the *Sydney Metropolitan*

Catchment Action Plan (CAP) (last revised in 2012), a wider attempt was made at promoting the uptake of WSUD (Sydney Metropolitan Catchment Management Authority 2012b).

The *Sydney Metropolitan Catchment Action Plan* (CAP) (Sydney Metropolitan Catchment Management Authority 2012b) forms the basis for natural resources management in the region and is intended to provide guidance to the State and local governments, industry bodies and other key stakeholder groups on how to implement the State plan priorities at local level. The CAP was developed in consultation with multiple stakeholders, including local government, State and Commonwealth government, aboriginal communities and local groups. The CAP established targets for Waterways protection (stormwater, aquifers, estuaries, coast and marine environment) for 2016.

Land management targets were developed with an emphasis on soil health preservation and catchment management. These include the minimisation of sediment loads to urban bushland in new release, infill and infrastructure sites via best practice erosion and sediment control methodologies, and the reduction of risks to aquifer, water ways and soil contamination by greywater reuse through coordination of a strategy on greywater planning, guidelines and approval at local government level (Sydney Metropolitan Catchment Management Authority 2012 a,b).

Among the actions specified in the CAP is the development of guidelines and regulations for WSUD infrastructure uptake at all councils, programs for stormwater quality, harvesting and reuse and incentives; and update of guidelines for water (effluent and greywater) recycling and water efficiency. Some councils require developments to achieve stormwater treatment targets, but WSUD is not compulsory.

In 2010, the Sydney Metropolitan Catchment Management Authority (SMCMA) released the *Draft NSW MUSIC Modelling Guidelines* (BMT WBM, 2010) and the WSUD Interim Reference Guideline for the South East Queensland Concept Design Guidelines (NSW Government 2010a) which provides advice on adapting guidelines from SEQ (SEQHWP and Ecological Engineering, 2007) to the Sydney region (Goyder Institute 2011). WSUD objectives derived for the Sydney region are adopted by councils in Sydney for their development control plan. The guidelines address stormwater quality, flow management and wetland protection. The water quality objectives (WQO) are applied to larger developments such as medium or high density residential developments, commercial areas (with impervious area larger than 150 m^2) or subdivisions with more than 6 lots or 2,500 m^2 in size. The interim guidelines (NSW Government 2010a) set objectives for a reduction in post-development runoff pollutant loads compared to untreated stormwater from the same development type. The performance and sizing of treatment measures need to be demonstrated using appropriate modelling techniques such as the MUSIC model, and in accordance with the draft *NSW MUSIC Modelling Guidelines* (BMT WBM, 2010), which is currently available for comments.

In 2014 the Sydney Metropolitan Catchment Management Authority and the Hawksbury-Nepean Catchment Management Authority merged into the Hawksbury-Nepean Catchment Management Authority (HNCMA) and to provide a wider regional approach to surface water management.

Meanwhile, to protect drinking water supply to Sydney, all developments within the designated Sydney drinking water catchment (the area provides 60% of all drinking water for greater Sydney, the Blue Mountains, the Illawarra, Shoalhaven and the Southern Highlands) are regulated under the *State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011* (SEPP). The Sydney Catchment Authority (SCA) has the role of managing and protecting the water quality and quantity of the catchments, the management of raw water supply and associated infrastructure, including dams, raw water provision to licensed operators, and the regulation of activities within the catchment, as stipulated in the *Sydney Water Catchment Management Act 1998*. This includes the ability to regulate certain activities within and also outside of the catchment that might impact the water quality.

Developments in the Sydney Drinking Water Catchment are regulated by the State Environmental Planning Policy (SEPP) 2011. Under the SEPP, proposed developments that require consent under a council's local environment plan must have a neutral or beneficial effect (NorBE) on water quality, and should incorporate current recommended practices or performance standards endorsed or published by the System Catchments Authority related to water quality. The NorBE on water quality means a development that:

- Has no identifiable impact on water quality;

- Will contain any water quality impact on the development site and stop it from reaching a watercourse, water body or a drainage depression on the site; or
- Any water quality impact outside the site where it is treated and disposed of to standards approved by the consent authority.

The 'Neutral or beneficial effect on water quality assessment guideline 2011' (SCA, 2011) provides clear instructions about the meaning of the neutral or beneficial effect, how achieve compliance, and how to assess an application against the NorBE test. The NorBE test is designed for use by councils and the SCA to assess development applications and under the SEPP it is mandatory for councils to use the NorBE assessment tool to undertake the NorBE assessments. Developments are classified into classes using a standard instrument, the Principal Local Environmental Plan, and then grouped into modules based on the development assessment process and the level of risk from the development. Assessment requirements are tailored based on the risk classification of a development, with greater detail (e.g. requirements for MUSIC modelling of stormwater) required as potential risk increases. The tool provides questions and thresholds to assess development applications, a web application to assist councils decide if the development is neutral or beneficial and if SCA has a concurrence role. In addition it also records the decision process for each development applications. Thus it standardises the development assessment process increasing the transparency of the process. In addition, the SCA developed a model clause for catchment councils to include in their development control plans, which describes the need for inclusion of a water cycle management study (including erosion control and sediment management during the construction phase), relevant reports and modelling for all developments based on the type and scale of the development proposal , as part of the assessment. The NorBe guideline also provides guidance on modelling and access to information sources tailored to the conditions of the catchment, and is further supported by documents such as the manual 'Using MUSIC in Sydney's Drinking Water Catchment' (SCA 2012), which provides guidance on the assessment based on the NorBE context and are tailored to the specific regional conditions.

Under the *Local Government Act 1993*, local councils have the discretion to levy a Stormwater Management Service Charge (SMSC) to rate payers for improved stormwater services (implemented in 2006 by amendment of the LGA 1993). An analysis conducted by the Office of Environment and Heritage reviewed the role of Stormwater management service charge (SMSC) for the period of 2006-2009 (NSW Government 2010b). In their survey they verified the implementation of the levy in fifty percent of councils (from a sample of 152 councils) in the financial year 2008-09. In these councils expenditure on stormwater management per household increased by eighty-nine percent compared to the period prior to introduction of the SMSC, this expenditure was also fifty-four percent higher than for councils not charging the SMSC . In addition among the councils using the SMSC, in forty-five percent of the councils, the revenue from the levy was used to fund over fifty percent of their stormwater expenditure for 2008-09. Thus, indicating that the fee structure was being effective in promoting investment in stormwater.

According to the NSW government, up to 145 stormwater harvesting and recycling projects have either been implemented or are under feasibility assessment around the Sydney area with financial support from the local council, State and/or federal Government as per 2011. However, the vast majority of projects were implemented by councils and focus on stormwater harvesting for irrigation and mains water savings. Only a few of the projects have flood management or water quality improvement as primary drivers. Majority of projects were implemented either with council funding or with the assistance of State and Commonwealth grants (http://www.waterforlife.nsw.gov.au/recycling/stormwater/stormwatermap) (see Appendix E). However, flood management was cited as the major driver for the vast majority of projects (NSW Government 2010b).

In 2012 the CAP was revised to *A plan for Sydney's liveability*, with the first round of public consultation concluded in November 2012 (Sydney Metropolitan Catchment Management Authority, 2012a, b, c). The revision examined the status and progress around the State regarding the SMCMA 2009 CAP targets and its perceived usefulness. However the process of WSUD integration is progressing slowly. All local councils in the Sydney area have established a process for developing, implementing and revising their stormwater management strategies. However, no local councils have yet reported the completion of the implementation of provisions in their revised local plans, development control plans, related codes and policies for promotion of WSUD (Sydney Metropolitan Catchment Management Authority 2012a,c). Fifty percent of councils were provided with information, tools and capacity building to support the adoption of WSUD and stormwater management best practices. However, only one percent of the targets for sediment load minimisation was achieved by 2012 and the impact on LEPs and DCPs has not been measured yet.

Feedback from stakeholder groups highlighted the need for development of more specific and realistic LGA targets for WSUD and NRM; wider data collection and monitoring for comparison to baseline data; integration of CAP with the planning process (including LEPs), improving collaborative efforts between agencies and among stakeholders to monitor, evaluate and report progress towards targets (including data sharing, capacity building and better coordination across LGAs and State agencies) (Sydney Metropolitan Catchment Management Authority, 2012c).

Section 68 of the Local government Act stipulates the need for approval from local council for water supply, sewerage and stormwater drainage work, including private recycled water schemes for sewage processing of size larger than a single dwelling. The Department of Water and Energy (DWE) and NSW Health act in an advisory role to councils during the processing of approvals. If the recycled water scheme proponent is a council the DWE is the approvals authority. The NSW Office of WATER adopts the National Guidelines on Water Recycling for water quality, likewise the Australian guidelines framework is adopted for assessment of section 60 applications for approval to treat and supply recycled water under the local Government Act 1993 and section 292 applications for approval to treat and discharge recycled water under the Water Management Act 2000. The current NSW guidelines for greywater and treated effluent use and operation of recycled water schemes are provided in appendix E.

The *Environmental Planning and Assessment Act 1979* (EP&A Act) regulates the planning and development in NSW and the development approval process. Each local council through their local environmental plan (LEP) specifies the requirements for development approvals including private recycled water schemes. Sewer mining schemes where the treated water is used for industrial purposes alone or with a capacity of less than 1.5 ML of sewage per day require a statement of environmental impact lodged with council. Larger schemes fall under a category of 'designated development" and require an Environmental impact Statement as per Environmental Planning and Assessment Regulation 2000. NSW Health under the Public Health Act 1991 has the authority to issue orders and direct public authorities to take action in the interest of public health. Water quality compliance values for recycled water are under the jurisdiction of NSW Health under the Public Health Act 1991, which needs to be informed of any incidents that may impact public health.

In water recycling, the *Water industry competition Act 2006* No.104 (NSW government 2012a) was introduced to increase competition in the water sector through a system of licensed operators for water, recycled water and sewerage supply and for construction and maintenance of the associated infrastructure allowing access by third parties (NSW Government 2012a). This was designed to facilitate the entry into water supply market by private operators under a licensing and regulation regime from the IPART.

The *Water Industry Competition (WIC) Act* aims to facilitate new approaches to water and wastewater service provision, whilst the *Local Government Act (LG Act*) was designed to regulate conventional wastewater infrastructure such as council sewage treatment plants and domestic septic systems. Prior to introduction of WIC Act, the LG Act was the framework for approval of private water and sewerage infrastructure.

To achieve greater alignment between the regulatory frameworks from the *Water Industry Commission Act 2006* (WIC Act) and the *Local government Act 1993* (LG Act), the government of NSW has amended the Local Government General regulation 2005 so that a WIC licensee no longer requires approval under section 68 from the LGA .

The NSW government undertook a joint review of the WIC Act and the regulatory frameworks for water recycling under the LG Act led by the Metropolitan Water directorate in the Department of Finance and Services, with submissions to the review accepted until Feb 2013 (NSW Government 2012b*).*

In 2012, further amendments to the *WIC Act 2006* were conducted to tighten the regulation of licensees and two codes of conduct (the Draft *Marketing code of conduct* (NSW government 2011a) and Draft *Transfer code of conduct* (NSW government 2012b)) were introduced for observance by retail licensees (see http://www.waterforlife.nsw.gov.au/planning-sydney/water-industry-reform/codes-conduct). Public comments have been received for the two codes of conduct and the modified version is currently waiting to be gazetted by the relevant minister (as per July 2014).

However further clarification is required on the legislation. For instance, at the time of writing, last resort arrangements were not clearly defined in WIC Act. Present regulation states that the minister for finance and services 'can declare a public utility or licensed retailer to be a retailer of last resort, however currently the legislation only has broad provisions for a retail licensee supplier failure and does not cover licensed network operator failure' . These are currently being reassessed in view of submissions from industry and government in regard to lack of clarity on themes such as the cost recovery and its distribution mechanisms, impact on infrastructure planning and communication/roles clarity, rigour of licensing process and monitoring, impact on existing capacity (see http://www.waterforlife.nsw.gov.au/planning-sydney/water-industry-reform/last-resort-arrangements) .

Guidance in NSW regulation can be found at:

- The NSW government website Water4Life serves as the repository for all state specific guidelines and information on recycled water and alternative water sources and includes links to the Sydney Metropolitan Water and Lower Hunter Plans (http://www.waterforlife.nsw.gov.au/). Additional information is also provided on the Office of Water resource page and the NSW Health Wastewater and Sewage resource page. Stormwater projects are published in a stormwater map (http://www.waterforlife.nsw.gov.au/recycling/map). Support material developed by the State government include guidelines on technical aspects, service installation and construction, erosion management and also updates on the stormwater management service charge from 2006 to 2009, economic incentives for management at urban fringe (see http://www.environment.nsw.gov.au/stormwater/publications.htm)
- The Sydney Catchment Authority website for requirements pertaining to development within the Sydney drinking water catchment area (see http://www.sca.nsw.gov.au/catchment/development).

A number of tools are also provided such as models on assessing demand, rainwater tank yields based on local conditions (http://www.water.nsw.gov.au/Urban-water/Country-towns-program/Best-practice-management/Integrated-Water-Cycle-Management/Integrated-Water-Cycle-Management/default.aspx).

- NSW Health has a wastewater and sewage resource page which outlines accreditation guidelines for on-site sewage management facilities, all of which had been developed pre-2006. The regulation of on-site systems is the role of the Local government (clause 40 and 41 Local government regulation 2005), whilst individual system technologies are accredited a priori by the NSW Department of Health (http://www.health.nsw.gov.au/publichealth/environment/water/waste_water.asp).
- New South Wales Government - Office of Water has a resource page on water recycling, stormwater. An amount of $80million funding was available from 2006 to 2012 for an Urban sustainability program to help councils undertake stormwater management projects, including harvesting and reuse.
- The *WSUD in Sydney* website (www.wsud.org) consolidates the information on WSUD from various earlier initiatives by local councils and government agencies and is maintained by the Sydney Metropolitan Catchment Management Authority.

Queensland

In Queensland the *Environmental Protection Act 1994*, establishes the framework for environmental values for waterways and the water quality objectives to maintain the waterways.

Water Sensitive Urban design is regulated under the *Environmental Protection (Water) Policy 2009*. At regional level a number of specific WSUD policies and guidelines apply (see appendix E). In addition local government planning schemes and local guidelines on WSUD, erosion and sediment control also apply.

In 2009 the Queensland Government amended the *Environmental Protection (Water) Policy 2009* setting requirements for urban stormwater management as part of the total water cycle management context. The Policy requires all LGAs with more than 10,000 inhabitants to develop and implement Total Water Cycle Management Plans specific to each government area before 1/07/2014. For South East Queensland the deadline was 1/07/2012 (Weber and Ramilo 2012). The policy outlines the hierarchy to be used in applying water quality guidelines in the context of water planning when there are multiple or conflicting guidelines. In summary, the preferential policies are primarily those available from local government. In the absence of these, state policies are selected, which in turn take precedence over national guidelines (DERM, 2009a). The Policy also set acceptable methodologies for defining the water quality objectives of urban stormwater based on monitoring, modelling or best management practices.

In 2006, the *WSUD Technical Design Guidelines for South East Queensland* (SEQHWP, 2006) established mean annual loads reduction targets for stormwater discharges recognising the difficulties in using concentration based targets. These included the temporal variability in outflow concentration and its associated issues in defining a median value, as well as the fact that moderate concentrations associated with large volumes of stormwater may still lead to degradation of ecosystems.

The *Queensland Water Quality Guidelines* (DERM, 2009a) set urban stormwater quality objectives for urban development in Queensland for pre- and post-development phases. In addition, the *Urban Stormwater Quality Planning (USQP) Guidelines 2010* (DERM, 2010) establish climatic regions for Queensland based on rainfall statistics (seasonality, pattern and annual mean). For localities in the boundary of regions, the most stringent condition is to be adopted.

The load reduction targets for Queensland were derived using the MUSIC Version 3 as detailed in the *Urban Stormwater - Queensland Best Practice Environmental Management Guidelines 2009 Technical Note: Derivation of Design Objectives* (DERM, 2009b). The reductions are based on achievable reductions when applying current “best practice” stormwater management, taking into account infrastructure operating in Queensland’s climatic and pollutant export conditions (DERM, 2009b). “Best Practice” was defined as infrastructure designed and constructed to contemporary standards and sized to operate at a reasonable limit of economic performance and benefit to water quality.

The load targets for Queensland were derived by sizing bioretention treatment systems at the “point of diminishing return” and, for all regions of Queensland, this was found to be a bioretention treatment area equivalent to 1.5% of the contributing catchment area (Goyder Institute 2011). The guidelines recommended runoff and pollutant generation parameters and set bioretention parameters. In addition to bioretention, further modelling was undertaken using other technologies to demonstrate that combinations of different stormwater treatment technologies (other than bioretention) could also be used to achieve the target to allow flexibility in solutions for particular developments (Goyder Institute 2011).

In addition to the State Government guidelines, specific guidelines were also developed by some local areas, such as Mackay (DesignFlow, 2008) and South East Queensland (WaterbyDesign, 2010). These guidelines also set water quality target values and provide locally specific guidelines for pollutant export modelling using tools such as MUSIC.

In December 2013 the Queensland government released the revised *State Planning Policy* (SPP). The SPP aims to simplify the development application process and to streamline and integrated the State, regional and local land use planning. The *State Planning Policy* (SPP) (Dec.2013) provides a single framework to guide local and state government in land use planning and development assessment based on the state’s interest. The SPP ensures that development for urban purposes under the *Sustainable Planning Act 2009*, is planned, designed, constructed and operated to manage stormwater and waste water in ways that protect the environmental values prescribed in the *Environmental Protection (Water) Policy 2009*. The SPP supersedes a range of separate planning policies including the prior *State Planning Policy Healthy Waters* (State of Queensland 2013a). The prior State Planning Policy 4/10 *Healthy Waters* (2010) required planning, design, construction and operation of developments to reduce impacts on waterways, which had resulted in greater uptake of vegetated stormwater assets (Jones et al 2012).

The SPP requires planning schemes to consider water quality objectives and environmental values of receiving waters in the planning, design, construction and operation of developments, through the observance of current best practices for stormwater management (State of Queensland 2013b). Best practice information for the management of construction and development activities is provided in the *Urban Stormwater Quality Planning Guidelines* (EHP 2010).

The 2012 review of the SPP 4/10 Healthy Waters recommended: (i) better integration of WSUD with other aspects of infrastructure such as roads, drainage, water supply, sewerage, parklands; (ii) Streamlining of WSUD approval process with deemed to comply and self-certification approaches for approval of standard WSUD applications and a risk assessment method for innovative practices; (iii) the consideration of high density living regarding implementation of WSUD, which may not always allow optimal adoption of WSUD on-site;(iv) integration of flood management, stormwater management and open space; and (v) an assessment of incentive schemes (Bligh Tanner 2012), as infrastructure charges levied on developers do not provide discounts for adoption of better outcomes than the minimum requirements in the guidelines. The SPP incorporates aspects of recommendation (ii) in the streamlining of the development approvals process, however the local government is responsible for implementation.

Currently, infrastructure charges for roads, stormwater, parks and community facilities are set by local government, whilst water and wastewater infrastructure are set by a water distributor retailer. Stormwater charges can be set by local government up to the maximum rate per impervious area (\$10 per m^2 for industry and rural and some commercial land use) as specified under the State Planning Regulatory Provision (adopted charges) (State of Queensland 2012).

Development applications are assessed under the *Sustainable Planning Act 2009* and the sustainable planning regulation 2009 (14 May 2009). The Queensland Development code and associated guidelines provide the legislation and associated interpretation relevant to water management and alternative water systems. Until 2012, the *Queensland Development code MP4.2* contained the requirements that new dwellings had to achieve minimum water saving targets which could be achieved through a range of measures such as alternative water sources, but which were most commonly fulfilled by the installation of rainwater tanks, typically a minimum 5kL tank for a detached dwelling, and water efficient fittings. Water reduction targets had been determined for each of the climatic zones in Queensland to account for their respective rainfall conditions. Since 1 Feb 2013 buildings in Qld no longer have to meet compulsory water savings targets, following the repeal of laws mandating the installation of alternative water supply systems. In the current legislation, local governments can apply to the Minister to opt-in to water savings requirements or for the inclusion of mandatory water saving features in recognition of Queensland's varying climatic conditions and regional circumstances. Builders in these local government areas will still need to comply with minimum requirements for water efficient appliance and fittings. Water supply systems such as rainwater tanks and grey water treatment plants can be installed voluntarily by homeowners and builders in all areas of the state. Builders who install a water saving system (either voluntarily or to meet local government requirements) must comply with the health and safety standards set out in the Queensland Development Code Part 4.2 – Rainwater tanks and other supplementary water supply systems (for residential – class 1, 2 and 10 - buildings) and Part 4.3 – Supplementary water sources – commercial buildings (for commercial and industrial - class 3-9 - buildings) (Department of Housing and Public Works, 2013).

Provision of recycled water falls under the *Water Supply Safety and Reliability Act* (2008) which requires recycled water providers (includes recycled effluent, wastewater from industrial or primary activities and coal seam gas water (treated, untreated or mixed)) and scheme managers to develop a recycled water management plan (RWMP) which outlines a risk management approach for the provision and operation of recycled water schemes and also reporting requirements for each scheme. Guidance on fulfilment of these requirements are outlined in *the Water quality guidelines for recycled water schemes* (Nov.2008) and the *Recycled water management plan and validation guidelines* (Nov 2008) (State of Queensland 2013c,d). Recycled water providers are defined as entities that own infrastructure for the production and supply of recycled water or for supply of recycled water alone.

Greywater and blackwater systems are covered through the *Plumbing and Drainage Act 2002* and the Queensland Plumbing and Wastewater Code. Approvals for on-site greywater diversion and treatment systems of capacity under 50kL per day fall under jurisdiction of local councils for assessment, approval and monitoring. However, homeowners or property owners are responsible for the care of the systems.

Many of the policies were focused on single issues and ended promoting uptake of single sources (QDC MP4.2 alternative water sources, *Regional Plan implementation guidelines 7* (2009) drives stormwater capture for in-stream protection) – but they could be better formulated and aimed at multiple integrated outcomes (Goyder Institute for Water Research, 2011). Gaps in capacity or inconsistency in legislation are being filled through collaborative initiatives, e.g. capacity building, forums, and compliance activities. Examples are the CEOs committee for Natural Resources Management and the Healthy Waterways network, both involve stakeholders from state, local government, water utilities and community groups. The initiative has been effective in addressing construction site erosion and sediment control. Whilst the issue was addressed in legislation, the actual implementation had historically been ineffective, but via coordination and collaboration between local and state government to undertake compliance activities and educate the industry has since improved the practices (Jones et al 2012). Another key gap identified was the lack of clarity in the requirements for management of the new WSUD assets post-construction, with most assets only managed reactively if community complains, a situation that creates uncertainty in resource budgeting (Jones et al 2012).

Tasmania

Historically, Tasmania's stormwater management strategy was based on the traditional drainage model focused on flood mitigation, but in recent years there was growing interest in the adoption of a more integrated approach to stormwater management that encompasses WSUD including pollution and water quality management. However, given the absence of a wider framework or plan across the State, WSUD initiatives were adopted in a fragmented manner led by initiatives from individual councils.

The *State Policy on Water Quality Management 1997* (SPWQM) aims to achieve the sustainable management of surface and groundwater resources in Tasmania by protection of water quality, whilst allowing sustainable development according to the objectives of Tasmania's Resource Management and Planning system (Schedule 1 of the *State Policies and Projects Act 1993*). The SPWQM also sets the water quality objectives for Tasmania.

Under the SPWQM all estuarine and coastal surface waters in Tasmania require protected environmental values (PEVs). PEVS are set based on catchment boundaries or municipal boundaries and provide a strategic framework for water quality management in view of the long term sustainability of surface water use. The process for setting PEVs occurs through collaboration between the Department of Primary Industries, Water and Environment (DPIEW), council administrators, regional park planners and marine planners where applicable; followed by public consultation led by the DPIWE. Based on the PEVs, Water Quality Objectives are developed. At the time of writing 22 municipalities/catchments had completed their PEVs.

The *State Stormwater Strategy* (Government of Tasmania, 2010), developed in consultation with local government, was intended as a State wide guidance document. It sets quality and quantity targets for new developments based on Integrated Water Cycle Management (IWCM) and WSUD principles. The Stormwater Strategy is in line with the approach set in the National Water Initiative (NWI) and NWQMS for stormwater management. The Strategy aims to provide development appraisers with planning and regulatory responsibilities with strategies, processes and tools for assessment of stormwater management strategies. The Strategy recommends Water Sensitive Urban Design, including rainwater tanks, wetlands, swales, porous paving and rain gardens, as best management practice for treatment and beneficial use of stormwater runoff in new developments. It recommends the development of stormwater management plans from Councils for the management of stormwater and encourages adoption of bmps for stormwater management of residential, commercial and industrial developments. It requires all new developments that create 500m^2 or more of additional impervious surface (including subdivisions, roads and large developments) to incorporate best practice stormwater management. It provides detailed information for a range of stakeholders on strategy and relevant details explaining WSUD and its applications. The strategy also provides examples and references from best practices from around Australia, including financing options, guidance on stormwater education programs.

The Strategy applies to individual homeowners and the community too, by promoting sustainability through water conservation, rainwater harvesting, native landscape design and environmental education, while also providing considerable visual and public amenity benefits.

Implementation of SPWQM occurs via local planning schemes through the Land Use Planning and Approvals Act. Stormwater treatment targets were stipulated in DPIWE (2010) as discussed in Goyder Institute for Water Research (2011). The water quality objectives set by the strategy apply to any new development with an impervious surface area equal to or greater than 500 m^2.

Management of stormwater in established urban areas is based on a risk-based prioritisation of catchments focused on "at source" management. Soil erosion and water management controls are required during construction stage, and need to be introduced during the Development Application process through the inclusion of detailed soil and water Management Plans. Clause 31 of the SPWQM requires the incorporation of stormwater management strategies to control runoff from development proposals at both construction and operation phases of any development for maintenance of the water quality objectives in planning schemes.

Clause 33 requires erosion and stormwater control to be addressed at design stage. In addition, it requires the development and maintenance of strategies for prevention of stormwater pollution at source by State and local government; and the implementation of a stormwater management plan (when there is risk of detriment to water quality objectives) by councils. Best practice guidance on sediment and erosion control measures are provided in *Soil and Water Management on Building and Construction Sites* (Government of Tasmania 2008).

Further guidance is provided in Stormwater Management Plan –A model for Hobart Regional Councils – A Focus on New Town Rivulet Catchment (Derwent Estuary Program 2004).

New developments are required to be designed to minimise impacts on stormwater quality and, where necessary, downstream flooding or flow regimes. Stormwater should be managed and treated at source using best management design practices (e.g. Water Sensitive Urban Design) to achieve the pre-determined stormwater management targets (Goyder Institute for Water Research 2011).

In the last 10 years in an attempt to consolidate stormwater management in southern Tasmania, the State government backed the Derwent Estuary Program with the aim to improve the water quality through the development of resources and the implementation of programs for various sectors: local government, industry, community and schools (Chrispijn and Wiese, 2012). To facilitate such investment the government has invested into the development of a stormwater task force, coordination of stormwater monitoring programs, development of Tasmania's Water sensitive Design manual and a model for the stormwater management plan, training workshops and forums and assistance in the preparation of grant applications through the creation of a stormwater officer position, whose role was to assist in the development of funding applications, technical advice, development and training and linking interested parties in implementing WSUD projects. This has lead to the implementation of 40 WSUD stormwater projects in the last 8 years by local government and industry. The funding for such projects came from a range of sources, especially from federal government grants given the absence of State funding.

The State government through the DEP established a stormwater project to improve the water quality through the development of resources and programs to support local government, business, industry, schools and community, and to increase WSUD opportunities in Southern Tasmania by focusing on high profile WSUD sites. Stormwater champions were identified and sought to implement WSUD projects in a range of settings. These ranged from local governments, road and transport departments, universities, major industries and retail/commerce sectors.

Through this process a number of WSUD projects at various scales were implemented and a number received recognition/awards. The DEP's role was to act as a broker between various stakeholders and assist in the application and receipt of Federal grants, which allowed better coordination between the various stakeholders and a more structured implementation process, with alignment between State objectives and council projects (Chrispijn and Wiese, 2012).

The *Land Use Planning and Approvals Act 1993* sets out the requirements for development and the amendment of planning schemes in Tasmania.

In order to support the Strategy, guidelines and supporting material tailored to Tasmania's climatic conditions were developed. Best practice guidance on stormwater treatment options to achieve the targets is provided in the following documents:

- Water Sensitive Urban Design Guidelines for Stormwater Management in Southern Tasmania (2006)
- Model for Urban Stormwater Improvement Conceptualisation (MUSIC, version 4, 2009)
- Water Sensitive Urban Design Engineering procedures for Stormwater Management in Tasmania (Tasmanian Government 2012)

Best practice guidance on managing urban waterways is provided in the document Tasmanian Waterways and Wetlands Works Manual (2003).This document also provides information on enabling mechanisms to improve the management of stormwater management in Tasmania which addressed capacity building and project financing. These include:

- A review of financing options to support stormwater management
- Education and training activities to increase community awareness and improve skills of stormwater practitioners.

The Tasmanian *Local government Act (1993)* has the provision to levy a number of charges for stormwater management systems for pollution control. Service rates/charges or special rates/charges under the LGA could be used for funding retrofit systems. The trigger for use of such systems is the apparent deterioration of waterways due to contaminated run-off in an established area and the general works program is unable to cover the capital cost of the management systems. For privately funded systems: caution is required on construction quality and O&M needs before handover to council, where pollution occurs enforcement is possible under EMPCA. Also covers permits, pay per use, incentives, and enforcement activities, grant funding and provides risk matrix for catchment assessment.

Reuse of treated effluent from wastewater treatment plants is actively encouraged under the State Policy on Water Quality Management 1997. The EPA conducts the assessment of proposed recycled water schemes, whilst local government is responsible for the regulation of recycled water schemes. Proponents of class B recycled water schemes are advised to consult the Environmental Guidelines for the Use of Recycled Water in Tasmania, December 2002 (Tasmanian Recycled Water Guidelines) which provides an overview of the environmental issues that need to be addressed, the management requirements and information on the preparation of a development proposal and environmental management plan for a recycled water schemes assessment. Proponents of class A recycled water schemes are required to submit applications in accordance with the requirements of the National guidelines for water recycling: Managing Health and Environmental Risk 2006. In addition, the *Effluent Reuse Feasibility Study guidelines* (2011) provide guidance on the information required by the EPA for assessment of reuse feasibility and issue of permits.

Northern Territory

The *Northern Territory Water Act 2004* is the main piece of legislation governing water resource management in the Northern Territory. The Act stipulates investigation, allocation, use, control, protection, management and administration of water resources. The Minister (Department of Land Resource Management) through Controller of Water Resources administers the Act and is responsible for approval of permits and licences under the Act. Public health controls in regards to water supply fall under the Public Health Act administered by the Department of Health and Families. Its implementation and the development of appropriate licensing, regulation and compliance is the responsibility of the Water Management Branch.

The *Act* also regulates the use of water, and allows for beneficial use for water bodies (surface and groundwater), defining applicable environmental values and associated water quality objectives. Under the *Water Act*, an area can be declared a Water Control District, requiring enhanced management for the preservation of groundwater reserves, river flows and wetlands. The current Water control districts are Alice Springs, Daly roper, Darwin Rural, Gove Peninsula, Great Artesian Basin, Tennant Creek, Ti Tree and Western Davenport regions. For such districts, Water Allocation Plans can be declared, where water resources are allocated to various uses and require strategies for management of water use and efficiency.

The *NT Planning Act* governs land development. Development consents are required for subdivision of land. For greenfield in unzoned areas a development application needs to include a land suitability assessment and a stormwater management plan, to address drainage, soil impacts, wastewater management and storm tide, riverine and localised stormwater flooding (NT Government 2014). In addition, development in priority Environmental Management areas may be required to prove that the subdivision will not have detrimental impact on the environment. The Development Consent Authority can place conditions on new developments (Mavlian and McManus, 2009). This mechanism has been adopted in the Darwin Harbour region to incorporate WSUD features as a requisite in new developments.

The *Environmental Impact Assessment Act*, gives the Northern Territory Environment Protection Authority (NT EPA) powers to assess the new development proposals and to provide advice to the Minister for the Environment, when these are deemed to pose a risk to the environment (NT EPA 2013 a).

The Northern Territory does not have a clear overarching policy statement or legislation that promulgates implementation of WSUD (DPI, personal communication 2013, NT Government 2014).

In terms of stormwater management, the Northern Territory government identified the need to manage the impacts of development at regional level and developed the Darwin Harbour Strategy 2009-2015 (Darwin Harbour Advisory committee 2010). The strategy provided a basis for strategic development planning for the Darwin Harbour region by establishing a vision and goals, and a range of supporting mechanisms to allow WSUD implementation on all new large greenfield developments in the Darwin Harbour area (McAuley et al., 2009).

The Water Sensitive Urban Design Strategy for Darwin Harbour focused on the development of policy, tools and resources for the region and was conducted as a collaborative project by the previous Department of Planning and Infrastructure (now Department of Lands, Planning and Environment, DLPE), Department of Natural Resources, Environment, Arts and Sport, NRETAS) with support from the Commonwealth Coastal Catchments Initiative program (NT government 2012b). The Strategy intended to create an enabling environment to ensure commitment to the water cycle and stormwater management through the development of a WSUD framework. This resulted in the development of extensive supporting material to support government agencies, landscapers, engineers and developers to build capacity for the implementation of WSUD, including quantifiable objectives and enforceable targets: through a workshop involving industry practitioners, researchers and local planners, preliminary WSUD design objectives suitable for the Darwin Region have been developed (NT government 2012c). According to the guidelines, stormwater discharged from development areas should be treated with best practice measures to achieve the targets (McAuley 2009b). The load base values derived in the WSUD Planning Guide are based on MUSIC modelling taking account of local conditions and best practice stormwater treatment infrastructure sized to operate at their limit of economic performance. The treatment systems were modelled using standard design parameters for subtropical and temperate regions, although systems in the wet-dry climate of Darwin need to be modified and the impact of such changes in the system performance is unknown (EDAW, 2007).

Up to 2009, there had been extensive activity on the development of guidelines and supporting material to build capacity on WSUD as part of the strategy, with the development of a WSUD objectives, policy and legislation framework, including development classification, modelling, design tools , design guidelines, etc, MUSIC modelling for Darwin, technical analysis, etc (available at the website http://www.equatica.com.au/Darwin/swudstrategy.html). Studies conducted at the time examined the potential for application of a range of WSUD features, such as rainwater tanks, wetlands and bioretention basins to the climatic conditions of the Darwin area. The initiative was also supported by the development of guidelines addressing technical aspects such as operation and maintenance and handover procedures from developers to local government and the documentation of WSUD features design and implementation in a development showcase, Bellmack.

Since 2009, there has been limited progress regarding the incorporation of WSUD into formal legislation, however in practice WSUD requirements are a requisite for any new greenfield development in the Darwin Harbour area stipulated in the Development Agreement for new subdivisions and adopted by local government (e.g. City of Darwin) (NTDPI 2012, personal communication). The interim guidelines are adopted for assessment of WSUD feature design and verification of implemented features which falls under jurisdiction of the DPI. Handover requirements establish that a developer is responsible for operation and maintenance of WSUD features for two years, after which the management responsibility is passed to the local government provided the expected performance and quality are achieved. The implementation in such regard has been facilitated by the limited number of developments and WSUD features in Darwin, approximately less than 30 features in total, which has allowed government approval agencies to closely examine and follow up the progress of WSUD implementation in each of the developments, thus allowing the build-up and capture of in-house capacity on WSUD assessment (NTDPI 2012, personal communication). Further information on WSUD guidelines and supporting material is available in appendix E.

Recycled water schemes are regulated by the Department of Health (DoH) under the Public Health Act and by the *Waste Management and Pollution control Act 1998* administered by the NT EPA. Approval requirements are stipulated based on the volume of recycled water generated. Schemes treating wastewater up to 150 equivalent persons or 22 kL/d fall under the classification of a*lternative on-site wastewater systems* and require (a) product approval, (b) installation by a licensed plumber, and (c) Fulfil the requirements set by the DoH. Operation of larger size schemes need to follow the *Guidelines for Management of Recycled Water Systems –September 2011* (NT DoH 2011a), which adopts a risk management approach aligned to the Recycled Water National guidelines , requires approval from NT Power and Water Corporation and is administered by the Department of Planning and Infrastructure (NT DoH 2011a personal communication). On the other hand the installation of small on-site systems, including greywater systems is controlled by the Building Act and these are certified by self-certifying plumbers or designers within designated building control areas under the *Code of practice for small on-site sewage and sullage treatment systems and the disposal or reuse of sewage effluent* (Northern Territory Government, 1996). Outside of those areas the administering authority is the Environmental Health under the Public and Environmental Health Act for septic tank installations (NT Government 2012a). On-site treatment systems including greywater treatment devices need to be pre-approved by the Department of Health prior to sale in the NT. Regulation/Factsheets on relevant on-site and wastewater management systems are provided at the Department of Health website (last update 2012). These include:

- Principles for incorporation of WSUD Objectives into NT policy and legislation (Mavlian and McManus 2009): assessment of WSUD implementation frameworks, the barriers and opportunities for WSUD in Darwin (McManus 2009) were examined from 2007 to 2009, whilst the intention for adoption into legislation has been stipulated, to date WSUD has not yet been formally integrated into legislation;
- Analysis of WSUD technology options: detailed analysis of technological options and treatment train options suitable for Darwin conditions was conducted and monitoring strategies for verification were developed (EDAW 2007, Knights et al 2009);
- Guidelines and tools for WSUD implementation and assessment: guidelines and tools developed covered concept development and planning (EDAW 2007, NT government 2009a,b, Knights et al 2009, McAuley and McManus 2009), site assessment (McAuley 2009a), modelling and technical design of features (Knights 2009d, McAuley 2009b , McAuley and Knights, 2009), operation and maintenance needs (Knights 2009a, b,c) and handover guidelines (McAuley 2009c).

- Training material and a development showcase: to foster the capacity building a series of ten lectures introducing WSUD and additional literature on case studies were developed, including a WSUD showcase development in Bellmack to demonstrate the design of a range of WSUD features.

Victoria

In Victoria the State Environment Protection Policies (SEPPs) provide the statutory framework of publicly agreed environmental objectives, based on beneficial uses and environmental values. The SEPP also contains some catchment specific schedules - for example for the Port Phillip Bay and the Yarra River. The policy requires that receiving waters should not be compromised by runoff from urban and rural areas and some sections specifically refer to stormwater control.

Melbourne, Victoria, is considered among the capital cities as the most successful in mainstreaming WSUD. This has been supported through a number of factors: (A) Best practice environmental guidelines and defined water targets linked to SEPP; (b) Defined and clear responsibilities for WSUD implementation marked between Melbourne Water (catchments >60ha) and LGAs (catchment up to 60ha), (c) Large number of demonstrations projects and analysis proving concept and cost effectiveness; (d) Capacity building programs: Clear Water and Living Rivers which have been on-going for 5 years, (e) Planning rules amendment of clause 56 in Victoria planning provisions requiring WSUD in new subdivisions, (f) Champions and leading municipal councils; (g) Organisational leadership: Stormwater Victoria, Melbourne Water, Municipal Association of Victoria (MAV), specific urban developers and consulting firms (Morison and Chesterfield 2012).

The *Urban Stormwater: Best Practice Environmental Management Guidelines* (Victorian Stormwater Committee, 1999) provide guidance on the preparation of plans or strategies for the environmental management of stormwater to achieve the water quality objectives established in the SEPP for Victoria. It recognised that there are several ways to estimate the level of treatment required to meet the SEPP objectives such as monitoring, modelling or generic values. The guidelines provide a range of tools and objectives that can be achieved based on receiving waters and best practice.

To standardize the assessment of proposed WSUD measures and to meet the water quality objectives, Melbourne Water has a detailed set of guidelines on the appropriate use of MUSIC modelling within the Melbourne Water catchment zone. The guidelines for the use of MUSIC (Melbourne Water, 2010) define rainfall zones, representative years, modelling parameters for runoff and pollutant generation as well as suggestions for appropriate treatment measures. The purpose of the guidelines is to maintain consistency and to ensure that the assessment and approval process is as efficient as possible.

Guidance for regions outside of Greater Melbourne are provided by the *WSUD Engineering Procedures: Stormwater* (Melbourne Water, 2005), which establish hydrological regions for the remainder of Victoria as well as adjustment factors based on mean annual rainfall. In this scenario, one can determine the area required by a particular treatment to achieve the reduction in pollutants for a development in Melbourne and using the adjustment factors, calculate the required area for a treatment device in a different region of Victoria.

In Victoria, all elements of WSUD - water, wastewater and stormwater - are integrated in Victorian planning policy. An example of this includes the Melbourne 2030 Greener City initiatives and their translation into Clause 12.07 of the Victoria Planning provisions.

The Victoria Planning Provisions regulate the implementation of WSUD in Victoria through Clause 56.07 (Integrated Water Management requirements). Clause 56.07-4 Standard 25 states that:

"The urban stormwater management system must be: Designed to meet the current best practice performance objectives for stormwater quality as contained in the Urban Stormwater – Best Practice Environmental Management Guidelines (Victorian Stormwater Committee 1999) as amended."

New subdivision and greenfield developments must meet the Clause 56.07 requirements, but existing urban areas can have developments approved under Clause 55 which are not subjected to these requirements provided justification for the reasons for an exemption from Clause 56.07 are accepted by the local council – this usually applies to residential subdivisions of one lot into two lots, or 'infill' development in an area of less than 1 hectare and unable to meet best practices for onsite stormwater treatment. Under such circumstances, offset payments may be applicable for the subdivision upon approval by local government and notification to Melbourne Water. Although commercial, industrial and residential developments under clause 55 are not required to adopt WSUD measures – a number of councils have attempted to incorporate IWM requirements for such type of developments by amending their planning requirements (Cities of Bayside, Melbourne, Port Phillip, Stonington and Yarra), but these changes are still under consideration at the office of the Minister of Planning (Morison and Chesterfield 2012). As a result, WSUD is typically implemented in large new greenfield developments. WSUD attempts at street-scale have been seldom, given the tension between traffic users and uncertainty regarding the costing.

In a survey of 36 councils in Victoria, 18% of LGAs indicated that they enforced the Clause 56.07 which forced many councils to consider WSUD assets in their policy, design, construction, community engagement and maintenance (Eggleton, 2012). However, not all councils enforce the requirement for WSUD in subdivisions as per clause 56 (82% out of a sample of 36 LGAs surveyed) (Eggleton 2012).

Clear Water Victoria is a capacity building body instituted in 2002 to improve the capacity of the water industry to enable the transition into water sensitive cities. It serves as a repository and dissemination hub for knowledge exchange, tools and skills build-up programs, providing resources (including links to current legislation and guidelines, case studies, etc for Victoria) and for the promotion of best practices through tours and activities. The program is funded by Melbourne Water, EPA, Municipal Association of Victoria (MAV) and DSE. Refer to Clearwater's webpage for a wide range of WSUD resources, including assistance on Clause 56 exemption application, checklists etc (www.clearwater.asn.com.au). Melbourne Water's website also provides detailed resources for land developers on stormwater management, targets, tools such as offset calculators, etc (http://ldm.melbournewater.com.au/).

The Living Rivers Program is an initiative from Melbourne Water in partnership with 38 LGAs aimed at the development of WSUD guidelines and capacity based on the needs of councils in Victoria initiated in 2006 (Melbourne Water 2012). It aimed to address development of design guidelines for the creation of a framework based on life cycle of WSUD features including design, planning, engagement, governance and capacity building for WSUD, in councils – for support of sustainable stormwater management, including treatment and IWM planning (D'Aspromonte et al, 2012). The program provides funding contributions, expertise and guidance from stormwater planners and WSUD experts to build-capacity, develop and implement projects at local government areas. Additional information on guidelines for WSUD is presented in Appendix E.

From 2006 to 2010/11 there was growth in capacity on WSUD implementation in Melbourne, driven by regulation mandating stormwater treatment of all residential subdivisions and Melbourne Water's initiative of funding capacity building programs via the Living Rivers Program. However, growth had not been uniform across all LGAs (Eggleton 2012). The current WSUD capacity and the factors influencing capacity development can be grouped in three LGA categories: High, low and medium performing councils, with characteristics outlined as per Table D-1. That study showed a strong link between capacity and WSUD commitment.

Overall WSUD is still seen as a passive practice, mostly driven at departmental level from bottom up (not by senior management), with a few exceptions where councils are strongly committed to WSUD practices (Eggleton 2012). Among the challenges is the ability to deal with the increased complexity of IWM, which due to lack of skills excludes the lower capacity councils from adopting more complex treatment features. Data also indicate the need for further build-up of capacity in councils before mainstreaming of WSUD can occur, particularly regarding adequate resources and long-term O&M of features (only 8% have capacity to assess planning permit applications that have stormwater quality management, 18% have targets for stormwater quality, 44% consider SW quality works whenever conducting other infrastructure projects and 34% have budget for stormwater quality works). Thematically developmental needs identified include:

- Commitment: support by senior management;
- Community: want for greater guidance on community engagement from Melbourne Water;

- Champions: valuable for councils with lower perceived capacity, as capacity improves cross-departmental groups take on this role;
- Knowledge and resources, significant increase in knowledge, but still low resource capacity;
- Policy and planning: LGAs seek for direction from Victorian Government via SPP, rather than having to develop and adopt local planning scheme amendments;
- Process management: good progress.
- Maintenance and enforcement: Inadequate knowledge or resources to maintain WSUD treatments – whilst 92% of LGAs undertake routine maintenance of WSUD features and qualitative data indicated adequate knowledge , resourcing may be the largest issue as only one council had a dedicated funding stream for WSUD assets ;
- Implementation: large number of demonstration projects on the ground.

To address the various needs Melbourne Water is implementing different programs on capacity development based on needs of each council and ties through contractual agreements, associated with access to program funding into future years for councils. The capacity building program is tailored to the needs of individual councils and includes training sessions within councils on assessment of WSUD health and operation and maintenance.

Table D-1: Performance attributes (Eggleton 2012)

Category	Characteristics
High	Comprehensive IWM strategies Implementation of targets adopted and in place Technical working groups that facilitate interdepartmental involvement Active champions
Medium	Outdated stormwater plans that have been implemented and are due for review Active champions with some interdepartmental involvement (e.g. via group meetings on project-by-project basis or facilitated individually by WSUD champion)
Low	Typically located in fringe areas faced with rapid growth No comprehensive IWM strategies in place Lack of champions or interdepartmental involvement WSUD implemented on a project-by project basis

Current steps required for further WSUD consolidation as identified by Morrison and Chesterfield (2012) include:

(a) Extension of urban run-off requirements from clause 56.07 to apply to other development types via planning or building regulations;
(b) Need to delineate WSUD responsibilities for stormwater management under the local Government Act – not currently covered by current legislation;
(c) Development of sustainable funding mechanisms: only one council (n=33) had a designated budget for O&M of stormwater features and 34% had a designated budget for construction of stormwater quality works Eggleton et al 2012). E.g. special charge as per the NSW local government Act.
(d) Revision of outdated stormwater management plans (updated targets, plans and actions).

Alternative water sources (rainwater, stormwater, recycled water) are regulated through a range of legislative pieces. The Victorian planning provisions encourage in principle the conservation and wise use of natural resources including water (De Sousa and Hardens 2012). VPP clause 14.02-3 encourages the use of alternative water sources and better management of water.

The *Safe Drinking Water Act 2003* is the regulatory framework for drinking water supplied by water businesses and requires compliance with ADWG and Australian Guidelines for Augmentation of Water supplies. Specific alternative water sources fall under State and national guidelines (appendix E).

Current water resource ownership arrangements are set in the Water Act 1989 (Water Act) which grants the Crown control of all water, except where individual rights are awarded, such as the free use of water from waterways and bores for domestic and stock use, use of rainwater or other water form that occurs on land occupied by a person for any purpose (section 8).

Wastewater and stormwater in the relevant sewerage and stormwater drainage infrastructure can be interpreted as owned by the relevant infrastructure owner, i.e. the relevant water authority, or LGA as per the *Local Government Act 1989* (Vic). Access to such structures for water recycling requires thus negotiation with the relevant parties.

Since 2011, the Victorian government has been conducting major reform of its policy and legislation to achieve better alignment with its current strategy. The *Living Melbourne, living Victoria roadmap* (Living Victoria Ministerial Advisory Council 2011, Government of Victoria 2012), outlines the strategic directions for reform in the water sector which aim to achieve greater diversification of water sources via integrated water management, better integration of urban and water planning and to increase customer choice. The Office of Living Victoria (OLV) was created to drive the reform through coordination of urban and water planning and thus to co-ordinate the delivery of integrated water cycle management in urban areas. The reform aims to facilitate the development of Integrated Water Cycle Plans for growth areas and inner Melbourne; and will examine Water industry regulation and amend the Victoria Planning Provisions to apply the current performance requirements for the management of stormwater more broadly. These will include (i) changes to the Water industry regulation to facilitate greater tariff choice for water customers and to ensure developer charges are cost-reflective; (ii) development of investment guidelines and decision-making tools that better reflect the value that the community places on urban amenity and the environment;(iii) extension of Melbourne Water's stormwater licensing arrangements to cover all government-owned stormwater infrastructure; (iv) Review of regulatory requirements to facilitate use of alternative water sources and (v) facilitate investment in wastewater reuse trough development of guidelines for sewer mining (http://www.livingvictoria.vic.gov.au/policy-objectives.html).

As part of the reform, Clause 56.07-04 of the Victorian planning provisions will undergo review to assess its effectiveness and to investigate the extension of requirements to commercial and industrial land use to improve stormwater management. In addition, among the factors being investigated are the barriers for management of stormwater. In particular, the stormwater offset program is being examined to verify if the current price of offsets is adequate or if it is having the perverse outcome of acting as a hindrance to improve stormwater quality. In the cities of Bendigo and Shepparton the Councils also operate a form of offset scheme (the last one as a trial) but focused on infill developments instead of greenfield.

The *Stormwater Strategy- A Melbourne Water Strategy for managing rural and urban run-off* (Melbourne Water 2013) aligns Melbourne Water's stormwater strategy of to the State's water strategies. It aims to support liveability by promoting the management and use of stormwater to support fit-for-purpose use to reduce mains water use, preserve amenities and support industry and agriculture, through increased collaboration with local government and other stakeholders.

The Department of Health is also currently undertaking review of its legislation and guidelines on alternative water supplies (as per March 2013).

Western Australia

The WA State Planning Policy 2006 (SPP) recognised the urban water cycle and the interconnectedness of all water resources. The State Water Strategy (2003) incorporated design objectives for WSUD and included targets for demand management, water quality and quantity, flood and recommendations for modelling (in Better Urban Water Management 2004).

The 2006 State Planning Policy *2.9 Water Resources* stipulated the consideration of total water cycle management and WSUD principles in local and regional land use planning for new developments consistent with current best management practice (Government of Western Australia, 2006). The policy seeks to achieve no net difference in terms of water quality, unless the post development conditions are better than pre development. The *State Water Plan* (Government of Western Australia, 2007) recognised the need for integrated water cycle management and WSUD for better integration of land and water planning. To provide guidance on the implementation of the Policy, the Western Australia Planning Commission released the document *Better Urban Water Management* (WAPC and WADPI, 2008), providing a framework for the consideration of water resources at different planning stages. Moreover, it identifies the agencies responsible for the required actions at different planning stages and project scales.

Differently from other States, water planning is under the responsibility of the Department of Water, whilst the Water Corporation is responsible for the development and implementation of the *Integrated Water Supply Source Scheme for 2005-2050* (Water Corporation, undated).

Regional or sub-regional strategies or scheme plans are prepared by State agencies and approved by the Western Australia Planning commission (WAPC) on advice from the Department of Water (DoW). Regional water plans are prepared to bring together existing statutory water management, drinking water source protection, drainage and floodplain management plans into one planning document based on a catchment management approach. The regional water plans and drainage and water management plans aim to support an overarching urban water management framework whereby the Department for Planning, the WAPC, local government and developers can obtain necessary data from the Department of Water to inform integrated water cycle management and water sensitive urban design.

Local planning schemes and local structural plans are prepared by landowners or local government and approved by the WAPC (with advice from DoW). Subdivision approvals and urban water management WAPC plans also have to be assessed and approved by the WAPC prior to commencement of civil works. Local government is then responsible for the approval of engineering/construction drawings and specifications regarding compliance with the previously WAPC approved urban water management plans and conditions and is also responsible for monitoring of construction activities. Compliance with water quality best management practices, stormwater management to prevent erosion and transfer of sediment are also expected. Urban water management plans are recommended for large subdivisions (min. 25 lots) or small sub-subdivisions within a priority catchment so that the development can demonstrate how they comply with the policy (State of Western Australia 2008). In summary, the consideration for urban water management is required at all spheres of planning from State to local government and development.

The regional water plans and drainage and water management plans will support an overarching urban water management framework whereby the Department for Planning, the Western Australian Planning Commission, local government and developers can obtain necessary data from the Department of Water to inform integrated water cycle management and water sensitive urban design.

Better Urban Water Management requires developments to maintain surface water concentrations at pre-development levels and, if possible, improve on these conditions. If the stormwater discharges (measured or modelled concentrations) exceed the ambient conditions, the proponent must achieve water quality improvements in the development area or achieve an equivalent water quality improvement offset inside the catchment. Achievement of water quality objectives may be demonstrated using appropriate modelling or other assessment methods acceptable to the Department of Water. For stormwater modelling set water quality objectives are recommended. The *Better Urban Water Management* is aimed for greenfield and urban renewal developments (residential, commercial, industrial), including rural town sites, and was not intended to apply for brownfield and infill or small scale subdivision unless significant water management issues were applicable. Its objectives are: (i) Water conservation with target of 100kL/pe/yr, (ii) water quantity management (to achieve post-development annual discharge volume and peak flow as per pre-development conditions, unless specified otherwise by the ecological water needs of the receiving environment and flood management for up to 1 in 100 ARI to pre-development peak flow, unless negotiated with drainage provider); (iii)Water quality: to maintain surface and groundwater quality at pre-development winter levels and if possible improve the quality of water leaving the development area; drainage (all run-off in the drainage infrastructure network is treated prior to discharge to a receiving environment as per the Stormwater Management Manual to the modelling objectives of minimum 80% reduction TSS, 60% reduction TP, 45% reduction TN and 70% reduction of gross pollutants.

The *Planning and Development Act 2005* sets the requirements for preparation of Local Planning strategies that impact land use and development control. The local strategy needs to identify objectives for water resource management in association with environmental, social and economic issues in the local government area and propose strategies for achieving such objectives. At subdivision level plans have to address the water sources, discharge and management strategies proposed as well as provide an assessment of local conditions and stipulate how these will fulfil water requirements, monitoring frequency (min. 12 months recommended). Assessment of local conditions is the responsibility of the local developer, but can be undertaken by local government with costs recouped from the developers through development contribution schemes.

Large subdivisions and small subdivisions in priority or high risk catchments require an urban water management plan. This is not required for infill/brownfield areas unless there is likely to be severe impact on water resources. The plan needs to address compliance with local and design objectives through modelling, agreed and approved measures to achieve water conservation and efficiency, measures for management of groundwater, detailed stormwater management design, measures for protection of waterways, lifecycle costs for any proposed water body to be constructed, erosion management and amelioration. The stormwater management plans should provide information on location, size, location of public open spaces, flood management capability, impervious surfaces, flood mapping, storages, staging of infrastructure and bmps (location, expected performance an agreed ongoing management including costs).

During the approval process Department of Water serves as main advisory/clearance body (prior to start of works) in addition to local council, during construction local council is the agency responsible for inspections and monitoring. The document recognised that enforcement at local level is challenging and recommends education, best practice development guides and requirements for land zones in town planning scheme, in the absence of zones covenants imposed by developers on residents can apply for landscaping and water efficiency.

Alternative water supply is covered through the *Guidelines for the non-potable uses of Recycled Water in Western Australia* (Government of Western Australia, 2011a) which adopts a risk management approach in line with the National Guidelines for Water Recycling. A Draft Approval framework for the use of non-drinking water in Western Australia is currently undergoing review.

Developments that want to implement recycled water are advised to undertake initial consultation with the relevant local government to obtain further advice and then contact the Department of Water which is the coordinating agency in urban areas. Recycled water schemes (capacity >5000L/d) need the approval of the department of Public Health executive director prior to implementation. Other agencies that may also be involved include water service providers (due to the risk of cross-connections), Department of Environment and Conservation, Economic Regulation Authority, Office of Environmental Protection Authority, Western Australian Planning Commission/Department of Planning (Government of Western Australia, 2011a). The draft approval framework for the use of non-drinking water in Western Australia has a framework for developers or councils that want to implement recycled water schemes and outlines the approval process (Government of Western Australia 2010a). Consultation with other government departments and the DoW is recommended for accessing information, such as consideration for alternative water sources, etc.

Towards a Water sensitive city - an overview of the stormwater science plan for better urban water management (Government of Western Australia, 2010b) was a draft science plan for assessment of stormwater status and condition in WA regarding the identification of knowledge gaps and prioritisation of needs to improve stormwater management. The recommendations included: (i) the development of planning and assessment tools for use at various scales, (i) the need for coordination, data management and knowledge sharing among stakeholders to provide increased access to synthesized data among stakeholders; and (iii) the need for developing long-term strategic water monitoring programs to determine impact, better understand structural and non-structural management devices for WA conditions, minimum environmental flow requirements and understand pollutant transfer pathways. The improvement in communication, networking and coordination were seen as key requirements to progressing WSUD (Walkerden, 2007). In response to the recommendations, the Department of Water developed a wide range of technical sheets and supporting documentation to explain WSUD step-by-step and facilitate the implementation of WSUD by local government and developers (Government of WA 2011b).

The Department of Environment is responsible for policy development, environmental criteria and strategic planning. Local government is responsible for management of stormwater in their area. Water Corporation is licensed to provide drainage services for main or arterial drains in selected declared areas. In rural areas landholders need to obtain approval to construct large drainage works, evaporation basins and groundwater extraction from the Commissioner of Soil and Land Conservation. Local government is in charge of including stormwater management objectives in town Planning Schemes, development plans and applications.

Information on WSUD can be found at the New Water Ways website (http://www.newwaterways.org.au/). The website was developed in 2006 with State and Federal funding to enable capacity building on IWCM among government and industry practitioners. It is a knowledge/resource sharing centre (legislation, case studies, training, programs, technical, bmps, tools, news), which serves as a bridging agency between agencies in the WA water sector. Currently it is a partnership between a range of government departments (Department of Planning, Department of Water, WA LGA, Water Corporation, UDIA (WA) and the Swan River Trust) and advocates for bmp for WSUD. UWA together with Monash University and University of Queensland have joined the CRC WSC. The website provides links to the relevant policies and guidelines for the region at State and local level.

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Appendix E. Legislation across Australia

National Guidelines

Water quality guidelines

- Australian Guidelines for Water Quality Monitoring & Reporting (ANZECC, ARMCANZ 2000a)

Diffuse and point sources

- *Guidelines for urban stormwater management* (ARMCANZ, ANZECC 2000)

Guidelines for Sewerage Systems

- Guidelines for sewerage systems - use of reclaimed water (ARMCANZ, ANZECC, NHMRC 2000)

Water recycling

- *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks(*NRMMC, EPHC, AHMC 2006)
- *Overview of the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) (*NRMMC, EPHC, AHMC 2008*)*
- *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2): Augmentation of Drinking Water Supplies (*EPHC, NHMRC, NRMMC 2008*)*
- *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2): Stormwater Harvesting and Reuse (*EPHC, NRMMC, AHMC 2009a)
- *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2): Managed Aquifer Recharge (*EPHC, NRMMC, AHMC 2009b)

WSUD

- *Evaluating Options for Water Sensitive Urban Design (WSUD)* is a comprehensive national reference, providing guidance on how WSUD options can be evaluated for those assessing and designing water sensitive urban developments (July 2009). It also outlines status of legislation across various States at the time(http://www.environment.gov.au/water/publications/urban/pubs/wsud-guidelines.pdf)

Australian Capital Territory

Relevant Legislation

National (Water Act 2007, Corporations Act 2001, Privacy Act 1988), ACT (Independent Competition and Regulatory Commission Act 1997, Territory-Owned corporations Act 1990, Work Safety Act 2008, Utilities ACT 2000, Water Resources Act 2007, Environment Protection Act 1997, Water and Sewerage Act 2000, Public Health Act 1997.

Water Quality Environment Protection Policy - April 2008 (EPA ACT 2008)

Alternative water sources

- *Rainwater tanks: Guidelines for residential properties in Canberra*- October 2010 (ACTPLA 2010)

- *Greywater Use: Guidelines for residential properties in Canberra* - October 2007 (ACT Government 2007)
- *Plumbing note 24- Grey water drainage separation and provision for rainwater plumbing* (single residential buildings) - May 2012 (ACTPLA 2012).

Water efficiency

- *Single residential waterways calculator,* a water reduction calculating tool, a waterways calculator for single residential waterways, commercial development waterways and Multi-unit waterways for water efficiency implementation based on Canberra local conditions (ACTPLA, 2008c)
- *Commercial development waterways calculator,* a water reduction calculating tool for comparison of water consumption of commercial, industrial or institutional developments with and without water savings features (ACTPLA 2008a)
- *Multi-unit waterways calculator,* a water reduction calculating tool for comparison of water consumption in dual occupancy to multi-storey apartments with and without water saving features (ACTPLA 2008b)
- *Water efficiency - Requirements for sustainable water and waterways management* (2008) (ACTPLA, 2008b)(http://www.actpla.act.gov.au/topics/design_build/siting/water_efficiency#residential, accessed Jan 2013)

Stormwater

- *Waterways - Water sensitive urban design general code -* July 2009, sets mandatory targets for reduction in mains water consumption and stormwater quality and quantity management (ACTPLA, 2009) (http://www.legislation.act.gov.au/ni/2008-27/copy/64663/pdf/2008-27.pdf)
- *Guidelines for the preparation of estate development plans* – May 2009, outlines the general planning requirements for greenfield subdivisions (ACTPLA, 2009) .
- *Stormwater pollution from residential areas* – June 2012, a factsheet for residents to provide information on management of stormwater from household activities carried at property scale (e.g. car washing, landscaping, gardening, swimming pools, handyman activities) (ACT Environment 2012).
- *Design Standards for Urban Infrastructure, 1 Stormwater (*ACT Government undated), specifies mainly design standards for stormwater infrastructure.
- Achieving sustainable residential development (ACTPLA): advises on WSUD measures in and around the home.

Wastewater reuse

Recycled water schemes in Canberra are managed the ActewAGL for non-potable uses such as open space irrigation. Access to recycled water requires approval from ActewAGL (Actew Corporation Ltd, 2011)

- *ACT Wastewater reuse for irrigation* –July 1999 (ACT Government 1999)
- *ACT environment and Health Wastewater Reuse guidelines* – April 1997 (ACTPLA 1997).

New South Wales

Policies and legislation for NSW on water can be found at website of the Department of Primary industries, Office of Water (http://www.water.nsw.gov.au/Water-Management/Law-and-Policy/default.aspx.)

Water supply and sewerage services: is the responsibility of three state owned metropolitan water utilities (Sydney Water, Sydney Catchment Authority and Hunter Water) and 105 regional local water utilities

(LWU). The 105 LVUs operate under the Local government Act. The three State owned utilities have their own Acts.

The NSW Office of Water (NOW) manages the Country Towns Water supply and Sewerage Program, oversees and monitors utility performance and is the primary regulator for the 105 LVU's under the NSW Best-Practice Management of Water Supply and Sewerage Framework. Compliance with the framework establishes the eligibility for local government financial assistance towards capital costs of backlog infrastructure and for dividend payments to councils. NOW also reviews LWU's business plans and licenses the extraction of water from natural surface and groundwater sources for supply to Hunter Water and LWU customers.

LWUs are required to prepare 20-30yr strategic business and financial plans, community consultation and drinking water quality management plans based on ADWG 2011. The 30-yr integrated water cycle management strategy for water supply, sewerage and stormwater has to be based on triple bottom line considerations and is reviewed by the NOW.

IPART (Independent Pricing and Regulatory Tribunal) is the licence compliance regulator for the three major metropolitan water utilities and sets the price caps for Gosford city council, Wyong shire Council and Essential Energy for provision of bulk water services, water and sewerage services.

NSW Health regulates water quality in New South Wales and administers functions relating to water suppliers (Sydney Water, Hunter Water and the LWUs) under the Public Health Act. NSW Health also enters into memorandums of understanding with the metropolitan water utilities to facilitate interaction between the agencies, and to establish the scope of drinking water management plans and procedures for communicating the results of water quality programs. NSW Health also conducts the NSW Drinking Water Quality Program, which tests and monitors the water quality of samples collected by the LWUs in accordance with the Australian drinking water guidelines 2011.

The Office of Environment and Heritage issues environmental protection licences and regulates the environmental impact of water utilities' operations under the Protection of the Environment Operations Act, and through memorandums of understanding with the utilities. Annual reports of compliance performance, required by the licences, are publicly available on the Environment Protection Authority website.

The Dam Safety Committee: regulates the water utilities with respect to dam safety. The Dams Safety Act enables the committee to direct the utilities to undertake works, surveillance and emergency planning to ensure the safety of dams in New South Wales.

Relevant Legislation

National (Corporations Act 2001, Privacy Act 1998), NSW (Water Management Act 2000, Water Act 1912, Protection of the Environment Operations Act 1997, Independent Pricing and Regulatory Tribunal Act 1992, Environmental Planning and Assessment Act 1979, State Owned Corporations Act 1989, the Dams Safety Act 1978, the Local Government Act 1993, the Fisheries Management Act 1994, the Public Health Act 2010, the Fluoridation of Public Water Supplies Act 1957, the Public Finance and Audit Act 1983, the Water Industry Competition Act 2006, the Hunter Water Act 1991, the Sydney Water Act 1994 and the Sydney Water Catchment Management Act 1998.

Alternative water sources/ Wastewater reuse

Guidelines

- *Guidelines for Greywater Reuse in Sewered, Single Household Residential Premises* – May 2008, explains the appropriate management, risks and best practices for untreated greywater for lawn and garden irrigation and for use in toilets and washing machines after appropriate treatment (DEUS 2008).
- *Environmental Guidelines: Use of Effluent by Irrigation* - adopted in NSW for the use of effluent for irrigation in non-domestic applications. The document covers the broad framework, principles, objectives and best management practices for effluent based irrigation systems (DEC 2004)
- *Interim NSW guidelines for Management of Private Recycled Water Schemes* – May 2008, covers private recycled water schemes larger than a single lot in NSW and includes advice on approval to install and operate a private recycled water scheme within the existing NSW legislative framework (DWE 2008).
- *On-site Sewage Management for Single Households* - the guidelines aim to assist local councils to assess, regulate and manage selection, design, installation, operation and maintenance of single household on-site sewage management systems treating up to 2000 litres of wastewater a day (DLG 1998).
- *Sewer Mining: How to establish a sewer mining operation* – SW8 07/13, an information brochure that contains details about sewer mining, requirements, and how to set up a sewer mining operation, including approval procedure, Sydney Water's Sewer Mining Policy, exclusion zones, and contact details (Sydney Water 2013).

Water efficiency

- *BASIX water efficiency program* (NSW Government 2008).

Stormwater

- *Managing urban stormwater: harvesting and reuse* (DEC 2006)

NSW Government has developed a series of guidelines to assist LGAs in stormwater management:

- *Marine water quality objectives for NSW ocean waters* (2005) (non-mandatory), applicable to the Sydney Metropolitan and Hawkesbury-Nepean, Hunter and Central Coast, South Coast and North Coast (New South Wales Government 2005).
- *Investing in our catchments: Water quality and its role in river health* (New South Wales Government 2004)
- *Local planning for healthy waterways – using NSW Water Quality Objectives*(New South Wales Government 2006, DEC 2006)
- *Water Sensitive Urban Design –Book 1- Policy draft* (Landcom 2009a)
- *Water Sensitive Urban Design –Book 2- Planning and maintenance* (Landcom 2009b)
- *Water Sensitive Urban Design –Book 3- Case studies* (Landcom 2009c)
- *Water Sensitive Urban Design –Book 4- Maintenance Draft* (Landcom 2009d)
- For other Stormwater resources see (http://www.environment.nsw.gov.au/stormwater/publications.htm)
- *Stormwater Facilities Database* (Upper Parramatta River Catchment Trust 2012): a database for searching features per LGA, feature type and catchment. The database contains information such as features, location, function, maintenance and contact details for a range of stormwater projects in the Upper Parramatta River Catchment.

- *Case studies: Effective stormwater education* (NSW Government 2011): a website in the NSW environment and Heritage website (last update 26 Feb 2011) outlining 21 case study/examples on stormwater education programs for the community.

Capacity building

- *WSUD in Sydney* (http://www.wsud.org/) is a website dedicated to WSUD resources in Sydney. The program was initiated by the SMCMA and is one of many stormwater management regional and national capacity initiatives. It aims at capacity building and knowledge exchange through provision of a forum for information exchange, case studies and other resources. The initiative coordinates training workshops, research initiatives, newsletters, etc. It also provides links to other programs aimed at WSUD across different states and to research organisation/programs aimed at WSUD. It was developed as a collaboration between the Upper Parramatta River Catchment trust (UPRCT), the Western Sydney Regional Organisation of Councils Ltd (WSROC) and Sydney Coastal Councils Groups (SCCG), the NSW Stormwater Trust and Sydney Water.

- *Capacity building in WSUD in the Sydney Region*: an initiative by the Upper Parramatta River Catchment trust, the Western Sydney Regional Organisation of Councils Ltd (WSROC) and Sydney Coastal Councils Groups (SCCG). WSROC is a conglomerate of ten LGA in the Western Sydney region (see http://www.wsroc.com.au/). SCCG is formed by fifteen LGA located in marine and estuarine environments in NSW (see http://www.sydneycoastalcouncils.com.au/). A steering committee was formed in late 2000 to guide planning and delivery of the Sydney WSUD capacity building program (2001) (http://www.uprct.nsw.gov.au/sustainable_water/projects/capacity_wsud.htm). It now directs users to *WSUD in Sydney* for current information.

- *Integrated Water Cycle* Management (Department of Primary industries 2011): the website provides information and factsheets on Integrated Water Cycle Management (IWCM), links such as Integrated Water cycle management guidelines for NSW local water utilities (DEUS 2004), decision support systems and models for IWCM demand management (2006), Rainwater tank model (2006) and demand trend tracking and climate correction provided in the website (last update September 2011).

Northern Territory

Relevant legislation

Water Supply and Sewerage Services Act sets the regulatory framework for water and sewerage in NT. The *Water Act* provides for investigation, allocation, use, control, protection, management and administration of water resources and related purposes, it gives the Dept. of Land Resource Management the power to issue of waste discharge licenses and water extraction licences for Water Resources. Waste Management and *Pollution control Act*. Key roles include:

Department of Treasury and Finance: oversees the economic regulation under the Act.

Minister of Essential Services: oversees supply and service provision under licences.

Department of Health: oversees water quality standards aspects (applies guidelines and monitors compliance).

Utilities commission: issues licences for supply of water and sewerage for defined, gazetted, geographical areas. These areas are defined by the minister of Essential Services.

Power and Water Corporation (PWC): is the licensed utility responsible for provision of safe drinking water, water quality monitoring programs and emergency directions. Emergency directions are issued by the

Department of Health as per the Drinking Water and Operational and Verification Monitoring Program as per the ADWG 2004. PWC assesses water recycling schemes. It is the licensed entity responsible for supply of water and sewerage to Darwin, Katherine, Tennant Creek, Alice Springs and Yulara and other 13 minor centres. In the NT no distinction exists between urban and rural areas under legislation regarding operation areas.

Northern Territory Utilities Commission: is the independent Industry regulator responsible for licensing functions under the Act.

Department of Land Resource Management and Environmental Protection Authority: has roles in protecting water quality, including the regulation and management of water resources and the regulation of pollution control.

Department of Construction: role in protecting water quality through land-use planning in the Northern Territory. In addition, legislation such as the Water Act and the Land Acquisition Act contains provisions for infrastructure and land use relating to water supply.

Northern Territory Environment Protection Authority: receives annual audit and compliance reports for observance of waste discharge licences and associated environmental impacts.

Water and sewerage tariffs and charges are regulated by the Northern Territory Government via a Water and Sewerage Pricing Order issued by the Treasurer as regulatory minister. The Utilities Commission monitors compliance with the pricing order and enforces it under section 23 of the *Utilities Commission Act*. The commission is also required to investigate any complaints made to it by customers about noncompliance with the prices outlined in the order.

Alternative water supply

The set-up of on-site treatment for wastewater and small scale greywater systems is found in the Northern Territory Department of Health and Families resource page on Environmental Health and Wastewater management (http://www.health.nt.gov.au/Environmental_Health/Wastewater_Management/index.aspx). In the Northern Territory the recycled water quality guidelines adopt the national guidelines by default. For single dwellings and on-site property reuse, the Department of Health (DoH) requires adoption of an approved system technology, compliance of plumbing as per the building Act 1993 and installation by a licensed plumber for on-site treatment systems. A list of greywater and aerated systems products/technologies approved by the Territory government is also provided. For any recycled water systems (applies to greywater and sewage) approval from the DoH is required, with additional consultation with Power and Water if the connection to the sewerage system applies and a license from the Department of Natural Resources, Environment and Arts (NRETAS) if the scheme fall under the Waste Management and Pollution Control Act 1998. Large scale recycled water schemes (> 150ep or 22kL/day) require the development of a proposal as outlined in the Guidelines for Management of Recycled Water systems (NT Government 2011). Local government had no jurisdiction over recycled water systems.

WSUD

The WSUD Strategy for Darwin Harbour aimed to create an enabling environment to ensure commitment to water cycle and stormwater management through the development of a WSUD framework linking:

- A definition of WSUD, including a set of guiding principles
- Clear quantifiable objectives and enforceable targets
- WSUD policy
- Guidelines and tools for WSUD concept development, technical design, operation and maintenance
- Training programs
- WSUD showcase developments and illustrative projects

This resulted in extensive development from 2009 of NT WSUD policy and legislation framework, including remarkable progress in all aspects of WSUD such as development classification, modelling, tools , etc, Design guidelines, etc, MUSIC modelling for Darwin) (found in the website http://www.equatica.com.au/Darwin/publication.html).

Alternative water sources

- Code of practice for small on-site sewage and sullage treatment systems and the disposal or reuse of sewage effluent – *November 1996.*
- Guidelines for Management of Recycled Water Systems –September 2011 (NT DoH 2011a): adopts a risk management approach aligned to the National guidelines; it provides a framework for public health and environmental risk assessment for large recycled water schemes (>150EP or 22 kL/d) , introduces approval requirements and examples of the operation of schemes
- Guidelines for Private Water supplies –Jan 2012 (NT *DoH 2012*): covers small private supplies from groundwater, surface water and rainwater and adopts a risk management approach for the compliance with the Australian drinking water guidelines
- Environmental Health Fact sheet No.503 – Permanent Greywater Reuse in Single Domestic Premises (Northern Territory DoH, 2011b)
- Environmental Health Fact sheet No.502 – Manual bucketing & temporary diversion of greywater in Single Domestic Premises (Northern Territory DH, 2011b)
- Environmental Health Fact sheet No.501 - Disposal of Septage from On-site Wastewater Systems (Northern Territory DHCS, 2005b).
- *Environmental Health Fact sheet No.500- Decommission or reuse of on-site wastewater systems* (Northern Territory DH, 2011a)
- *Environmental Health Fact sheet No.512 – Standards for microbiological quality of recycled water for irrigating food crops (NT DH 2011c)*
- *Environmental Health Fact sheet No.513 – Recycled water irrigation: information guide for applicants (NT DH 2011d)*
- *Environmental Health Fact sheet No.404 - Disinfection of Rainwater Tanks, Northern Territory Department of Health and Community Services* (Northern Territory DH 2011e)

Stormwater

Resources are found in the Darwin Harbour Water sensitive urban design strategy website at http://www.equatica.com.au/Darwin/about.html.

- *Darwin Harbour Strategy* (Darwin Harbour Advisory committee/Northern Territory Government/EPA NT 2010)
- *Fact sheet - Stormwater Safe Car Washing NT Governmen*t (Northern Territory Government undated a)
- *Fact sheet - Stormwater and washdown water pollution from building sites and Commercial/Industrial premises* (Northern Territory Government undated b).
- *Fact sheet - Vehicle/Plant or Equipment Washdown Facilities* (Northern Territory Government undated c).
- WSUD Practice Guide final, May 2009 – (McAuley and Knights 2009).
- WSUD Rainwater tank discussion paper – May 2009 (Knights et al. 2009).
- WSUD implementation framework for Darwin discussion paper final, May 2009, (McAuley et al 2009)
- WSUD operation and maintenance guidelines, April 2009 (Knights 2009a).

- Water sensitive urban design water quality monitoring strategy (Knights 2009b)
- Constructed wetlands in the NT – guidelines to prevent mosquito breeding a review, May 2009 (Knights 2009c).
- Vegetation selection guide, May 2009, (Knights 2009d)
- Water Sensitive Urban Design Objectives and Options for Various Development Types, May 2009, (Knights, Henderson, C and McManus 2009)
- Draft Stormwater Management Strategy, March 2006 (NT EPA 2006).
- Factsheet 1 - Introduction to WSUD, Northern Territory Department of Planning and Infrastructure, (NT government 2009a) .
- Factsheet 2 – WSUD process, tools and resources, Northern Territory Department of Planning and Infrastructure (NT government 2009b)
- NT government (2012a), Water Act, Northern Territory government, http://www.austlii.edu.au/au/legis/nt/consol_act/wa83/, accessed Jan 2014.
- Recommendation for implementation of WSUD strategy within existing legislation and policy framework – discussion paper, May 2009, NT Department of Planning and Infrastructure (Mavlian, and McManus 2009).
- WSUD site assessment guide, May 2009, prepared for the Northern Territory Department of Planning and Infrastructure, (McAuley 2009a)
- WSUD technical design guidelines, May 2009, prepared for the Northern Territory Department of Planning and Infrastructure, (McAuley 2009b)
- WSUD Construction, establishment, asset handover and maintenance guide, May 2009, (McAuley (2009c)
- WSUD stormwater quality modelling guide, May 2009 (McAuley and Knights 2009).
- WSUD planning guide (Mcauley and McManus 2009).
- Water sensitive urban Barriers and Opportunities in Darwin - Discussion Paper (McManus 2009).

Queensland

Relevant legislation

The *Water Supply (Safety and Reliability) Act 2008* (the Water Supply Act) provides a framework for the delivery of water and sewerage services throughout Queensland.

The *South-East Queensland Water (Distribution and Retail Restructuring) Act 20*09 provides for council-owned distributor–retailers in south-east Queensland (SEQ). The *South-East Queensland Water (Restructuring) Act 2009* outlines bulk water service providers in SEQ. Department of Energy and Water Supply (DEWS) jointly administers this Act with the Department of Treasury and Trade. On 1 July 2011, WaterSecure and Seqwater merged to provide bulk water supply. Allconnex, the Gold Coast distributor–retailer, was disestablished on 1 July 2012, and services will now be provided by the Gold Coast, Logan and Redland City councils. On 1 January 2013, the Queensland Water Commission was disestablished; its policy functions were transferred to the Department of Energy and Water Supply (DEWS); and its planning and regulatory functions were allocated to the new bulk water supply authority (Seqwater), and the SEQ council water business (distributor-retailers).

Seqwater was formed by the merge of the Seqwater Grid Manager, Seqwater and Linkwater. It has the mandate to develop a water security program for SEQ. It manages all bulk water infrastructure: dams operation and management, water treatment plants, recycled and desalinated water and major pipelines, flood mitigation services and irrigations services to around 1000 rural customers.

The Bulk Water supply code regulates the supply of bulk water and replaces the Seqwater market rules on 1 Jan 2013 (State of Queensland and DEWS 2013).

Water utilities are referred to as ‘water service providers’ (WSPs) in Queensland’s legislative framework. Queensland has a total of 162 registered WSPs, of which 82 are urban water and sewerage service providers (urban service providers) and 80 are non-urban water service providers. The largest populations are supplied by service providers in the south-east corner of the state and the major centres along the coast. The smaller providers commonly service small and remote locations, such as Indigenous council areas and rural towns. The 71 urban service providers outside SEQ are predominantly small and medium-sized, including 16 Indigenous providers. Sixty one of the urban service providers outside SEQ provide both water and a sewerage service. Very few urban WSPs supply solely a water or sewerage service. A water service outside SEQ may include water storages, groundwater and surface water extraction, treatment facilities, and transmission and retail distribution networks.

WSPs are governed by the *Water Supply (Safety and Reliability) Act 2008*. Of the 82 urban service providers in Queensland, 71 are located outside SEQ (11 large, 26 medium and 34 small service providers). Of these, 62 are local government entities. They include: local government, government owned corporations, water boards, drainage boards, bore water boards, statutory bodies and private companies.

In SEQ, there are five large service providers: the three local government-owned distributor–retailers (Allconnex Water, Queensland Urban Utilities and Unitywater) and the two bulk service providers (Seqwater and LinkWater). WaterSecure and Seqwater merged to form one bulk supply authority on 1 July 2011, and the authority trades as Seqwater. The Seqwater Grid Manager procures services from Seqwater and LinkWater and sells the potable water supplied through those services to grid customers, such as the distributor–retailers.

The *South-East Queensland Water (Distribution and Retail Restructuring) Act* provides for the separation of the retail and distribution functions from SEQ local governments and the establishment of the three separate distribution–retail businesses described above. The bulk service providers supply only a water service, while the distributor–retailers provide both water and sewerage services. They operate within the following framework of regulation:

• DEWS: is the water supply regulator, administrator of various plans and in charge of information storage under the Water Supply Act. It is also responsible for the Customer Water and Wastewater code.

- Department of Environment and Heritage Protection controls water quality and discharges to the environment (*Environmental Protection Act 1994*, regulations and policies).
- Department of Energy and Water Supply (DEWS) oversees infrastructure management (*Water Supply Act, South-East Queensland Water (Distribution and Retail Restructuring) Act, South-East Queensland Water (Restructuring) Act*);
- Department of Local Government (DLG) oversees local government role (*Local Government Act 2009* and Regulations). Under the Local Government Act 2009, there are numerous reporting requirements applying to councils in their role as local governments but not specifically in their role as WSPs.
- Department of Housing and Public Works (DHPW) oversees the building regulation (*Plumbing and Drainage Act 2002* and Queensland Development Code)
- Department of State Development, Infrastructure and Planning (*Sustainable Planning Act 2009*).
- Queensland Water Commission controls pricing (*South-East Queensland Water (Distribution and Retail Restructuring) Act; Fairer Water Prices for South East Queensland Amendment Act 2011*)
- Queensland Competition Authority investigates and reports on the pricing practices, competition and arbitrates access and water supply disputes (*Queensland Competition Authority Act 1997*).
- Queensland Health oversees public health aspects of water supply (*Public Health Act 2005* and Regulations; *Water Fluoridation Act 2008* and *Water Fluoridation Regulation 2008*). Drinking water guidelines based on the ADWG 2011.

The draft State planning policy *Guidelines Healthy Waters* (April 2013) set requirements for inclusion of total water cycle management in the planning and making of community and private development and the development of strategies for the protection of environmental values and achievement of water quality objectives, planning instruments need to be linked to Urban Stormwater Quality planning guidelines 2010 , which promote the adoption of sustainable practices for residential, commercial and industrial development to include WSUD principles and water conservation (State of Queensland 2013).

The policy stipulates at state level the inclusion of TWCQM and WSUD principles to achieve compliance with environmental objectives, requirements for WSUD in planning and local development plans are established such as water quality targets. The policy is non-prescriptive in that it provides guidelines on how to develop local objectives and conduct environmental assessments. In addition it is also supported by a wide array of documentation that facilitates the uptake of WSUD including technical guidelines, economic assessment, plant selection, examples of best cases among others.

The *Urban Stormwater Quality planning Guidelines 2010* supports improved urban stormwater quality and flow management, including the State Planning Policy Guideline for Healthy Waters. The Guidelines provide design objectives for stormwater quality and flow management, planning controls, guidance on selection of structural treatment measures, urban stormwater quality management plans, set conditions and plans for best practices for sediment and erosion control. They also provide references to Qld specific resources at State, regional and local level such as modelling tools tailored to the local climate and recommendations on local systems (State of Queensland 2013).

In addition a range of Qld specific guidelines, tools and resources are available in the Water by Design Website, including the business case for WSUD in Qld. Current resources under development include an asset handover and operation and maintenance guidelines in recognition of the current gaps in the area.

The primary water quality management legislation in Queensland is the *Environment Protection Act* (EP Act), which provides a clear statutory framework for setting and achieving community endorsed environmental values (EVs) and water quality objectives (WQOs). Queensland Urban Drainage Manual serves as guideline for engineers and designers for planning and design of stormwater systems in Queensland (http://www.nrm.qld.gov.au/water/regulation/drainagemanual.html).

The current EP Act framework comprises three State planning instruments acting through local government planning schemes:

- *Environment Protection (Water) Policy 1997*— the EPP (Water) establishes the State interest in protecting and managing urban stormwater in development assessment and State/regional/local planning. The EPP establishes the EVs of Queensland waterways and the WQOs to protect those EVs and state how they should be considered in decision making. The WQOs include planning targets for receiving water (freshwater, estuarine and marine) quality in ambient conditions to help achieve the objective of the *Environmental Protection (Water) Policy 1997* and protect the EVs in Queensland waterways. The EPP is due to be reviewed by 2008. A draft EPP Water 2008 is currently available.
- *South East Queensland Regional Plan 2005–2026*—the SEQ Regional Plan endorses the consideration of EVs and WQOs in planning and development assessment decisions (Principles 11.5, 2.5).
- *State Coastal Management Plan 2001* (SCMP)—the SCMP includes water quality and urban stormwater management policies for coastal waters—to be considered in planning and development assessments under the *Integrated Planning Act 1997* (IPA). The SCMP's aim is to maintain and protect the EVs of coastal waters. Its regional derivative, the *South East Queensland Regional Coastal Management Plan 2006*, is consistent with the *SEQ Regional Plan*, and has the effect of a State planning policy under the IPA.

The South East Queensland Healthy Waterways Strategy 2007-2012-Water Sensitive Urban Design Action Plan, sets the policy framework for the region's stormwater management and a series of location specific action plans (SEQHWW, 2007).

The EPP Water also contains catchment specific EVs and WQOs in Schedule 1 for selected catchments. Further catchment EVs and WQOs are under development. The EPP Water and Queensland Water Quality Guidelines 2006 provide receiving water EVs and WQOs in other freshwater, estuarine and marine waters where no catchment specific values have been established in Schedule 1.

Other relevant publications include:

- SEQ Regional Plan 2009–2031 and Implementation Guideline No. 7 Water Sensitive Urban Design Objectives for Urban Stormwater Management (November 2009)
- Water Sensitive Urban Design Technical Design Guidelines for South East Queensland (South East Queensland Healthy Waterways Partnership 2006).

• Concept Design Guidelines for Water Sensitive Urban Design Version 1 (Water by Design 2009a): includes information on the conceptual design development for best practice sustainable urban water management, information on design tools and best planning practices tailored for SEQ (South East Queensland Healthy Waterways Partnership, Brisbane, March 2009).

- Draft Stormwater harvesting guidelines (Water by Design 2009b)
- MUSIC Modelling guidelines (Water by Design 2010a): guidelines tailored to SEQ conditions.
- Deemed to Comply Solutions—Stormwater Quality Management (South East Queensland) (Water by Design 2010b).

• Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands Version 1.1, (Water by Design 2010c).

• A business case for best practice urban stormwater management (Water by Design 2010d): economic benefits and constraints from WSUD analysis by Water by Design established that the benefits from WSUD outstrip the costs.

• Bioretention Technical Design guidelines (Water by Design 2012a)

• Transferring ownership of vegetated stormwater areas (Water by Design 2012b)

• Maintaining vegetated stormwater assets (Water by Design 2012c)

• Rectifying vegetated stormwater assets (Draft) (Water by Design 2012d)

- 'Toward a Water sensitive city' (State of Queensland 2010b): a handbook that illustrates the thinking process for holistic planning through a number of case studies which adopted IUWM principles. It was designed to assist in the change of mindset required for increasing the capacity of urban water managers.
- Queensland Water recycling guidelines- Dec 2005 (Queensland Government 2012).

In addition, there are a number of Regional NRM Plans and Water Quality Improvement Plans, such as Far North Queensland Regional Plan 2009–2031 (State of Queensland 2009), Townsville/Thuringowa (Aecom & McGarry and Eadie 2011) and Mackay Whitsunday Water Quality Improvement Plan (Drewry et al 2008).

Tasmania

Legislation

Water and Sewerage Corporations Act 2008 addressed the structural elements of the reforms, while the *Water and Sewerage Industry Act 2008* (the Industry Act) addressed the economic regulatory elements. Industry Act requires any persons or entity owning and/or operating water and/or sewerage infrastructure, or supplying water and/or sewerage services to others, to be licensed, unless otherwise exempted.

The operator licences place a number of regulatory obligations on licensees through reference to various regulatory instruments such as codes and guidelines, as well as requiring the preparation of management plans in relation to matters such as asset and emergency management and compliance.

The Water and Sewerage Industry Act provides for the establishment of an economic regulatory framework for the provision of water and sewerage services. It also provides for a number of transitional arrangements to apply until all elements of the new regulatory framework are fully implemented.

The economic regulatory framework is focused on ensuring competitive market outcomes from the sector in relation to both price and service, ensuring the financial sustainability of the water and sewerage corporations and providing sufficient funding to meet other regulatory obligations.

Industry regulators for the sector include the Tasmanian Economic Regulator, the Director of the Environment Protection Authority, the Director of Public Health and the Secretary of the Department of Primary Industry, Parks, Water and Environment.

Economic regulator: administers the licensing system, establishes and maintains the customer service code, regulates prices and terms and conditions for regulated services.

Director of Public Health: responsible for drinking water quality and safety through the application of drinking water guidelines and for the fluoridation of drinking water. Department of Health and Human Services ensures compliance with regulatory obligations under the *Public Health Act 1997* and the *Tasmanian Drinking water quality guidelines 2005*. Under the guidelines, any laboratory tests of drinking water must be performed by an accredited laboratory. If results obtained from drinking water tests indicate that there is, or is likely to be, a threat to public health, then the laboratory that performed those tests must notify the Director of Public Health.

Tasmania EPA: administers and enforces the provisions of the *Environmental Management and Pollution Control Act 1994* and is principally concerned with the prevention, reduction and remediation of environmental harm.

Department of Primary Industries, Parks, Water and Environment is responsible for the administration of the *Water Management (Safety of Dams) Regulations 2011*.

Three regional water and sewerage corporations oversee provision of services to 28 local council areas: Ben Lomond Water, Cradle Mountain Water and Southern Water. These three entities are owned by local government. Onstream provides common services to the three, e.g. call centre operations. From 1 July 2013, a single water corporation was in charge of water and sewerage to the state – this aimed to integrate infrastructure planning across the state and ensure consistent service delivery.

Stormwater

A series of technical guidelines have been produced to aid in the implementation of WSUD based on best practices:

- Water Sensitive Urban Design – *Engineering procedures for Stormwater management in Tasmania* 2012, prepared by the EPA/DPIWE (State of Tasmania 2012). The manual provides a framework to assist in the design of stormwater treatment systems for urban landscapes in Tasmania, and was based on the Derwent Estuary Program's *WSUD Engineering Procedures: Stormwater for Southern Tasmania* (2006) and *Melbourne Water's WSUD Engineering procedures: Stormwater* (2004). It provides detailed construction, engineering and development assessment advice for stormwater management systems and directed initially at engineers. Examples include how to size specific WSUD features based on hydraulic requirements and rainfall conditions across Tasmania, maintenance requirements, worked examples, check-lists for each feature, asset transfer check points, references to other design guidelines and information sources, plant lists, hydrological maps for Tasmania, product suppliers (http://epa.tas.gov.au/Documents/WSUD_Manual_2012.pdf).
- Model for Urban Stormwater Improvement Conceptualisation (MUSIC, version 4, 2009).

Guidance on flood estimation:

- A Model Stormwater Management Plan for Hobart Regional Councils – Focus on New Town Rivulet Catchment (Derwent Estuary Program 2004): showcases best practice guidance on the development of stormwater plans.
- Tasmanian Waterways and Wetlands Works Manual (DPIPWE 2003): this document outlines legislation and policy, showcases best practice guidance on managing urban waterways and provides information on enabling mechanisms to improve the stormwater management in Tasmania. These include: a review of financing options to support stormwater management and

education and training activities to increase community awareness and improve skills of stormwater practitioners.

In addition a number of councils have also developed their own individual supporting material, such as the Derwent Catchment councils through initiatives such as:

- WSUD Resource Kit for Hobart City Council (located at http://www.hobartcity.com.au/Environment/Stormwater_and_Waterways/Water_Sensitive_Urban_Design),
- Maps of storm and flood prone areas (http://www.hobartcity.com.au/Environment/Stormwater_and_Waterways/Storm_Surge_and_Flood_Prone_Land); and
- Rate rebates for native vegetation protection: annual rebates of $5.60 per hectare protected with a minimum and maximum of $56 and $560 per property. The value is deducted from the rates bill each year until June 2012 applicable mostly to Land Owners (http://www.hobartcity.com.au/Environment/Rate_Rebate_Scheme_for_Native_Vegetation_Protection)

Greywater and irrigation

- Environmental Guidelines for the use of recycled water in Tasmania (Dec. 2002), provides information on greywater use and irrigation with recycled water (Dettrick and Gallagher 2002).
- Stormwater Management plans (from 2011 onwards) details for Hobart, New Town, Sandy Bay and Wayne Rivulet are located at the Hobart city council; website (see http://www.hobartcity.com.au/Environment/Stormwater_and_Waterways/Local_Waterways)

Wastewater

- Environmental Guidelines for the use of recycled water in Tasmania (2002) (Dettrick and Gallagher 2002).
- Effluent reuse feasibility study guidelines, August 2011 – provides guidance to wastewater managers on the information required for to be submitted to the EPA to satisfy the Reuse Feasibility Requirements established in a permit or Environment Protection notice (EPA Tasmania 2011).

Victoria

Relevant legislation/guidelines

The draft Victorian Waterway Management Strategy (Improving Our Waterways- an overview of the draft Victorian Waterway Management strategy, DSE 2012). The review recognises the need to include local government and its role in stormwater management and the wider urban planning and also the need to develop frameworks that integrate stormwater management into waterway management and facilitate collaboration among key stakeholders to achieve multiple benefits and preservation of water ways. The final Strategy outlines policy on waterway management for Victoria and replaces the Victorian River Health Strategy (2002). It also plans to promote the development of integrated Water cycle Plans for rapid growth areas in the metro (by 2014) and subsequently in regional areas (by 2016) in collaboration with key stakeholders and development of a strategy to promote adaptive management (improve management frameworks, monitoring, data management standards, knowledge gap identification, transfer mechanisms and capacity building).

Healthy Waterways Strategy 2013/14 -2017/18 released in November 2013 proposed a range of targets and associated programs for 2012-2018 by Melbourne Water (Melbourne Water 2013a). In addition, the

Stormwater Strategy also released in November 2013 focuses on the management of stormwater in rural and urban areas for protection of the health of waterways and bays (Melbourne Water 2013b).

In Victoria, the Department of Environment and Primary Industries (DEPI) has overall corporate governance oversight on behalf of the Minister for Water for the establishment of water utilities and their performance. The oversight of certain aspects of water utility performance is also shared with the Department of Treasury and Finance (business financial risks), the Department of Health (water quality), the Environment Protection Authority (EPA) (environmental performance) and the Essential Services Commission (ESC) (price regulation and service standards).

Reporting and compliance obligations are imposed by Commonwealth legislation including the Privacy Act 1988, and Victorian legislation including the Water Act 1989, the Water Industry Act 1994, the Financial Management Act 1994, the Statement of Obligations (2012), the Water Industry Regulatory Order 2003, the Safe Drinking Water Act 2003, the Environment Protection Act 1970, the State Environment Protection Policy (Waters of Victoria) and the Planning and Environment Act 1987. There are 19 water utilities across the state.

The Department of Treasury and Finance has governance oversight for water corporations' proposed strategic directions and business management activities in terms of their potential for financial risk to the business and its implications for the government, focusing on the state's budget, net debt position and credit rating.

The Department of Health has governance oversight for water quality under the Safe Drinking Water Act and the Safe Drinking Water Regulations 2005. This provides a framework for drinking water quality that includes risk management obligations, a set of standards for key water quality parameters, and information disclosure requirements for water businesses. The Regulations establish an auditing framework. Under the legislation, the Department of Health is required to publish an annual water quality report that is tabled in parliament by the Minister for Health.

The EPA regulates the environmental performance of the water utilities, particularly as it relates to treated sewage effluent quality, through a corporate licence (previously, each sewage treatment plan was licensed). The level of sewage treatment required usually depends on the type of waterway into which the treated sewage is discharged. Under the licence provisions, water businesses must regularly sample and monitor sewage effluent quality and advise the EPA if there are specific incidents of noncompliance. A corporate licence also includes a requirement to submit an annual performance statement to the EPA.

Most sewage treatment plants operated by the water businesses are subject to the State Environment Protection Policy (Waters of Victoria) schedules, which are developed and administered by the EPA. The schedules require that sewage treatment plant operators ensure that the sustainable reuse of treated effluent and biosolids is maximised wherever possible.

ESC is responsible for price regulation and setting service standards for water services in Victoria under Part 1A of the *Water Industry Act 1994*, the *Essential Services Commission Act 2001* and the Water Industry Regulatory Order. The legislative framework provides the ESC with powers and functions to:

- make price determinations
- regulate standards and conditions of service and supply
- require regulated businesses to provide information

Victoria has an integrated catchment management system established under the Catchment and Land Protection Act 1994. Under the Act, the state is divided into 10 catchment regions; a catchment management authority is established for each region. Catchment management authorities are provided with regional waterway, floodplain, drainage and environmental water reserve management powers under the Water Act 1989.

The *State Environment Protection Policy (Waters of Victoria)* outlines the objectives for the protection of the State's receiving waters whilst the *Water Act 1989* guides the planning, allocation and management of water, and includes objectives for environmental water release and security of water rights.

The White paper, *Our Water, Our Future* outlined Victoria's policy for water management including security of supply and environmental demand for the next 50 years (DSE, 2004). It included discussion on the adoption of alternative water supplies, including water recycling and managed aquifer recharge. Individual water authorities developed their water supply and demand strategies based on the White paper. Then in 2012 the *Living Melbourne, Living Victoria* policy was released (State Government of Victoria 2011) and the Office of Living Victoria was created to promote the strategy and lead the reform to embed integrated water cycle management into planning across Victoria at city, regional, precinct and building scales (OLV 2012).

The *6 star Homes standard* rating became mandatory in May 2011 to increase the energy and water efficiency of new dwellings, renovations and relocated homes (from May 2011) by encouraging the increased energy efficiency in buildings, adoption of water efficient fittings and the provision of either a rainwater tank to toilet connection or a solar hot water heating unit (Victoria Building Commission Authority, 2011).

In 2006, Victoria Planning Provisions were amended to include mandatory requirements for all new residential subdivisions to adopt integrated water management and meet stormwater objectives under *Sustainable Neighbourhoods Clause 56 – Victorian Planning*.

The development of stormwater strategy and guidelines for Melbourne is described in Brown and Clarke (2007). The *Urban Stormwater Best Practice Environmental Management Guidelines* (1999) provide objectives for stormwater quality and flow management.

Clause 56 of Victoria Planning Provisions (October 2006) sets integrated water management provisions (Clause 56.07) and urban run-off management objectives (clause 56.07-04) as per the *Urban stormwater best practice environmental management guidelines* (BPEMG).

The EPA offers a wide array of publications *on* reducing point source stormwater pollution, including fact sheets tailored for a diverse range of industries (http://www.epa.vic.gov.au/our-work/publications/). Relevant WSUD publications include:

- Water sensitive urban design (publication 989) (EPA 2005)
- Maintaining Water Sensitive Urban Design Elements Manual (EPA 2008) (to assist local government with maintenance issues and costs relevant to WSUD features – based on WSUD Manual CSIRO 2005)
  - Case studies: Interactive map with multiple examples (http://wsud.melbournewater.com.au/content/case_studies/case_studies.asp)

Western Australia

Relevant legislation

Department of Water: responsible for water resource policy, planning, management and regulation and the administration of water entitlements and water rights in Western Australia. The reporting of water utility performance is primarily the responsibility of the Economic Regulation Authority (ERA); however, the Department of Health, the Department of Environment and Conservation and the Environmental Protection Authority also have some reporting responsibilities. (National Water Commission 2013, National Water Performance report 2011-12: urban water utilities, March 2013, Appendix B –Jurisdictional summaries: p.138-154, http://www.nwc.gov.au/__data/assets/pdf_file/0019/29170/Urban.pdf)

Reporting and compliance obligations are imposed by Commonwealth legislation including the Corporations Act 2001 and the Privacy Act 1988, and by Western Australian legislation including the Water Services Licensing Act 1995, the Metropolitan Water Supply, Sewerage and Drainage Act 1909, the Health Act 1911, the Environmental Protection Act 1986 and the Planning and Development Act 2005. The Water Services Act 2011 received royal assent on 3 September 2012. The Act repealed and replaced the Water Services Licensing Act 1995

ERA: is the independent regulator responsible for administering the licensing scheme for WSPs pursuant to the requirements of the Water Services Licensing Act and for reporting on industry performance. To obtain an operating licence, a WSP has to demonstrate that it has the financial and technical capacity to provide the required service or services and that the grant of the licence is not contrary to the public interest. Licences include performance standards covering customer service and quality of service that are to be met by the licensee. The licensee is required to provide the ERA with data for performance monitoring purposes, as set out in the ERA's Water compliance reporting manual. The manual specifies performance reporting templates for each type of licence. Licensees are required to submit completed performance reports to the ERA for every financial year end (30 June).

The performance indicators in the templates for licensees who are not required to report under the NWI Agreement have been aligned with the NPR indicator set for consistency. The Water compliance reporting manual requires licensees to provide a report to the ERA on their compliance as per the the terms and conditions of their licence. The ERA uses the compliance reports to monitor the overall level of compliance by licensees; the content of each report is confidential to the licensee and the ERA.

The licence terms and conditions for WSPs require the licensee to enter into a memorandum of understanding, which specifies drinking water quality standards, with the Department of Health, which audits compliance. The memorandums of understanding are reviewed every three years. The ERA does not have water price setting powers but receives a reference from government requesting it to undertake an independent review of water prices for the Water Corporation, Aqwest and Busselton Water. The authority's report makes recommendations to government on pricing.

The oversight of water utility operation in Western Australia is shared by the ERA and other agencies.

The Department of Health sets standards for drinking water quality and regulates activities and the provision of services relating to public health, pursuant to the Health Act 1911. The department also supports the Advisory Committee for the Purity of Water, which advises the Minister for Health and the Minister for Water on issues associated with protecting public drinking water.

The Department of Water's responsibilities include the collection and analysis of water resources information, the protection of water quality and water resources, and water industry planning and policy, management and regulation.

The Department of Environment and Conservation regulates the environmental impacts of WSPs through the Environmental Protection Act 1986. The Act prescribes an environmental registration and licensing scheme, which sets limits on the type and volume of waste that can be discharged from a site. In some circumstances, WSPs may be required to arrange for audits of their compliance with the conditions attached to their registration and provide a copy of the audit report to the department. WSPs must notify the department if there is an unauthorised discharge of waste from registered premises.

The Environmental Protection Authority is an independent adviser to government on a broad range of environmental matters. The functions of the authority include conducting environmental impact assessments, preparing statutory policies for environmental protection, publishing guidelines for managing environmental impacts and providing strategic advice to the Minister for Environment.

The Western Australian Planning Commission, a statutory authority that operates with the support of the Department of Planning, oversees the land-use planning implications of WSP operations, according to requirements of the Planning and Development Act 2005.

The Water Services Licensing Act 1995 requires licensees to arrange for an operational audit and asset management system effectiveness review at least once in every two years. The audit and review are to be conducted by independent auditors appointed by the licensee but approved by the ERA. The ERA approves the final audit and review reports and arranges for their publication on its website. The ERA provides a report on each audit to the Minister for Water.

There are three water service providers in WA: Water Corporation, Aqwest and Busselton Water.

The Water Corporation is a statutory state-owned corporation that provides potable and non-potable water, irrigation water, wastewater services and drainage services to most areas of Western Australia. It also undertakes catchment management activities under delegation from the Department of Water according to an operational agreement for catchment management between the two organisations.

Water Corporation is the principal supplier of water, wastewater and drainage services to hundreds of thousands of homes, businesses and farms, and provides bulk water to farms and growers' cooperatives for irrigation. Its services, projects and activities span more than 2.5 million square kilometres.

Aqwest is the trading name of the Bunbury Water Board, a self-funding statutory authority operating under the Water Boards Act 1904. It provides potable water services to the regional centre of Bunbury, approximately 190 km south of Perth. Its licence permits Aqwest to also provide non-potable water.

Busselton Water is a self-funding statutory authority administered by the Busselton Water Board under the Water Boards Act. It provides potable water services to the regional centre of Busselton, approximately 250 km south of Perth. The Busselton Water licence permits the supply of non-potable water services. Busselton Water also supplies raw water to the Water Corporation in Dunsborough.

As statutory bodies and state-owned corporations, the utilities are subject to performance reporting requirements under the Financial Management Act 2006. The annual reports prepared by Aqwest, Busselton Water and the Water Corporation include non-financial performance indicators that are independently audited by the Office of the Auditor-General. Other, smaller water and sewerage service providers include Hamersley Iron, the Rottnest Island Authority and a number of small rural local governments.

The Department of Water and the New Water Ways websites also have a number of brochures and information tools available (see http://www.water.wa.gov.au/PublicationStore/first/99294.pdf and http://www.newwaterways.org.au/Resources/Policy-and-guidelines).

Resources

Alternative water supply

- Guidelines for the non-potable uses of Recycled Water in Western Australia (Government of Western Australia 2011): provides a planning and implementation framework for water recycling schemes based on the risk management approach adopted in the National Guidelines for Water Recycling. It covers grey, yellow and black treated and industrial wastewater schemes for less than 20kL/day of treated wastewater. Larger schemes require additional approval from the Department of Environment and Conservation.

- Code of Practice for the reuse of greywater in Western Australia (DOH 2010): covers greywater usage for single or multiple residential dwellings and commercial dwellings producing up to 5000L/d of treated wastewater. It sets minimum design and installation standards for greywater systems, sets the approval process in sewered areas of WA. Single dwellings approval are granted by local government whilst multi dwelling and commercial premises are approved either by local government or DoH based on treatment method and volume produced. (http://www.public.health.wa.gov.au/cproot/1340/2/COP%20Greywater%20Reuse%202010_v2_130103.pdf)

- Guideline for the approval of non-drinking water systems in Western Australia – Urban developments (DOW 2013) provides simplified and clearly defined approval requirements for non-drinking water systems in urban developments.

- Tankered Recycled Water Supply Policy (DOH 2009).

- Draft alternate water supply guidelines –Stormwater and Rainwater (DoH 2009) – Reinterpretation of the National guidelines in view of WA conditions. It outlines regulatory framework, compliance and reporting needs, roles and responsibilities, conditions of use for stormwater, surface water and rainwater and sample forms

- Stormwater Management Manual for Western Australia (Department of Water 2004-2007): The manual promotes at source structural controls (infiltration) and non-structural methods such as infiltration. The manual was developed for local government, industry, developers, State agencies, service providers and community groups. It provides policies and planning principles, as well as on-ground best practice advice. It supports and provides information to enable implementation of Western Australian Planning Commission planning policies and Environmental Protection Authority environmental policies. It also provides specific Western Australian guidance in keeping with the national guidelines. (for access to the manual see http://www.water.wa.gov.au/Managing+water/Urban+water/Stormwater/Stormwater+management+manual/default.aspx)
- Liveable neighbourhoods (WAPC 2007) defines best planning practices for urban water management, including specific requirements. Element 4 provides guidance on integration of stormwater into public parkland. It also serves as guidance for objectives and requirements for preparation of structure plans and subdivision plan applications.
- Urban rainwater collection Factsheet (DoH 2011)
- Urban Water Management plans (DoW 2008): are guidelines for preparing plans and for complying with subdivision conditions.
- Water monitoring guidelines for better urban water management strategies and plans (DoW 2012)
- Stormwater Management at industrial sites (DoW 2010)
- Constructed Wetlands for stormwater management (DoW 2011a)
- Stormwater design considerations (DoW 2011b)
- Water sensitive urban design –rainwater storage and reuse systems (DoW 2011c)
- Operational policy 1.01 - Managed Aquifer Recharge in Western Australia (DoW 2011d) outlines the principles and policy relevant to on-the ground advice and supports the WAPC policies implementation. The site provides contextual information and introduction to WSUD techniques and examples of WSUD development in WA and their lessons.
- Waterwise community toolkit provided for developers, local government and householders on how to increase water efficiency an investigate alternative sources (supported by the DoW at http://www.water.wa.gov.au/Managing+water/Recycling/Waterwise+community+toolkit/default.aspx#1)

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Appendix F. Stakeholder roles

Table F-1. Stakeholder groups and their roles in SA

State Agencies				
Entity	Classification	Role	Influence on WSUD	Influence on WSUD implementation
Govt. of South Australia	State Government	Sets overall State strategy	Integrated water management(water for good initiative), Planning and development fund initiative for providing landscapes for open space projects	Could be increased. Potentially high.
SA EPA	Independent statutory body under State Government	Develop tools to ensure reasonable and practicable measures to protect restore and enhance the quality of the environment through advice and guidance, partnering with other organisations, education and regulation.	Adoption of WSUD targets for delivering water quality policies. (Played major role in the setting out of water quality and quantity regulations in waste water recycling and reuse project at Mount Gambier in South East in the year 2007). Sets license requirements for any projects related to discharge of treated wastewater to surface waters and aquifers. Provides licenses to wastewater treatment plant and operators for discharges above threshold level (Schedule 1 EP Act), including discharge of stormwater to aquifers for catchment greater than 1ha in Greater Adelaide and Mt Gambier (SA Health 2012).	Medium. It has influence on water quality targets and guidelines but not directly on implementation, which is covered in local development code.
Essential Services commission (ESCOSA)	Independent economic regulator	Regulator for water and wastewater services sector. Responsible for price regulation and licensing of water and wastewater services, Monitors and	Licensed agencies set recycled water prices in accordance to ESCOSA guidelines. Power to grant license for operators in recycled water.	Low.

		enforces compliance with service standards, consults with consumers and advises Treasury regarding economic regulation		
Department of Planning Transport and Infrastructure (DPTI)	State Government	Have business areas with diverse responsibilities including management of public transport, supporting economic, social and environmental development by identifying infrastructure priorities in South Australia and facilitating timely delivery of key projects. Different sections within the department operate independently – e.g. planning which is responsible for planning library and policy and the advisory and approvals section responsible for assessment and engineering. The first has most of the responsibility and power for WSUD policy implementation, but not the expertise, which the second carries.	Ensuring that ongoing inclusion of WSUD (and eventually mandated) in the Planning Strategy and the appropriate alignment of WSUD policy in Development Plans; Planning department: Ensuring the ongoing consideration of WSUD in structure planning for corridors and growth nodes under the 30-year Plan for Greater Adelaide; Planning department: On-going refinement and improvement of the WSUD policy module within the South Australian Planning Policy Library; Planning department: Were involved in the development of technical manual for WSUD for Greater Adelaide region in the year 2010. The Roads and Transport section in the DPTI provides advice to councils on development applications and their impact on road drainage, if requested. DPTI Roads and Transport is also part of the advisory committee that examines SMPs for council areas.	Medium. In current policy WSUD is not mandated. Whilst there is an overall statement in the Planning Library that endorses in principle adoption of WSUD and total water cycle principles. There are no clear mechanisms that promote the adoption and implementation at local government and development level. DPTI though its planning policy has potential for high influence in policy. However, the technical know-how on WSUD and on their impact on other infrastructure resides with the engineering and road and drainage groups in the DPTI, not in the planning group.

SA Water	Statutory Corporation under SA Government	Provides water and wastewater services to approximately 1.5 million people in South Australia and manages water, wastewater, infrastructure assets and contracts	Provision of reticulated drinking water and sewerage services to customers; Promotion of 'Water Wise Measures' and demand management/water conservation as part of WSUD; Provision of alternative water supply and management and WSUD infrastructure when economically and technically feasible. Interests are focused on water supply and wastewater collection system and treatment.	Low. Specific to mains water supply and recycled water.
Department of Environment, Water and Natural Resources (DEWNR)	State Government	Manage environmental and natural resources to achieve productive and balanced use of natural resources; Help improve condition and resilience of natural systems.	Development of overarching State policy approach and targets for WSUD; Ensures an integrated water management approach to infrastructure planning/design and implementation especially in new development areas; Coordinates activity across Government to ensure a consistent approach to WSUD activity and support. Permits and licenses water drained and discharged into an aquifer (SA Health 2012).	Potential for high.
Stormwater Management Authority Board	Statutory Body under SA Government	Prioritizes stormwater planning and infrastructure projects on a catchment wide basis throughout the State and manages available funds	Facilitates stormwater planning and provides guidance to local councils in relation to the preparation of Stormwater Management Plans.	Low. Has influence on larger picture (>40ha only). Could have potential to be higher.
Natural Resources Management Council (NRM)	State Government	Provides expert advice to the State Government about the long term strategic directions for the management of the State's natural resources.	Supports WSUD projects in their regions; Helps to raise awareness and educate local communities. (The initiatives of the Adelaide and Mount Lofty Ranges and the Murray Darling Basin NRM Boards in implementing and monitoring WSUD principles in their localities is worth of mention);	Medium to high.

Natural Resources Management Boards	State Government	Responsible for preparation of, review and amendment of water allocation plans for each regions's prescribed water resources. There are eight NRM regions in SA: Adelaide and Mt lofty Ranges, Alinytjara Wilurara, Eyre Peninsula, Kangaroo Island, Northern and Yorke, South Australian Arid Lands, South Australian Murray-Darling Basin and South East. Plans are reviewed at least every 5 years and their reviews require consultation with water users, stakeholder groups and community	The Adelaide and Mount Lofty Ranges NRM Board is funding the implementation of the WSUD Capacity – building project, based on recommendations from the Business case for WSUD capacity-building (Alluvium and Kate Black 2012) .	Medium.
SA Health (Department of Health and Ageing, DHA)	Statutory body	Responsible for the development of State policy for protection of public health and its implementation (e.g. Public Health Act 2011). Defines roles and responsibilities of other State and local government on health protection and enforcement.	Develops policy and guidelines for the protection of public health public that impact some WSUD features (e.g. recycled water). See: SA Recycled Water guidelines (2012) Evaluates plans and grants approval for operation of recycling scheme for recycled water. It has negligible involvement with rainwater and stormwater. It has power to shut-down any water supply scheme seen as a risk to public health after construction.	Low. Has power on alternative water supplies.

Urban Renewal Authority	State Government	Develops an integrated and innovative approach to urban development for residential and industrial communities in South Australia by stakeholder as well as community engagement.	Facilitates the incorporation of WSUD in urban developments in which it is a partner (e.g. Lochiel Park development); Provides demonstration sites to showcase the effectiveness of WSUD.	Medium to High. Particularly with emphasis on demonstration projects.
Integrated Design Commission	State Government initiative	To provide expert advice and strategic direction to SA Government to ensure the quality and sustainability of publicly funded buildings, infrastructure programs and urban design by providing assistance in developing guidelines for good design policy, processes and practices, based on evidence and best practice	Promotion of WSUD opportunities in the future design of Adelaide.	Low. Has not been very active.

Local Agencies				
Entity	Classification	Role	Influence on WSUD	Influence on WSUD implementation
Local Government Association (LGA)	Association of Local Councils	Peak representative body of Local Government, involved in policy, funding and inter-government relations, including WSUD.	Representative body of Local Government, involved in policy, funding and inter-government relations, including WSUD.	Low. Could be medium.
Local councils	Local government	Management of local council areas, including stormwater drainage and local environment. Responsible for collection, treatment and recycling of on-site wastewater installations. May build own and operate community wastewater management schemes, after	Manage, develop, protect, restore, enhance and conserve the local environment in an ecologically sustainable manner; Ensures provisions within Local development Plans align with the WSUD principles and policies articulated in the volumes of the Planning Strategy for South	High.

		approval of EPA, and licensing of EPA.	Australia. Verifies and ensures new developments construction adheres to the WSUD policies in Local development Plans.(TBC) The councils actively involved in WSUD implementation in their urban developments include: City of Salisbury, City of Norwood, Payneham and St Peters, Mitcham City Council, Adelaide Hills Council, City of Onkaparinga, Councils of Yankalilla (both being in the process of developing Development Control Plan, for WSUD Targets; .	
SIA(SA) (Stormwater Industry Association SA)	Independent Technical Association (consultant)	Provide focus on promoting best practice stormwater management for Adelaide Metropolitan Areas.	Actively involved with NRM Boards for sustainable stormwater management.	Low.
Urban Development Institute of Australia (UDIA)	Consultants	To promote, foster and advance a healthy, dynamic and efficient development industry through the provision of high-quality information and services to members including developers, builders, industry consultants, government entities and the community	Actively involved in the recycled water supply to residents of Adelaide and currently working on implementation of the third pipe reticulation system. Involved in the implementation of 'The 30 year Plan for Greater Adelaide'.	Medium.
University of South Australia	Consultants	Leading University in South Australia, with world competent research expertise and Industrial collaboration.	Technical expertises in WSUD; Successfully implemented major WSUD projects in South Australia;	Low-medium
Australian Water Association (AWA)	Independent membership	Aims to support the Australian water sector in the delivery of effective and	Organise comprehensive program of conferences, workshops, publications,	Low.

	association	sustainable water management practices	industry programs, training courses and networking associated with WSUD	
IPWEA (Institute of Public Works Engineering Australia)	Independent Professional Association	Provide member services and advocacy for those involved in and delivering public works and engineering services to the community.	Funding of Water Sensitive SA Project; Technical guidance on implementation of WSUD.	Low.
Engineers Australia	Independent Professional Association	National forum for the advancement of engineering and the professional development of our members	Lead role in developing Australian Runoff Quality- A guide to WSUD	Low.
Goyder Institute of Water Research	Collaborative Research organisation	Expertise and capabilities in areas including capacity building, knowledge exchange and/or specific research projects.	Promotes research for effective implementations of WSUD	Low -Medium.
Developers and Building Industry	Developers	Develop land parcels for construction/ renovation of built infrastructure.	Expected to adhere to relevant statutory requirements, for implementing WSUD measures; Prepare developments plans in accordance to policies in Local development Plans. Decision-makers on the WSUD features incorporated in their developments. Notable relevant contributions have been made in this sector by number of agencies representative agencies (UDIA, MBA SA, GBCA, HIA) regarding lobbying and industry submissions to policy.	High.
Consultants	Independent consultants	Provide technical and managerial expertise in design, construction and implementation of development	Examples of consulting companies that have contributed to WSUD in SA include DesignFlow, Tonkin Consulting, KBR (Richard Marks), Kate Black Consulting, Alluvium Consulting, Wallbridge and Gilbert Consulting Engineers.	Medium
Body Corporate	Body corporate	Management agency for common property	Liable and responsible for operation of communal WSUD features on common property for a cluster/ development.	Low

			Servicing of features may be conducted by appointed contractors or private service operators.	
Property owners	Property owner	Property owner	Responsible for management of WSUD features on own private property (E.g. Rainwater tanks, rain gardens) unless other arrangements are established.	Low.
Planning Institute of Australia	Independent representative body of the planning and planning profession, includes chapters in each State.	It promotes better planning, capacity development and capability building in the planning community through education, communication, professional development, advocacy and policy development to improve overall planning.	Planning SA members has an interest in WSUD and runs capacity building and information sessions on the topic. It also has a role in advocacy and policy development for the planning sector. Planning SA members cover a wide range of sectors in the private and government arena.	Medium. Mostly via members.
Plumbing Industry Association	Representative body of plumbing professionals in SA	Not-for-profit agency interested in the development of sustainable urban living with expertise in plumbing services.	Plumbing SA is not directly involved in WSUD. Members are at times involved with WSUD mostly through installation contract work. Their expertise is typically at the building interface. Plumbing SA has some concerns about health risks associated with proper maintenance of alternative water systems and particularly hot water services risks associated with Legionella and ageing of the population. Member experience also varies. Despite sustainability courses interest has fizzled due to current market forces.	Low. Due to specificity of role. Typically members have not been involved in planning and design.

Table F-2. Approval processes for selected water streams

	Recycled wastewater	Greywater	Stormwater	Rainwater
Pre-approvals	Consult DHA Public and Environmental Health (Waste control) Regulations	Consult local council for approval. Public and Environmental Health (Waste control) Regulations	Recommended but not mandatory consultation with DHA. Not specifically covered by DHA but Public Health Act 2011 (allows DHA to cease operations if public health risk is identified)	Not applicable
	Consult EPA if irrigation proposed and needs to develop a wastewater irrigation management plan (WIMP) ; discharge of treated wastewater to an aquifer. Contact DWENR or in soem cases NRM if water is discharged into a well not licensed by the EPA.	Local councils Water supplier Community wastewater system operator	Contact EPAfor MAR scheme and submit application for authorisation (for scheme >1ha in Adelaide metro or Mt Gambier.	
	SA Water if using supply of treated or untreated wastewater from SA Water's sewerage system.			
Reference Approval process	Section 4.1 in SA Health (2012), p.27	Section 4.1 in SA Health (2012), p.28	Section 4.1 in SA Health (2012), p.29	

References:

Alluvium and Kate Black Consulting (2012) The business case for a water sensitive urban design capacity-building program for South Australia. Report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.

SA Health (2012) SA Recycled Water Guidelines, State Government of South Australia (Last revision 16 October 2012).

Appendix G. Analysis of barriers to WSUD from capacity building report

Introduction

The "Business Case for a Water sensitive urban design capacity-building program for SA", released in December 2012, examined the needs and developed a business case for WSUD Capacity building for SA. The project was based on extensive consultation with government and industry stakeholders and mapped stakeholders based on their impact on capacity building in WSUD (Alluvium and Kate Black Consulting, 2012). The project also surveyed WSUD practitioners regarding their views on capacity, constraints, barriers to WSUD uptake and areas for further improvement.

That project identified as areas of industry capacity needs: "appropriate design standards, construction guidelines, research, stakeholder engagement, evaluation of WSUD, the need for State policy to promote WSUD in SA".

Whilst the focus of the project was on capacity building, the data gathered provides a useful source of information on the perceptions of barriers to WSUD by practitioners. Therefore, the dataset was mined to gain further insights into the barriers to WSUD in SA.

Methodology

The Alluvium data collection included a web survey of 348 practitioners who were queried on: experience with WSUD, identification and rating of barriers to WSUD (question 15) and knowledge gaps areas which respondents would like to improve (question 18). We re-analysed the data to determine the composition of respondents and their perceptions of barriers and needs within the major stakeholder groups in the survey. It is noted that participants in the Alluvium survey responded questions as individuals and based on their own experiences.

An alternative CSIRO web survey was also developed and targeted at the building industry. This survey was distributed with the assistance of the UDIA and MBA SA via dissemination of a web link to the survey through newsletters from the two associations.

Results

There were 331 valid responses in the Alluvium survey. The Alluvium data was analysed for the major sectoral groups to which individuals belonged: State agencies, EPA, local government, consulting/contractors, researchers and non-government organisations (NGOs). Respondents answered the survey based on their personal views and perceptions.

Respondents were mostly individuals working in local government, state government (including SA Water and EPA) and the consulting/contractor sectors comprising respectively 36.9%, 30.5% and 18.1% of the sample (Figure G-1). Other sectors represented included researchers (4.5% of respondents), non-governmental organisations (NGOs) (2.1% of respondents), industry (manufacturers) (0.6% of respondents) and others (community group members, general public, elected representatives, students, architects and professionals whose profession may or may not necessarily have been related to WSUD) (7.6% of respondents). SA Water had only one employee in the survey (0.3% of sample). None of the respondents identified themselves as developers, although eight respondents were members of the UDIA. In addition no respondents identified themselves as members to any other development industry related organisation (e.g. HIA, MBA, Property Council). This shows that there was limited representation from the building sector in the Alluvium survey.

In view of the low representation from the building industry, a CSIRO survey was designed to target specifically the development industry. The CSIRO survey also had a low response rate (ten responses), despite being distributed via UDIA and HIA. The data from the CSIRO survey is shown separately (Figure G-5 and Figure G-6) and should only be considered as indicative, given the small sample size. However, further input was harnessed from the development industry through interviews with specific developers.

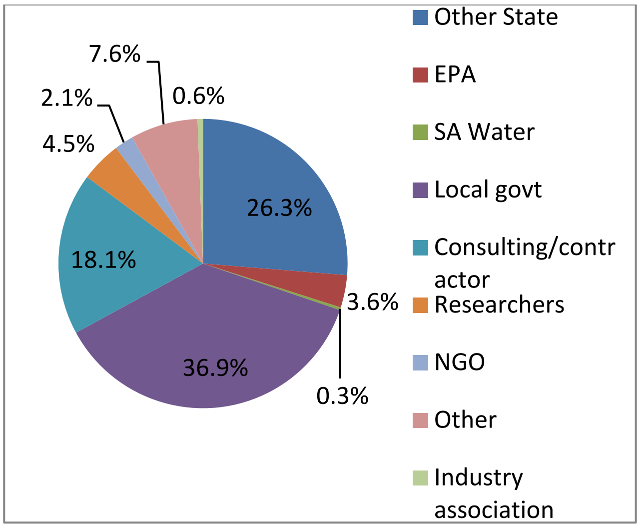


Figure G-1. Breakdown of participants by sector in the capacity building survey

(Adapted from Alluvium and Kate Black Consulting, 2012)

Self- perception of WSUD knowledge

Figure G-2 shows how each sector perceived their knowledge of WSUD. The confidence of respondents regarding WSUD varies across sectors: 44.8% of the respondents in State agencies, 44% in the "Other" sector, and 33% in the EPA, Local government and contractor/consulting sectors assessed their WSUD knowledge as *poor*. The highest confidence levels were noted for NGOS, Researchers, Local government and EPA with 85.7%, 73%, 69.7% and 66.7% rating their knowledge as *Ok to Good*. However, only 36.7% to 40% of NGOs, contractors and researchers rated their knowledge as *good*, whilst in other sectors (State agencies, local government, EPA and other) less than 25% described their knowledge as good. The single respondent from SA Water assessed his/her knowledge as *good*. A number of respondents have also not answered the question (Figure G-2). Hence the results indicate that the WSUD knowledge based on self –assessments varies widely across each sector. There seem to be between 25-33% of respondents who believed they had strong WSUD skills, but similarly a significant share of the practitioners do not feel confident about WSUD.

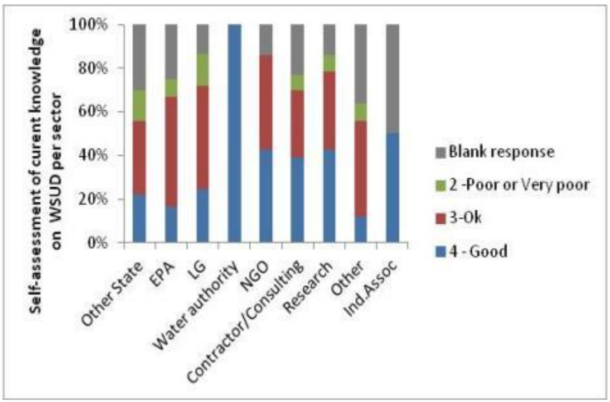


Figure G-2. Self-assessment by respondents of their knowledge on WSUD

(Based on data from Alluvium and Kate Black Consulting, 2012)

Perception of major barriers

Figure G-3 shows the perception of the main barriers to WSUD uptake by each sector. Survey respondents had been asked to rate the importance of a series of barriers to the uptake of WSUD ('1' was a very small barrier, '10' a very large barrier). Barriers given a score of 7 or more (i.e. major barrier) were selected and the agreement among responses was compared within each of the various stakeholder groups.

Table G-1 provides a summary of the major barriers based on the perceptions within members of each stakeholder group. Given that Industry associations and water utility had two or less respondents, we excluded the results from those two groups from the discussion. In addition the 'others' group was also very heterogeneous in composition.

Multiple barriers were identified to be influential by each stakeholder sector. Whilst the perception of the largest barriers varies per stakeholder group, there was strong agreement on the top two barriers among all stakeholder groups as shown in Figure G-3 (a) and Table G-1:

- Lack of knowledge of value of WSUD (i.e. uncosted externalities/environmental benefits) – was identified by over 63.5% of respondents in all groups as a major barrier.
- Insufficient budgeted resources – identified by all groups except NGOs as a major barrier.

The importance of barriers was perceived differently across the various stakeholder groups as exemplified by the degree of agreement within each group.

Local government members, which are key stakeholders for WSUD, perceived lack of budgeted and human resources, and lack of knowledge of WSUD cost benefits as their top barriers to WSUD uptake, with agreement levels of 87.5%, 63.5% and 62.5% respectively (Table G-1).

Contractors and consultants also saw lack of knowledge of WSUD cost-benefits and lack of lifecycle data and/or its application on forecasted operation and maintenance as key barriers, with over 70.8% agreement.

In addition, State agencies and the 'other' group saw the lack of long-term organisational vision /strategy/ organisational framework (70% agreement) as one of the top three barriers.EPA professionals also saw as a key barrier the lack of leadership (poor organisational commitment at a senior management level (88.9%)).

Limits of the regulatory framework is also perceived by over 60% of members of State, EPA (88.9%) and consultants/contractors and by 50% of local government and NGOs as a key barrier.

Regarding political will, interestingly State agencies (including EPA), NGOs and local government perceive lack of State political will as more significant than lack of council will. Whilst more contractors/consultants and researchers perceive the opposite: lack of federal, state but particularly Council will as a greater barrier (Figure G-3 c).

NGOs perceived the largest range and number of barriers among all groups. All six NGO professionals perceived unanimously as key barriers (100% agreement):

- Lack of knowledge of value of WSUD (i.e. uncosted externalities / environmental benefits);
- Lack of political will by State and Federal government;
- No long-term organisational vision/strategy/organisational framework;
- Limited monitoring of in-ground systems;
- Insufficient information on best practice and maintenance practices, life cycle data and its application for operation and maintenance; and
- Lack of technical information, knowledge and understanding (83.3%).

Regarding knowledge on WSUD (Figure G-3), there is strong agreement within sectors for the need in particular of information on post-implementation aspects of WSUD systems, such as operation and long-term costs. This factor is closely linked to the allocation of budgeted resources for WSUD, as inadequate knowledge of WSUD needs.

The lack of human resources was seen as a barrier across the sectors (over 40% of respondents in all sectors), by particularly by the government sector compared to the academic, NGO and private sectors. (Figure G-4 (e)).

Community support whilst perceived by a number of respondents as a barrier did not achieve the same level of agreement as the other barriers (Figure G-4 (f)). For instance among local government respondents only 30% perceived it as major barrier, but 78% of EPA respondents perceived it as a key barrier.

Thus, whilst all sectors tend to identify a similar range of barriers the perception of the importance of the various barriers differs among members of each sector.

Overall, perceptions are based on the experience and domain of each stakeholder group. Hence, the more specific gap areas, such as the importance of political will and regulatory framework for specialised segments such as State agencies, compared to NGOs that identified a wider and more diversified range of barriers. Overall, a number of barriers will need to be considered simultaneously.

Survey of the Development Industry

An attempt was made to gather information from the development industry. However, the number of responses was low (ten). The background of the respondents was analysed in Figure G-5 and Figure G-6. Whilst the respondents operated in relevant backgrounds to WSUD: builders, manufacturers, project managers, consultants and operation and maintenance officers/managers; and eight of them had previous experience with WSUD, only two of the respondents ended completing the full survey. Given that developers are as a segment the second most influential group regarding WSUD feature adoption after local government, we feel it is important to harness their feedback. However, the survey as a data collection method proved inadequate for the task.

Conclusions

In the Alluvium survey participants were predominantly from local government (36.9%), State agencies (30.5%) and consultants/contractors (18.1%). The remaining 15.5% participants were researchers, industry organisations, NGOs and a diverse range of other professionals and community members with an interest in WSUD. The private development sector was not represented and the significance for their lack of involvement in that survey and in the later CSIRO survey requires further investigation.

A number of barriers to WSUD have been identified by practitioners. Perceptions of the importance and significance of each barrier vary based on the stakeholder segment considered. Yet all stakeholders agreed on the two key barriers, which are closely:

- Lack of knowledge of value of WSUD (i.e. uncosted externalities/environmental benefits) – was identified by over 63.5% of respondents in all groups as a major barrier.
- Insufficient budgeted resources – identified by all groups except NGOs as a major barrier.

A number of barriers are inter-related and were outlined for each specific group.

Reference

Alluvium and Kate Black Consulting (2012) The business case for a water sensitive urban design capacity-building program for South Australia. Report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.

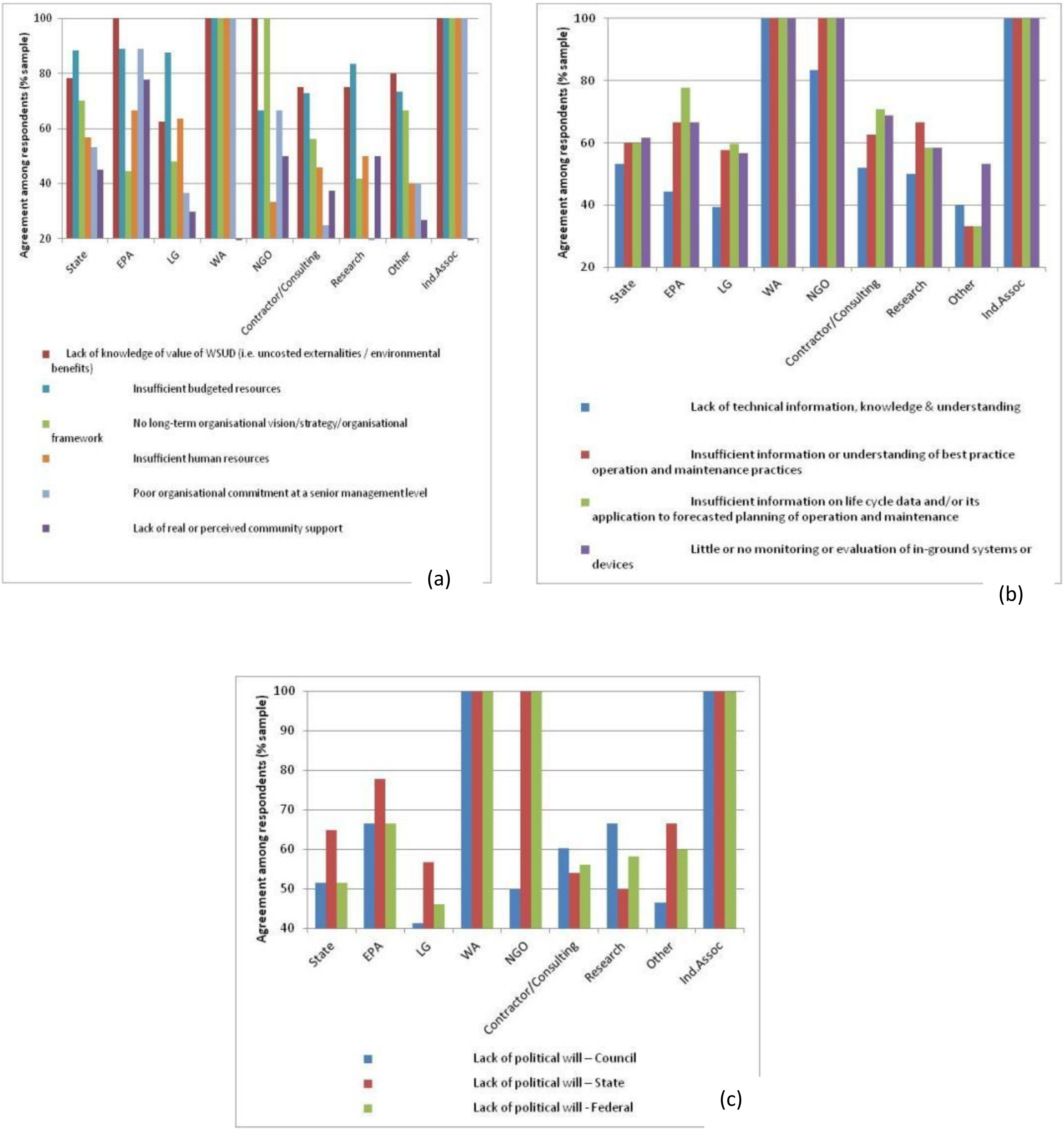


Figure G-3. Perception of large barriers (strength $\geq$7/10) to WSUD per sector: (a) Overall comparison, (b) Comparison of knowledge barriers, (c) Comparison of government political will as a barrier

(Based on data from Alluvium and Kate Black Consulting, 2012)

Table G-1.Perception of major barriers per sector

Sector	Rank	Top barriers (% total responses)
State government	1	Insufficient budgeted resources (88.3%)
	2	Lack of knowledge of value of WSUD (78.3%)
	3	No long-term organisational vision/strategy/organisational framework
EPA	1	Lack of knowledge of value of WSUD (i.e. uncosted externalities / environmental benefits) (100%)
	2	Limits of regulatory framework (88.9%)
		Insufficient budgeted resources (88.9%)
		Poor organisational commitment at a senior management level (88.9%)
	3	Lack of political will – State (77.8%)
		Insufficient information on life cycle data and/or its application to forecasted planning of operation and maintenance(77.8%)
Local government	1	Insufficient budgeted resource (87.5%)
	2	Insufficient human resources(63.5%
	3	Lack of knowledge of value of WSUD (62.5%)
Contractors/consultants	1	Lack of knowledge of value of WSUD (73%)
	2	Insufficient budgeted resource (73%)
	3	Insufficient information on life cycle data and/or its application to forecasted planning of operation and maintenance(70.8%)
Research	1	Insufficient budgeted resources (83.3%)
	2	Lack of knowledge of value of WSUD (i.e. uncosted externalities / environmental benefits) (75%)
	3	Insufficient information or understanding of best practice operation and maintenance practices (66.7%)
		Lack of political will – Council (66.7%)
Other	1	Lack of knowledge of value of WSUD (i.e. uncosted externalities / environmental benefits) (80%)
	2	Insufficient budgeted resources (73.3%)
	3	Lack of political will – State (66.7%)
		No long-term organisational vision/strategy/organisational framework(66.7%)

(based on data from Alluvium and Kate Black Consulting, 2012)

Note: Total number of responses per group: State (60), EPA (9), Local government (109), Water utility (1), NGO (6), contractors/consultants (48), Researchers (12), Other (15), Industry association (1).

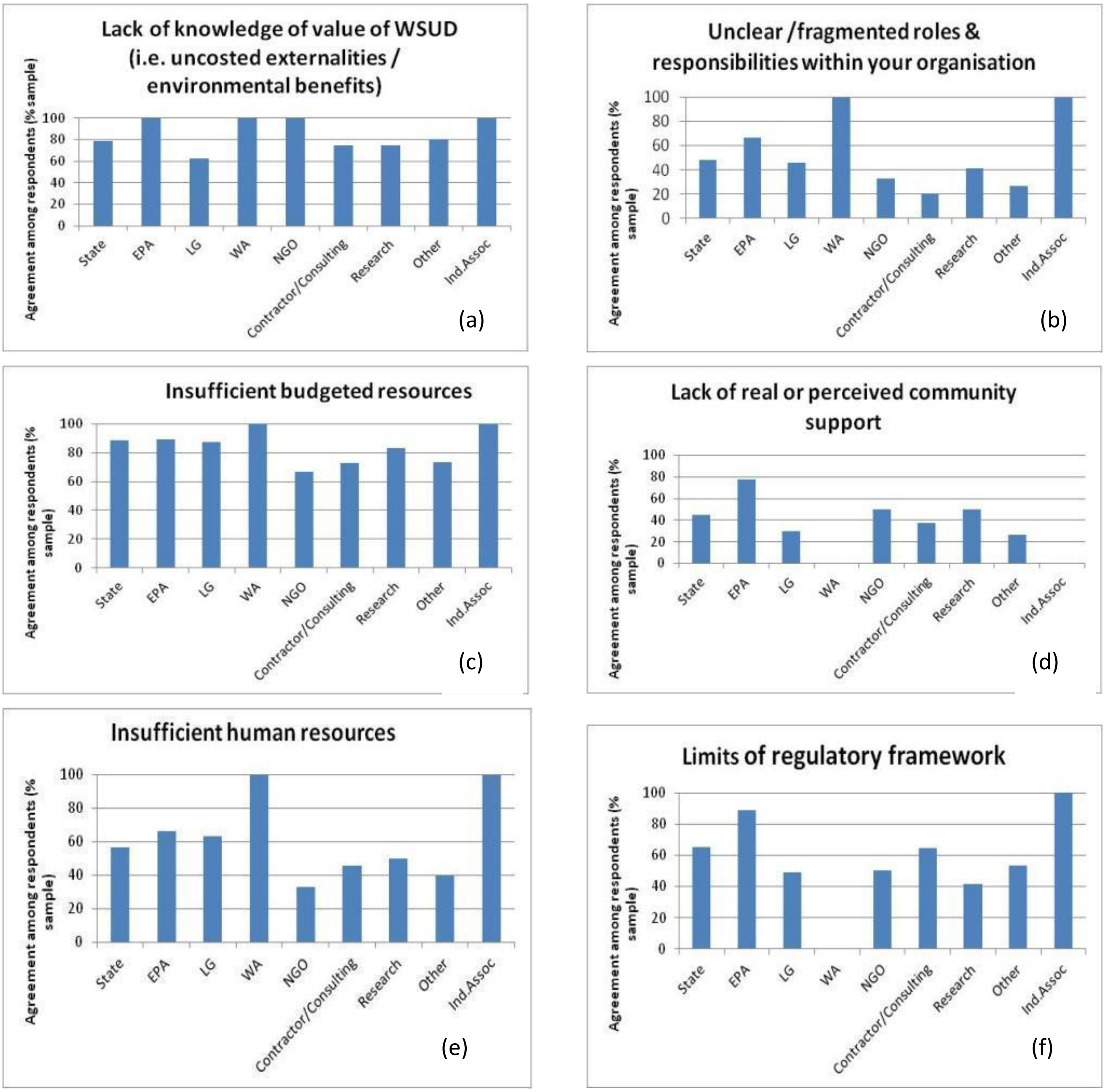


Figure G-4. Perception of key barriers by individual stakeholder groups: (a) Lack of knowledge, (b) Unclear roles in an organisation, (c) Insufficient budgeted resources, (d) Lack of real or perceived community support, (e) Insufficient human resources, (f) Limits of regulatory framework.

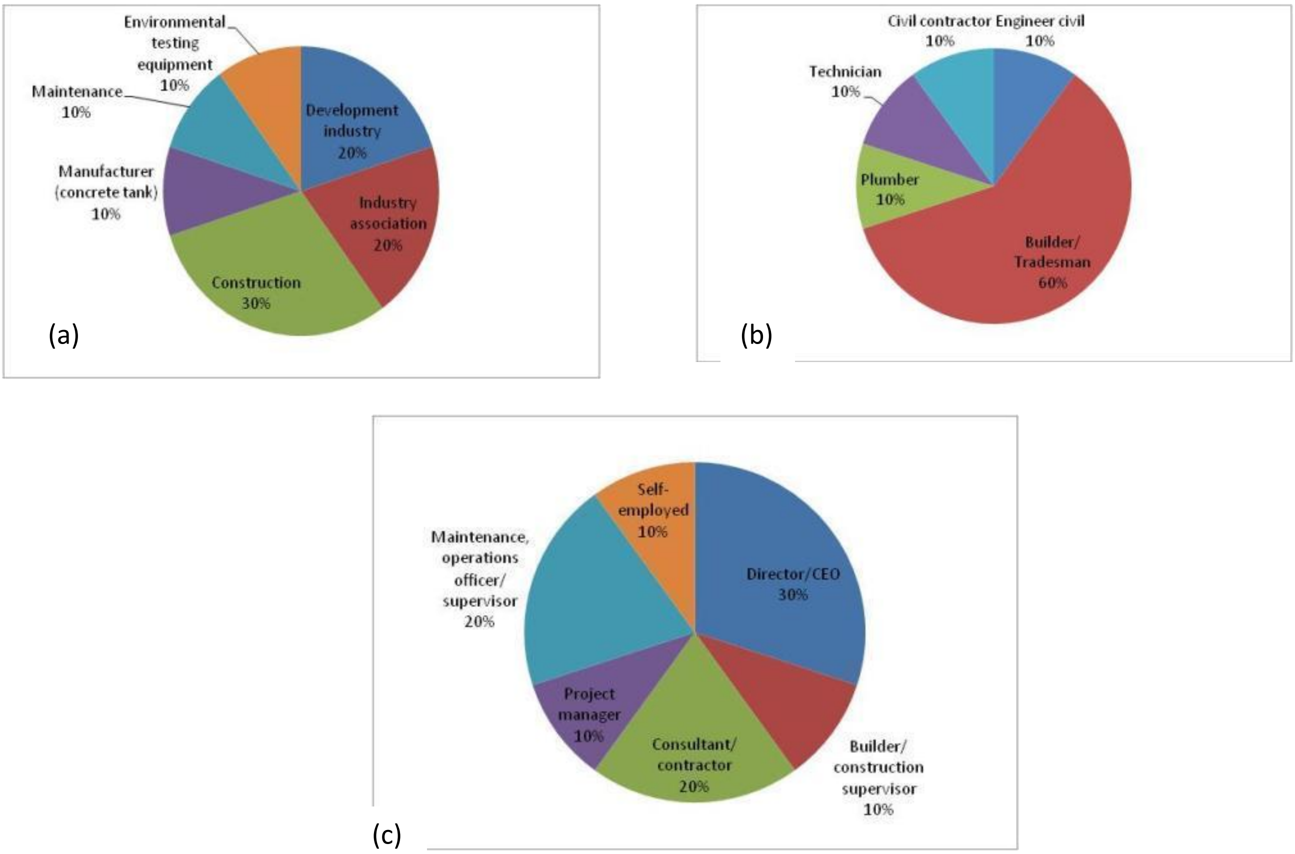


Figure G-5. Background of 10 respondents of the development industry sectors: (a) Development industry sector they work in, (b) Qualifications, (c) role

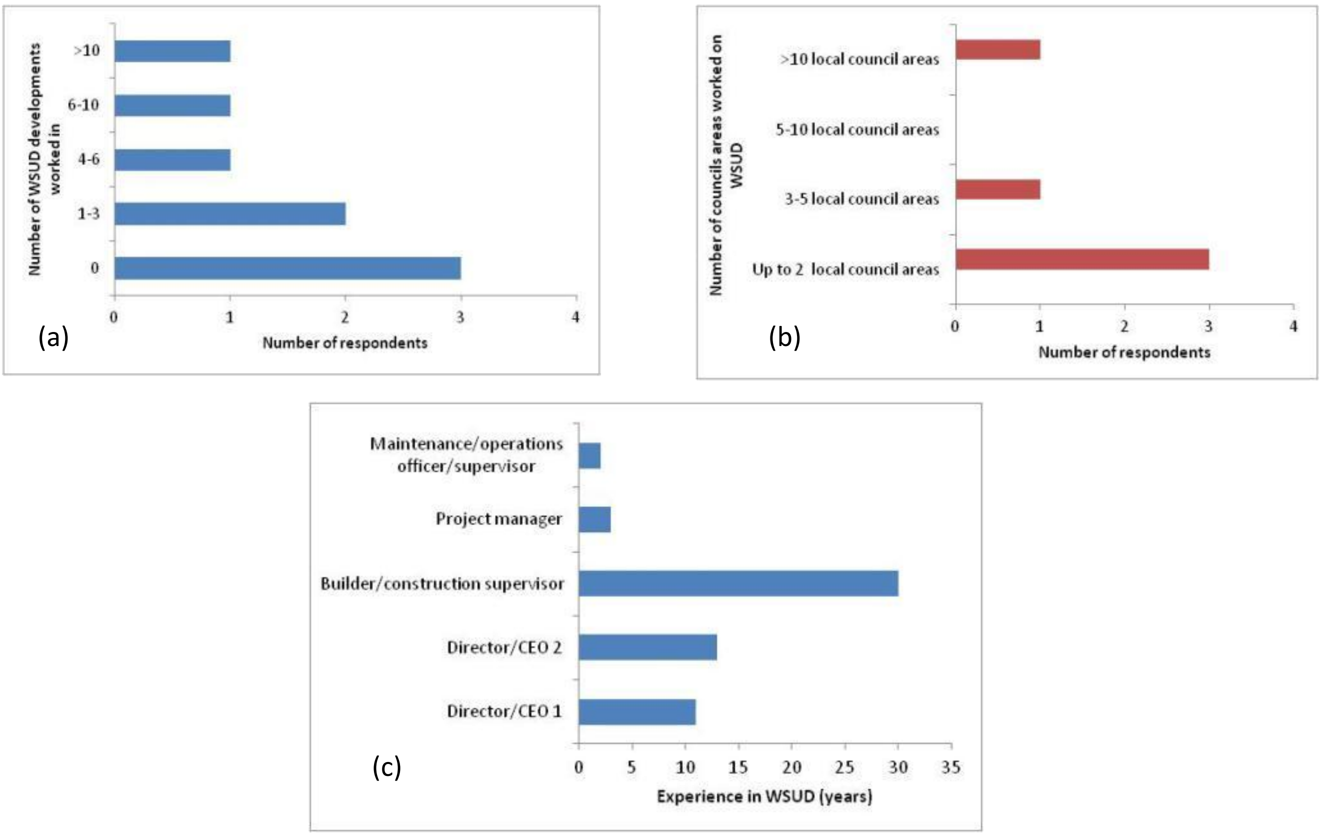


Figure G-6. Experience of respondents with WSUD. A total of 5 respondents worked directly in WSUD developments, the level of experience. (a) Number of WSUD developments individuals worked in, (b) Number of council areas where they worked on WSUD, (c) Number of years of experience in WSUD.

Appendix H. The development industry perspective

Initial consultation with development industry bodies (UDIA, MBA SA and GBCA) indicated the need for further clarification from the development industry members on WSUD issues.

Interviews were conducted with six development companies that operate in South Australia. These companies represent a cross-section of the various typologies of developers operating in Adelaide. The companies consulted were:

- AV Jennings is a large scale residential land development and building company operating in Australia and New Zealand. AV Jennings is listed in the Australian Stock Exchange (ASX) and in the Singapore Stock Exchange (SGX). In 2013 it had 9952 lots under development, with 3175 in SA. AV Jennings has been involved in a number of iconic developments featuring WSUD features in SA, such as Regent Gardens, Springbank and St.Clair. St. Clair is a 65 ha development with 35% open space being developed as a joint venture between private industry, local and state government.
- Environmentally Sustainable Developments (ESD): is a family business and small development company that adopts the ethos that development can be sustainable and commercially viable. ESD aims to demonstrate alternative ways to do business and to generate better results for the environment and for the lifestyle of development residents by adopting best practices and in the hope of setting an example for future development. ESD's major project in SA is Beyond Today, an environmentally sensitive development with 75% green space, i.e. much larger than the minimum requirement of 12.5%. ESD also provides consultation services to other developers that adopt similar philosophies interstate.
- Fairmont Group is South Australia´s largest privately-owned integrated housing and land development company, having constructed more than 20,000 homes and delivered several thousand land allotments in new communities across the State since being established in 1966. Projects include the Salisbury Campus Redevelopment, South @ Seaford Meadows and Playford Rise.
- Lanser Communities is a residential land development company that builds residential subdivisions and specializes on land division. Lanser focuses mainly on greenfield development in peri-urban areas, but the company has also built a few infill developments. Lanser has experience with conceptual and the preliminary stages of strategies to deal with stormwater, including WSUD. Its developments include the Freeling Estate and Strat Alban.
- Qattro is a developer and building company that constructs predominantly residential medium density infill properties in suburban Adelaide (inner west, north west and south west areas). Commencing in 2005, Qattro has built in excess of 250 dwellings per annum and has an ISO 9001:2008 accreditation. Qattro has constructed developments in areas such as Mawson Lakes, St.Clair and Northgate, where reclaimed water is adopted for indoors and irrigation. Whilst Qattro has not driven such developments, the company has adapted well to the methodology and was comfortable working with WSUD features.
- Renewal SA is South Australia's government land development agency which delivers building projects that the private sector cannot or fails to deliver for commercial reasons. It also facilitates the delivery of land to the private sector and imposes encumbrances on the private sector upon sale for delivery of minimum environmental outcomes. Renewal SA typically has higher social, environmental and economic objectives than the private sector. It also overseas projects from concept to implementation. Its developments include Lochiel Park and Bowden.

Development sector characteristics

- South Australia has a small and diverse pool of developers. There is overall recognition that there are various players in the sector, including those that will deliver to minimum standards, specialised boutique developers that have high environmental targets and the government agencies such as Renewal SA.
- The business model adopted by the development industry is based on the need to deliver a product at a price. Land development incurs a significant upfront cost, as the developer needs to construct infrastructure upfront, before lots or dwellings are sold and any income is received. Therefore the industry typically aims to minimise development costs and maximise the number of lots – 'We work on costs per m^2. The value of land is determined by land size, the number of lots it can carry and the profit increases as more lots can be built.' Developers are obliged to value land at the onset of a project, therefore if unexpected costs arise during a project execution and are larger than what can be accommodated in the original estimate, there is a high financial risk. The features adopted in developments are therefore driven by the demand of home buyers and by regulatory requirements set by local government.

Value of WSUD

- There is a general perception among the development interviewed that the WSUD principles and ideas are good/beneficial. However, whilst principles are supported by the parties, developers feel more discussion is needed on the value proposition/business case for WSUD. Five out of six developers were uncertain if the adoption of WSUD would be translated into a financial or marketing benefit on the sale of a development or that a return on investment could be proven. Some of the features are aesthetically appealing. There was a general perception that more often WSUD is perceived seen as a cost burden by the development industry. According to the interviewees, the adoption of WSUD occurs because of a company's own philosophy, regulatory compliance or council requirements. As expressed by one of the interviewees: 'WSUD is adopted more as a good will or philanthropic measure by developers or for awards. It is no done to impress the market'.
- The community does not understand nor value WSUD. The overall perception is that in the current environment home buyers and the government do not place high priority on environmental features, including WSUD: ' The home owner prefers a better benchtop than an energy saving feature, except for a small share of the market'. The lack of demand by home buyers is a major influence on developers. Developers feel that the current focus for the suburban home buyer market is on 'affordable' housing, not 'sustainable' housing. This differs from the period of drought, when there was greater appreciation for alternative water sources and a green garden was a selling point. However, the community values lifestyle space and amenity that residents can enjoy, such as open green spaces and water features, in such cases WSUD adds value if it can create such indirect benefits as aesthetics. However, these are not to the primary function of WSUD features. The experience from majority of the developers was that community and a number of councils do not necessarily value the environmental aspects of WSUD. 'The community likes ponds filled with water, not ephemeral features'.

Status of WSUD

- WSUD is more advanced overseas. WSUD efforts were seen to be by some at pair with other states, by others in need for more widespread uptake.

- Standards are higher – driven by council requirements and industry exposure to new technology the standard on what is delivered on the ground has improved.
- Exposure to WSUD varies with developers, with their size and project history. There was recognition that due to the limited number of large WSUD projects, opportunities for exposure were constrained.
- There is the recognition that there are various players in the development industry, with a majority that delivering to minimum standards. This is further compounded by unclear objectives and requirements from local government.
- There is an overall perception that the expertise of councils on WSUD varies. In addition, councils also had limited resources for inspections and verification of implementation in general, which is important to ensure compliance and proper design.
- There is an overall perception that among consultants WSUD expertise also varies.
- Often developers and residents do not understand the value of landscaping and WSUD.

Challenges of WSUD

- Disparity of knowledge among councils, consultants and developers.
- Fear/perception of uncertainty associated with WSUD cost for councils.
- Uncertainty is a major issue due to the investment required by developers during the early stages of development. Anything that impacts the cost and time before construction proceeds (even a 1-2-years time requirement) is a major issue. Typically uncertainty is associated, with the time delays required for development approvals, and often with unforeseen requirements, not specified at the start of the development application. More information on costs of WSUD systems would assist to reduce uncertainty.
- Lack of confidence on WSUD system performance – developers are at times not convinced that a specific WSUD feature either performs effectively or is the most effective solution for a problem. This concern applies particularly for solutions applied at local scale (allotment, street or site) compared to a larger scale feature (e.g. wetlands for a few neighbourhoods or a district). Similarly there is a concern that in some councils policy is focused too much on small bioretention features (on-site or at street level), without having a proper understanding of the O&M cost implications, nor a proper investigation of the best options for a catchment (i.e. the best solution or scale of treatment may vary from a lot to a group of developments), particularly for greenfield and large infill sites. On the other hand, some developers feel that councils are starting to realise that the cost of managing multiple small WSUD features, and thus councils prefer larger features, with opportunities for WSUD innovation seen as limited. Either way, there is the perception that there is no advantage in engaging expensive consultants to design state of art WSUD, if it is going to be rejected by council assessors.
- Perception that councils provide inadequate maintenance of WSUD features after handover.
- The need for site specific solutions which can vary from case by case in scale and type of solution.
- The non-sequential nature of land development (it may take up to 10 years to develop a parcel of land), requires solutions that allow some flexibility over time.
- Large developers have the resources to investigate WSUD alternatives for a development and they tend to develop on greenfield, however small developers are unlikely to have the resources and to be able to make WSUD happen at this scale. Yet among the players in the industry, large developers are driven by the same model as the smaller ones, and may not necessarily implement WSUD unless forced to do so.
- Industry is likely to rush for WSUD if cost benefit can be proven.
- Councils, developers, consultants all expressed the need for data on costs and benefits of WSUD.

Barriers

The barriers identified by the developers include:

- Councils are the major point of contact for developers, followed by selected agencies depending on the statutory agency referrals determined based on the development characteristics and location. However, councils are seen to dictate WSUD requirements, whilst being risk adverse.
- Uncertainty in council requirements for WSUD and lack of guidance from councils in development plans. This is associated with the perception of lack of understanding by a number of councils on WSUD options, their long-term costs and the lack of a bigger picture strategy. There was often a disconnect between different council departments regarding policy and advice for development applications. This was again closely linked to council capacity or understanding limitations. As expressed by one developer: "...*sometimes we do what council wants, even if we know it is a waste of time and money to install them, just to avoid delay costs*."
- Perception that lack of capacity results in a lack of understanding by councils of the associated cost realities of some of the WSUD requirements they pose (i.e. lack of commercial reality), as expressed by one developer: "in a development area we were asked to build three wetlands instead of the original two proposed, which for that site was not practical and not realistic given the cost implications."

  Lack of understanding of benefits and costs: councils are reluctant to take WSUD on because of maintenance and the need for more land, however many people see it as a beneficial aesthetic tool. Lack of data on the costs on O&M and renewal of WSUD features, given the short history of many of such installations. Developers are unsure if such type of data has been collected and released.
- Perception that "*some councils think developers have a lot of money and can pay for all costs*".
- Perception of a lack of willingness in some developers and lack of understanding of costs and benefits of WSUD, given there is no tangible market response to WSUD.
- For one of the developers, the EPA was the major agency they dealt with after council. Before the issue of a development approval, councils can request and environmental report, including soil and bore water analysis for a site for evaluation by the EPA. The developer feels that the onus is on the developer to prove that the site is "fit for purpose" , but that the requirements for such classification and the justification for demanding such test by councils lack transparency resulting in very high costs and that increasingly such test are being demanded for infill sites, including small lots.
- Pre-conception that WSUD is more expensive by some developers and councils (or that costs are unknown).

Other issues:

- Better streamlining of the approvals process and better internal integration would facilitate the process: "as a developer we can give the council whatever document they want, provided we know what it is they want".
- Despite of the availability of standards, poor accountability and lack of policing are seen as larger issues, particularly with the reduction in the number of building inspectors in councils.
- State government needs to investigate if future growth may run into infrastructure capacity issues particularly with increase of density. Are the targets realistic based on infrastructure capacity?
- Inconsistency across councils when it comes to WSUD implementation – need for more strategic leadership by council. Strategic direction also would allow better integration and coordination of different objectives from different groups (agencies) (EPA, NRM board) for a development.
- Councils are seen to take more responsibility every time, but do not necessarily have the resources to match.
- Danger of building tool kits or include WSUD in planning in a prescriptive manner. This is risky as there is not enough rigour or technical expertise from the planning policy department side of DPTI. There needs to be some form of input from developers experienced in implementing such features on the ground to get proper insight on real issues and to tap on actual knowledge base.

- Ownership of assets: wetlands are not classified as open space, who owns purple pipe before it becomes functional (SA Water, Private supplier)? There is need for centralised planning and better coordination of the staging of developments.

Recommendations – way forward

- Consistency: need for clarity in guidelines, council requirements and transparency in the approval process. A common approach for all tiers of government, for experts and the development industry. The respondents felt that the great need was need for more clarity from councils. There was concern that soon a planning module will require WSUD implementation, but that the technical options prescribed may not be the most appropriate for a specific site, leading to token efforts. Hence, there is the need for severe careful consideration on how implementation should proceed. This is also expressed in the perception of lack of consistency from one site to another, and at times between different officers within a same council and among councils (particularly for councils that are unclear on what they require).
- Capacity building and consistency across Council departments and assessors, which should also be linked to the strategy of a council. There was need for WSUD requirements/policy to be linked to council strategy. "Councils have a bigger picture than developers for implementation of services and hence could facilitate the implementation of guidelines and target that are relevant to the whole of a council area." (developer comment). One suggestion was for councils to link WSUD requirements to their SMP to deal with water and obtain proper expertise on the cost implications of various features.
- Focus on capacity building on professionals in planning departments and engineering industry: "*If all engineering firms are well versed in legislation, then engineering firms will drive the implementation. Have firm guidelines that engineers have to sign off on and then give engineers the responsibility to implement*"- stated a developer. "*Engineers vary in capacity, and the younger generation wants to learn WSUD. But the engineering industry has a lot of turnover and engineers regularly change firms. Thus, we have experienced that the level of knowledge varies and at times we have followed good engineers across firms. Thus it is better to focus on education and understanding of legislation on the professionals – due to the legal onus*."
- Quantify benefits: monetise and demonstrate benefits, develop cost comparison between traditional and WSUD techniques to prove the cost benefit, monetise and demonstrate environmental benefits (seagrass health, stream health, survival of aquatic species), show cost savings to people involved in WSUD and to end user.
- Better education/communication of data above. Even if data is available messages are currently not communicated effectively.
- Firmer action from State planning, but not a prescriptive action.
- Incentives for developers to take on WSUD (not only penalties). For instance:
    - Dispensation: if a developer implements certain design /features, he/she gets dispensation in other areas.
    - Local government willingness to contribute to design/construction as they see fit in selected areas, for instance the developers grant a parcel of land and the local government contractors do part of the civil work as per their requirements. This would avoid much of the typical back and forth miscommunication between developer and council that occurs during the design stage. For example, in Mawson Lakes there were no issues as a Master plan was already in place for the site.
    - A proportion of state or local council fees is discounted after quantifying local cost and providing a compensation for any additional cost of installing a WSUD feature, e.g. provide a 10% off fee or the council offers do undertake certain tasks – something that can soften the cost load to the developer.
    - Easing of the land tax for developers, as it is a big impost for developers, i.e. reduction of the cost burden instead of the handing out incentives. For a developer holding land, a land tax of $5k per lot per year for 20 plots becomes a big burden.
- Demonstrate evidence of market place value. '*For an individual household with a 1.5kL rainwater tank increasing to a larger volume does not cost much more*. *Another problem with rainwater harvesting legislation, that the desalination plant acts as a disincentive for government as it needs to*

get the return on investment, hence there will not be be water restrictions for a while. Therefore it is unlikely that any more changes to rainwater harvesting policy will occur.'- commented a developer.

- "*Council should take a bigger role in planning – particularly on the orientation and design of development controls. Councils should also mandate a certain level of rainwater harveting and solar energy, as these features place less burden on the overall infrastructure long term Local Government should have more confidence in tailoring their planning instead of relying on state government directives as such measures are also beneficial to local government as a business."*

Appendix I. Local government perspective

This section is a summary of Myers *et al* (2013), which prepared an inventory of WSUD in SA and details the outputs from interviews conducted with 25 local councils in the greater Adelaide regions and their consultants.

Drivers for WSUD uptake

There have been three major drivers for WSUD uptake by local government: flow management, creation of an alternative water source for irrigation and improvement in stormwater quality.

Flow management was the primary driver for most WSUD uptake in councils, with WSUD elements designed with a focus on flood control and reduction of peak flows. This is likely to continue given the projected trends in urban form for increased dwelling density and infill scenarios for Adelaide.

In addition, WSUD has also been adopted because it offers multiple direct benefits such as producing alternative water resources (to reduce drinking water use during water restrictions) and improving stormwater quality.

Other important drivers were indirect benefits, such as costs savings from alleviation of capacity constraints on centralised infrastructure, improvement of amenity in public open space for recreational and environmental benefits, and the reduction of the environmental impact of urban development on receiving waterways and coastal waters.

Enablers and Barriers

- ***WSUD requirements***

Councils across Greater Adelaide differ regarding their WSUD requirements in the development approval. process. Historically, WSUD uptake has been fragmented in nature due to capacity and resource constraints, this has implications for the long-term overall stormwater strategy across LGA's boundaries and catchments, given the potential interdependency between upstream and downstream stormwater flows.

Ensuring that individual LGA strategies are sustainable in the long-term is likely to require a level of overall planning coordination across shared catchments.

- ***Capacity***

Local government representatives, supported by the literature, acknowledge the fragmented nature of WSUD implementation across councils. WSUD across local government appears to be influenced by the in-house capacity and commitment to WSUD.

Practitioners have recognised the need for a site specific configuration for WSUD features, driven by local conditions (physical constraints, such as restrictions on the availability of open space and physical conditions (suitable geology, slope), the technical capacity and expertise of proponents and policies (either council policy or policy support)). However, differing levels of expertise among consultants engaged in projects influence the uptake of WSUD.

The capacity for WSUD planning and implementation, whilst evolving, varies across consultancy firms, local government and within State Government departments. The technical design of larger WSUD projects tends to be undertaken by external consultancies on behalf of developers and local government. Smaller systems were often conducted within local government. For construction and implementation, smaller projects, such as trial systems and roadside infiltration and soakage pits tended to be installed by local government operation crews as part of routine road maintenance works. Larger projects tended to require a scale and level of expertise which requires external construction services; however they were perceived as positive opportunities for learning and knowledge development between local government, developers and consultants.

Capacity development and the adoption of WSUD in organisations was mainly driven by individual champions, and each organisation's history on WSUD. Councils which have had a longer WSUD implementation history have typically learnt from experience, and have developed either formal or informal approaches for improving WSUD implementation across the organisation. Yet transfer of lessons across local government areas, whilst potentially beneficial for WSUD capacity building, is not a common or formalised practice.

Almost all practitioners at the local government level received internal support from the elected members for implementing WSUD technology. Stakeholders at the elected level tended to be positive toward WSUD because it is associated with 'sustainability' in the broader sense. In some circumstances, it was found that elected members remained conservative due to different aspects ranging from fear of loss of community support to concerns regarding immediate economic returns. Some local government practitioners indicated there were internal barriers to WSUD due to concerns expressed by more senior staff. These concerns generally revolve around non-traditional stormwater management and the perception that the implementation of trial or experimental WSUD technologies may have negative results.

Despite the availability of many guidelines for WSUD, there remain some issues around technical guidance for WSUD systems. For example, there was generally a high level of awareness of the South Australian WSUD Technical Manual (SA Government, 2010). However, some practitioners indicated that these guidelines provided good background information on WSUD and many useful technical details of note, but lacked something in the 'middle ground' which would make it a useful design document.

- ***Funding***

Access to resources or funding for implementation is a challenge for local governments, particularly for the on-going maintenance of WSUD features. In particular, street scale distributed WSUD infrastructure, whose performance and impact is not as well understood is seen as a major challenge for the future, compared to large scale features.

- ***Operation and maintenance needs***

Lack of understanding of O&M needs and associated costs for WSUD is a major concern for many councils as often local governments do not have specific funding allocated for maintenance of WSUD features. Whilst larger scale wetland systems are well understood few councils have formal maintenance procedures in place for smaller scale systems, such as tree pits and streetscape bioretention works.

The upkeep of sub-optimal WSUD systems was considered an issue of concern where local government has inherited WSUD installations from developers, where they perceived some of the features requiring high maintenance due to aesthetics.

- ***Policy***

State government requirements for alternative water supplies to all new homes (and some renovations to existing allotments) has resulted in greater implementation of rainwater tanks at the allotment scale, while larger developers explore the integration of a 'third pipe' water supply into developments. In some circumstances, developers have opted for rain water tank volumes above the state government minimum requirements of 1 kL to achieve detention because the increased volume of on-site storage is seen as an opportunity for reuse. Approval authorities indicated some concern with this approach because when tanks are full there is little impact on stormwater detention.

The implementation of policies on stormwater detention at the local government level has also resulted in mandatory integration of detention mechanisms limiting flows from development, from allotment scale tanks to detention basins in larger developments. Several councils have a requirement on permissible site discharge to limit (mitigate) peak flows to the street drainage system.

Several local government representatives valued the ability to directly negotiate WSUD outcomes with developers as a significant driver for achieving outcomes. While this is difficult at the allotment level where the number of projects is higher, several commercial and large scale residential projects were seen as a success by local government in terms of WSUD. This is because there was opportunity and scope in the development approval process to discuss WSUD with the developer and produce a mutually beneficial outcome.

- ***Community support***

Community awareness and engagement has been recognised as an important enabler for the implementation and long-term performance of WSUD features. Unfulfilled community expectations and negative feedback due to civil works are seen as powerful influences on WSUD uptake and even design.

Thus community engagement has been warranted. Community engagement varies according to project scale and is adopted mainly for larger projects. Smaller projects tend to adopt less intensive consultation, such as use of community newsletters, direct mail-outs to residents affected by construction and sometimes face-to-face consultation with the public at the project site. Face-to-face methods were seen as more effective at harnessing residents' interest and support than passive methods.

Impediments

- ***Lack of commitment at the policy level by State Planning*** is seen as one of the major impediments to WSUD. For most local government, WSUD was referred to in the local development plan, but lacks a strong underlying policy or proper guidelines which may assist in the encouragement of developers to adopt WSUD principles.

- ***Unquantified externalities and difficulty in assessing the long term benefits and costs*** are seen as a barrier to developing a business case and to the allocation of appropriate maintenance budgets for WSUD by councils and developers.

- ***Lack of detailed construction guidelines*** including for topics such as the selection of adequate soil and filter media for infiltration technology design, the selection of locally appropriate vegetation, recommendations on the scale of structures per unit area and of suitable areas for installing water management schemes.

Recommendations to improve WSUD uptake

- **Stronger Legislation and policy drivers:** formal recognition of WSUD as a development requirement in planning legislation would allow councils to control development more stringently than they currently can. This is seen as one of the strongest needs.
- **Improvements to the development assessment process** as a series of steps where WSUD is flagged based on the development proposal type being considered.
- **Mechanisms for coordination and integration of WSUD across catchments** for catchments that span across council jurisdictions. Development of a boundary rule or mechanisms for cross-council coordination and collaboration would be beneficial where individual councils could force upstream councils to introduce infrastructure to manage upstream quality and quantity for creek health and minimum flows.

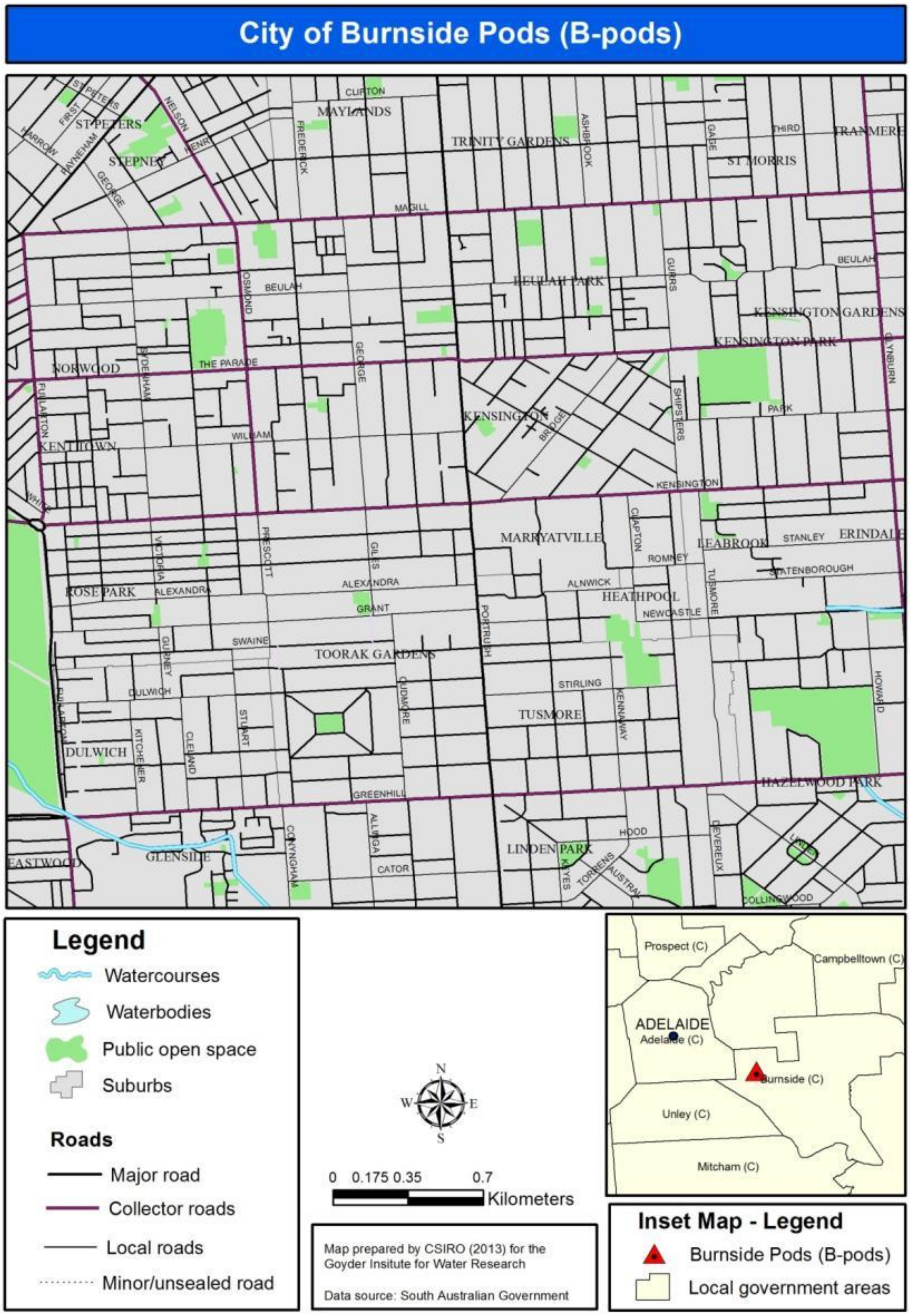
- **Recognition of small scale options for WSUD in** planning requirements because these are the only available solutions for infill development scenarios.
- **Development charges:** Most local governments were supportive of the concept of a developer levy as it seemed to be working well in Melbourne and on a smaller scale in Adelaide.
- **Develop capacity in WSUD maintenance and** a capacity building program for all stakeholders involved in WSUD.
- **Publication of WSUD benefits and costs:** quantify the benefits of WSUD to have a realistic idea of how much a WSUD project may cost, including maintenance needs and any beneficial outcomes, how effective WSUD measures are at 'stretching the hydrographs' (reducing peak flow) for various storm events. Lack of this data is one of the major inhibitory factors for local governments engaging in the routine implementation of WSUD

Reference

Government of SA (2010). Water sensitive urban design technical manual - Greater Adelaide region, December 2010, Adelaide, SA, Australia, Department of Planning and Local Government.

Appendix J. Detailed WSUD Site Assessments

Burnside pods (B-pods) Detailed Assessment



Overview

City of Burnside is famous for the treed streetscapes compared to the other municipalities in Adelaide, which is highly valued by the residents in terms of general amenity, aesthetics, healthy environment and social wellbeing (Tree Management Strategy 2013). The Tree Management Strategy was introduced, based on city of Burnside's '2020 Strategic Vision' and 'Community Land Management Plans', to promote sustainable use of natural resources for reducing dependence on mains water for watering the trees.

The Local Government Act 1999 required the councils to place an adequate system for managing the tree health due to greater reliance on council's tree watering program and the reduction in the house hold water availability for the new trees. Also lack of greenfield sites in the council area, the 'heritage status' assigned to most of the trees and parklands, the percentage of un-kept grass verges, aging conditions of the existing water infrastructures (existing stormwater facilities were old and designed for 1 in 1 ARI) and the frequent flooding issues in council suburbs prompted the council to device alternative source control technologies for water management, within the council. The attractive scale of economy of pod infrastructure (cost less than 20% of the total cost) when constructed along with the routine road /drainage up gradation works was another driver for B-pod uptake.

B-pods were devised as an alternative to water bowls which was commonly used along the streets of the council for holding water in the vicinity of trees (Figure J-1). These bowls could collect at least 40L of water at one time. Once the planting is completed, the water bowl system is maintained for three years.

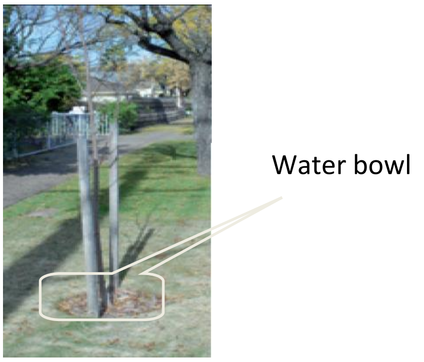


Figure J-1 - Water bowl provided for young trees

(Source: Tree Management Plan, City of Burnside)

The council investigated alternative verge treatment systems with minimum requirement of watering and maintenance where adequate space or location for 'water bowls' were not found. As a result Burnside Council developed a water detention system called "B-pods" to irrigate street trees with harvested roof runoff (Figure J-2).

Figure J-2 – B-pods

The table below represents the overview of the location and WSUD aspect of the pod system.

Table J-1 – Overview of B-pods

Rainfall zone (mm)	Alternative water source used	WSUD elements	Development type	Scale of development	Availability of monitoring studies
600-800	Roof runoff	Infiltration pods (B-pods)	Retrofit	Medium/ Large	Burnside Council

Design and construction of pods

As per the discussions with council staff, simple and flexible concept has been adhered in the design of pods, which was developed by the in-house engineering team. The construction was mainly undertaken while modifying or replacing the kerbs or replanting the trees. Figure J-3 represents the pods under construction. The pods were named as 'Burnside-pods (B-pods)' to distinguish them from other service installations.

Figure J-3 – B-pods being constructed

(Source: City of Burnside 2012)

B-Pods were designed to intercept the roof runoff (to avoid silt and debris getting into the pods) which was conveyed to the pods through downpipes and a series of lateral pipes, connected to the pods. Thus, along with providing water for younger trees, the pods also acted as a first flush device during heavy rain fall events. The pods were designed to get filled up after five minutes of the initial precipitation and to cause any runoff excess to overflow through the stormwater outlet pipe, B-pods were installed a meter or a meter and a half from the younger trees as per the suggestions from the arborist. The construction of pods began in the year 2010. To date the pods have been installed in the following streets.

- Hautville Terrace, Eastwood
- Tudor Street, Dulwich
- Union Street, Dulwich
- Treolar Avenue, Kensington Park.

B-pods consist of plastic crate pods within the kerbside trench, the typical dimensions being 600mmx400mmx450mm. The crates are provided with impermeable lining at the top and bottom surfaces and with a geo-textile lining on all the lateral surfaces, which is then packed with cement treated rubble to prevent the water seepage into the road. The whole trench is then filled with gravel for allowing soakage and gradual dispersion of the stored water to the surrounding regions. The typical plan and sectional view of the pod is shown in Figure J-4.

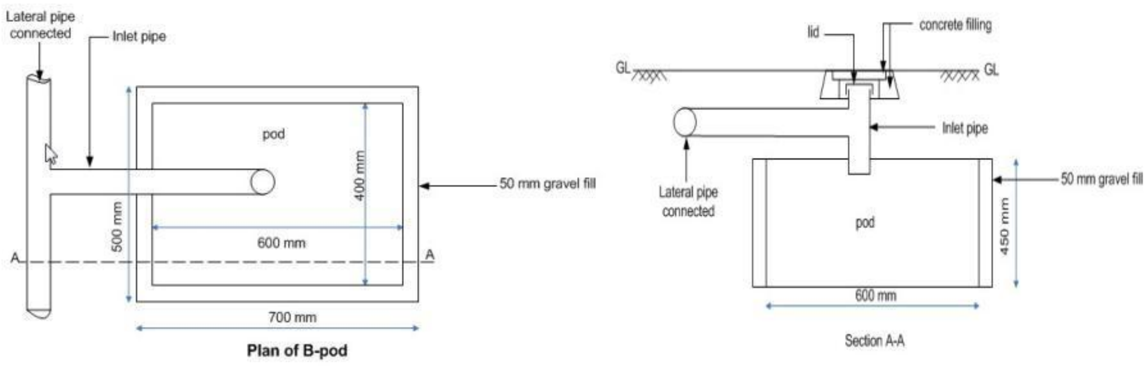


Figure J-4 – Plan and sectional detail of B-pod

Each cell has a theoretical capacity of 108L and the holding capacity of the pods is enhanced by the heavy clayey soil predominant in the council area. These pods are constructed 20 to 25mm above the gutters to prevent sediments entering into them. Recently the pod design was modified by the addition of an inspection chamber connected to the water holding crate, within the pod.

According to the council, it costs about $400/system for the overall construction of a set of pods along a street and to implement an individual system would cost the council around$800 to $1000 per pod. The initial installations were made in Tudor Street, where the pods were provided for each downpipe connection, which was then interconnected with lateral pipe systems. Since it turned out to be uneconomical due to the excessive pipe works involved, the further installations were made based on the location of the younger trees and the availability of down pipes for conveying the roof runoff, even though this affected the flexibility of providing pods near to all younger trees. As a result some plants could not be served due to lack of a nearby stormwater drainage pipe.

Stakeholders and pod management

The major stakeholder in the design, implementation and maintenance of the pods is the Burnside council.

The implementation of the B-Pods is still relatively new in the Council, therefore the appropriate maintenance practices and implementation schedule for the pods is still being developed. They are planning to implement the system in conjunction with planting of younger trees and are anticipating developing the system into a larger storage system, where the entire roof runoff from the street could be collected, stored and used for tree irrigation, even though the reliability of the source of water is still unclear. However the council presumes that the maintenance of these systems should not be an issue as the risers in the pods used as inspection chambers could be used for sucking the debris out and the system could easily attain a functional efficiency of 80% to 90%.

There have been no reported issues with the functioning of B-pods, yet. The council considers it too early to determine the effect of B-pods on street tree health and does not have any specific funding for the maintenance of these features. Most of the systems are maintained only during the initial years of construction.

Community involvement

There has been little community involvement with installation of B-pods as they are installed underground and are not significantly visible to the public. The concept and installation of pod systems were demonstrated in a community event in 2012 and received an appreciable positive feedback.

WSUD Performance

The council is yet to determine the actual volume of runoff that could be detained by the pods, the dispersion rates across the gravel media, the reduction in water demand from external sources and the low flow assessment. A field test was conducted in Union Street, Dulwich to assess the performance strategy of the pods and it was found that an individual pod was able to hold more than three times the initially estimated capacity. However the council is keen on further investigation as to clarify whether the successful performance was merely due to the system efficiency or the improper implementation of the entire system.

Modelling performance

The effectiveness of the pod system in managing the roof runoff quality and quantity was analysed using the MUSIC model. The pods installed along the Union Street were considered for the simulation as they were connected independently to individual residences depending on the availability of the downpipes from the roofs and also the availability of council site plans for this street representing the pod locations. The major challenge in the modelling process was to best fit the B-pod system to a typical treatment node in MUSIC. Different treatment nodes including pond, rain water tank, infiltration system and bioretention were examined.

Considerable amounts of evapotranspiration losses and lack of options for defining infiltration processes happening in the pod system, made ‘pond’ a non-viable node. A rain water tank, which was conceptually very similar to pod system had limitations associated with restricted water loss to a fixed daily rate regardless of storage depth and soil characteristics and the absence of infiltration process happening in the system. Even though the ‘infiltration system’ node was considered, there was no option to simulate a system with permeable liner at the base. Thus the bioretention node was selected to simulate the pod system with the following assumptions (Figure J-5).

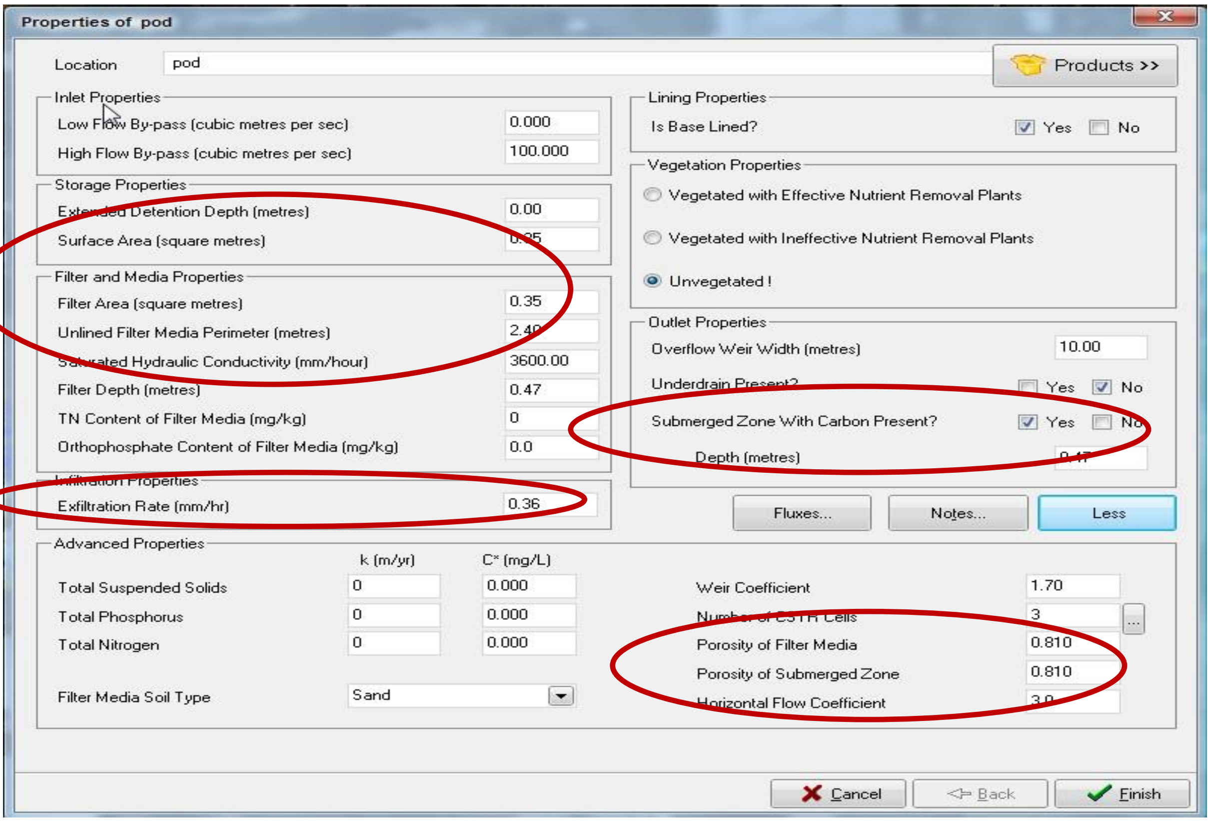


Figure J-5 – B-pod simulated as a bioretention system in MUSIC

- ‘A submerged zone with carbon present’ was assumed to incorporate exfiltration into the surrounding soil via the vertical sides and was assumed to extend over the depth of the entire pod (0.45m) (refer to Figure 4 for the details of pod dimension).
- The surface area of the bioretention system was assumed to be equal to the filter area (0.35 m^2).
- Since the pod and the gravel lining were considered to function as an integrated unit, the weighted average porosity of 0.81 was used (Table J-2).

Table J-2 –Calculation of weighted porosity

Determination of weighted porosity of the filter media.				
volume of the tank	V1	045x.4x.6	0.108	cubic meter
volume of the gravel	V2	(0.7x0.45x0.5)-(0.108)	0.0495	cubic meter
Assuming a porosity of 1 for pod and a porosity of 0.4 for the gravel				
weighted average porosity of the entire system		[(0.495/0.7x0.45x0.5)x0.4] + [(0.108/0.7x0.45x0.5)x1]	0.81	

- Extended Detention Depth (EDD) was assumed to be zero as there was no pooling of water happening above the surface of the pod in actual scenario. An extra .02m was added to the depth of filtration media to counter for this (total depth of the filter media was assumed to be .47m).
- A large overflow weir width of 10 m was assumed to represent the absence of any flow accumulation at the outlet.

Performance Assessment

The whole street was divided into two segments depending on the location of the major stormwater drain, first half draining into the Cleland Avenue drain and the other half draining into the Warwick Avenue drain (Figure J-6).

Figure J-6 – Union Street draining into Cleland and Warwick Avenue

Even though most of the pods were individually connected to a single roof area, houses (5, 15A, 31 A-C, 22, 6, 21, 25, 14C and 40) did have their roofs connected to multiple pods where the roofs of the houses 13 and 15 were connected to a single pod. Five scenarios were established to understand the sensitivity of the model parameters which are listed below.

- 50% roof area connected to the pod (base case)
- 100% roof area connected to the pod
- Double the volume of the pod keeping the roof area at 50%
- Double the ex-filtration rate keeping the roof area at 50%

- 435 L pod capacity (based on the field test conducted) keeping the roof area as 50%

The base scenario was established as 50% of roof area draining into the pod. The remaining 50% of the roof runoff was assumed to drain into the local strom water channels. The second scenario analysed the performance of the pods system when 100% of the roof area was connected to the pods. The impact of increase in pod volume (providing two crates instad of one) on flow and quality of roof runoff was analysed in third scenario. The exfiltration rate was doubled (.72 mm/hour) from the base scenario assumption of 0.36 mm/hour to evaluate the impact of the soil media on the pod performance. A scenario was developed with approximately thrice the volume of the pod (435 L) with no change in perimeter or porosity to replicate the actual conditions that existed on ground during the field test and compare the performance results.

The model developed for the base scenario for the Warwick Avenue is represented in Figure J-7. The assumptions made for each of the scenario described above is tabulated in Table J-3, below.

Figure J-7 – Typical layout of the pods capturing 50% of roof runoff along Union Street draining to Warwick Avenue (base case)

Table J-3 – Assumptions made for sensitivity analysis of model parameters

		Assumptions made				
scenario defined		exfiltration rate (mm/hour)	Surface area (sq.m)	Filter area (sq.m)	unlined filter perimeter(m)	porosity
	Base scenario (50% roof connected)	0.36	0.35	0.35	2.4	0.81
	100% roof connected	0.36	0.35	0.35	2.4	0.81
	double the volume of the pod	0.35	0.65	0.65	3.6	0.84
	double the exfiltration rate	0.72	0.35	0.35	2.4	0.81
	435L pod capacity	0.36	0.95	0.95	2.4	0.81

Modelling performance results

The simulation results for various scenarios are depicted in Figure 8.

The results shows that increase in the storage volume and the doubling the ex-filtration rate of soil media have the greatest impact on the flow volume reduction. The provision of 38 B-Pods along Union Street can reduce stormwater annual flow by 5.4% with the base case scenario. The reduction in the transport of the pollutants for the entire street also reduced around 6% for TP, TN and TSS per year), proportional to the runoff volume reduction. The results showed considerable amount of reduction in gross pollutants (Table J-4), which is not very critical for the B-pods as the only possible pollutant into the pod would be the leaf litter, which is effectively removed by constructing the pods 20 to 25mm above the gutters, to prevent the entry of the debris.

As depicted in Figure J-8 and Figure J-9 connecting 100% area to B-Pods does not significantly add to stormwater reduction, however doubling B-Pod storage, increasing infiltration rate can significantly decrease the stormwater annual flows.

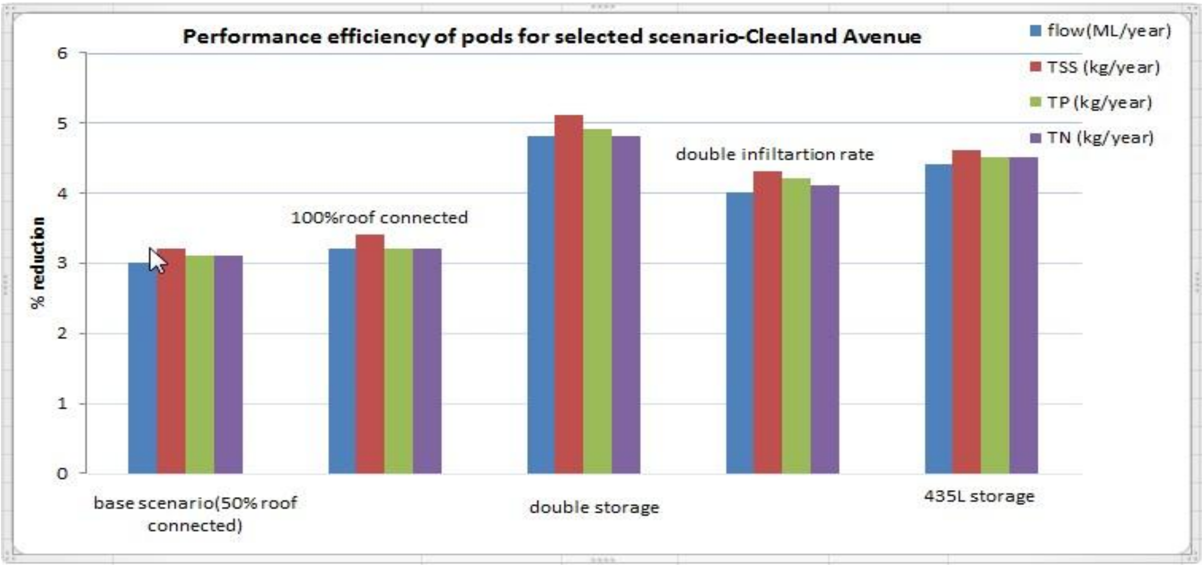


Figure J-8 – Performance of pods in roof runoff management along the segment draining towards Cleeland Avenue

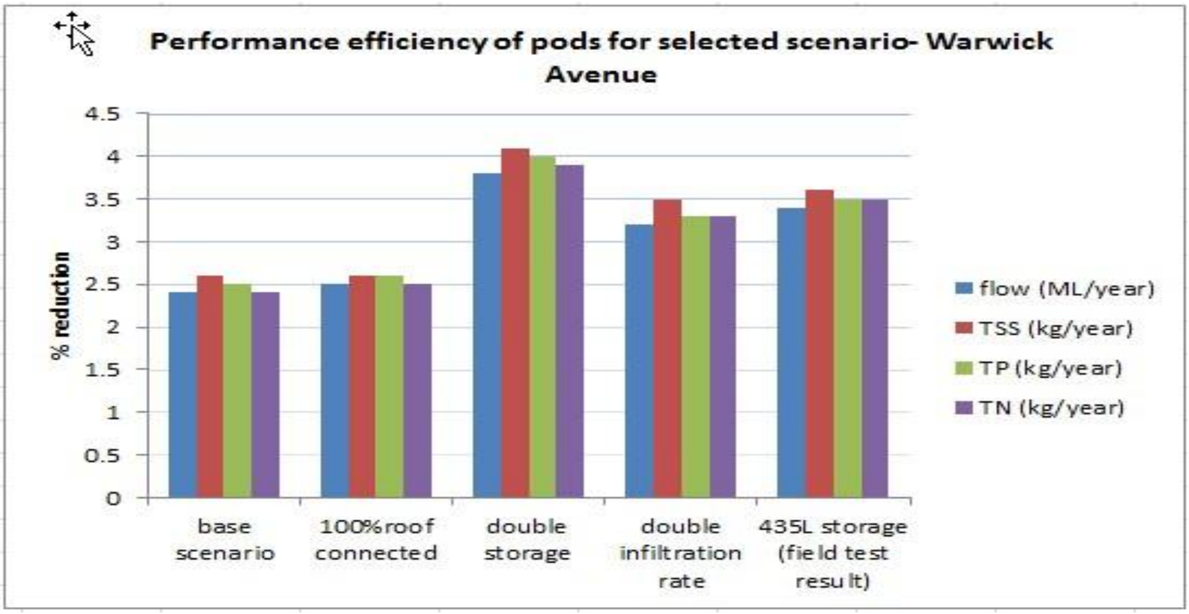


Figure J-9 – Performance of pods in roof runoff management along the segment draining towards Warwick Avenue

Table J-4 – Overall performance of pods for the base scenario for the entire Union Street

	Base Scenario (50% roof area)				
	% reduction in parameters				
	Flow (ML/year)	TSS(kg/year)	TP(kg/year)	TN(kg/year)	Gross pollutants (kg/year)
Cleeland Avenue	3	3.1	3.1	3.2	18.5
Warwick Avenue	2.4	2.6	2.5	2.4	19.6
Entire Union Street	5.4	5.7	5.6	5.6	38.1

As per the base scenario, nearly 2.5% of annual flow reduction is obtained from each segment of the Union Street, which is significant when emphasising the importance of such small scale systems in retaining the runoff and gradually dispersing it off, which could be effectively captured by street trees, which agrees with the council's driver for the installation of pods, i.e., enhancing the tree health. It would also help to reduce the council's dependence on tree watering trucks for maintaining the 'tree assets' within the council.

The sensitivity of the underlying soil medium was also analysed to understand the performance ability of pods in different soil media. Five different exfiltration media were considered which were:

- Heavy clay (0.36 mm/hour)
- Medium clay (3.6 mm/hour)
- Sandy clay (36mm/hour)
- Sandy loam (180 mm/hour)
- Sand (360 mm/hour)

Figure J-10 presents the analysis results. As depicted, the increase in exfiltration rate decreases the annual discharge of stormwater into the drains. The reduction in flow rate increases from 3% to 12%, when the soil strata beneath changes from heavy clay to sandy clay, showing the suitability of such small scale systems along coastal councils, where flow attenuation could be obtained by simple and small scale subsurface systems like B-pods.

However lack of any performance studies restrict from validation of modelling outcomes.

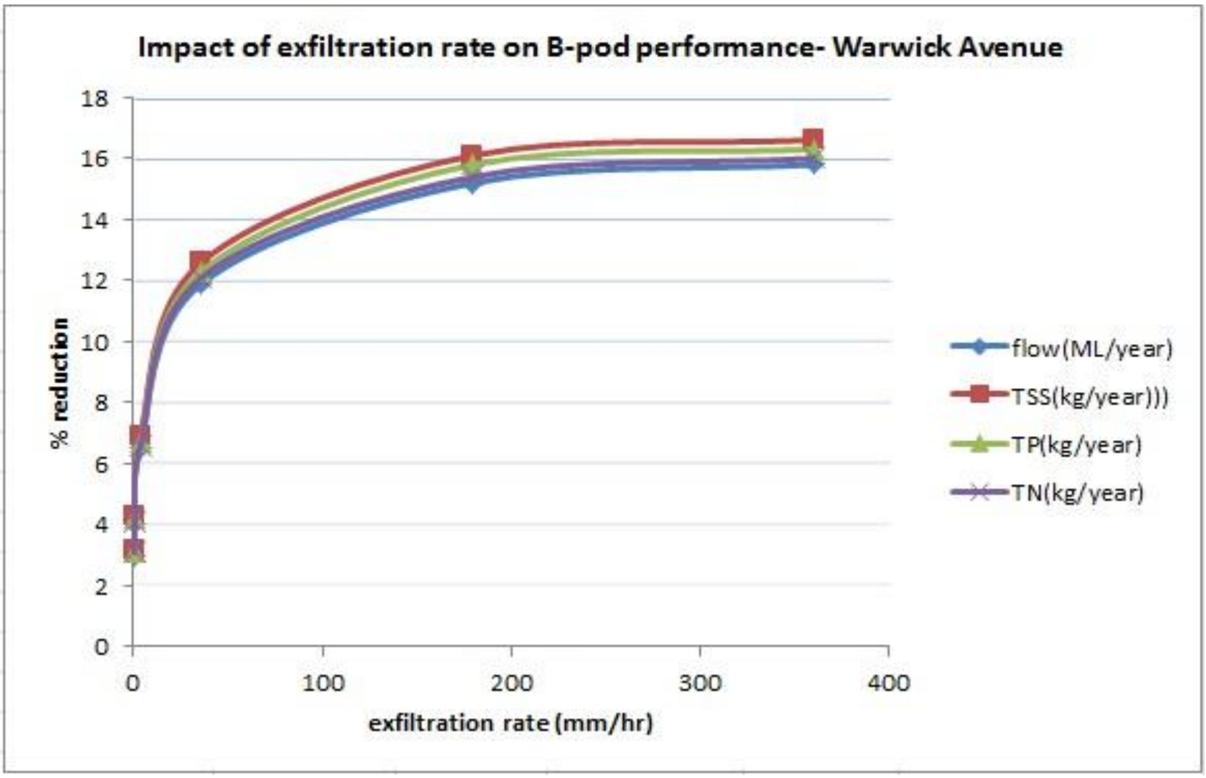


Figure J-10 – The impact of exfiltration rate on pod performance

Summary and Implications

Review of the overall performance strategy of B-pods

B-pods are unique features developed by the Burnside council for passive irrigation of young trees as well as for indirect flow management. The practical design concepts, compatibility, flexible and simple installation techniques make B-pods different among other councils' flow management strategies.

Even though the concept of B-pods was devised for improving the tree health, it indirectly had influence on runoff water quality and quantity management. The efficiency of the system in managing the runoff was analysed using MUSIC model, as the council lacked any data regarding the performance monitoring of the systems. As per the simulation conducted on the pods along the Union Street, Dulwich, the installation of pods resulted in an annual reduction of flow volume by 5.4% and an average reduction of 6% in TSS, TN and TP for the entire street. The simulation results agree with the fact that infiltration systems do not perform well in clayey soil media. Such subsurface systems could reduce the council's dependence on tree watering trucks, even though the mains water savings and the long term economic benefits are yet to be quantified. However it need to be confirmed though, whether the high water holding capacity of pod system, as per the field test conducted is due to the system effectiveness or improper filling done beneath the ground. The council has plans for upgrading the streets with pods and eventually developing it into elaborate water capturing system for tree irrigation and effectively reducing the flooding impacts and dependence on street tree watering systems.

Impact of infiltration rate on the pod performance indicated that, with the increase in the porosity of underlying soil strata, there would be an increase in flow volume reduction and subsequent increase in the runoff quality. The result ascertains the suitability of such pods for flow management along coastal councils where favourable conditions exist.

Impediments and opportunities

The validation of B-Pods modelling results can't be performed as there is no monitoring data for stormwater runoff reduction and stormwater quality improvement due to the provision of B-Pods. Monitoring data is required to understand the effectiveness of these systems and validation of modelling outcomes. The analysis indicates that these systems are not suitable as flow management device in heavy clayey soil areas..

The exfiltration rate studies have brought forward the suitability of the system as a flow detention system along the coastal areas, the most attractive aspect of these pods being its economics to scale, easiness in construction and the subsurface location.

Monitoring and validation

The following monitoring studies are crucial to assess the pod performance

- Determination of the stormwater storage capacity of the pods
- Identifying the exfiltration rate in the actual soil strata Water quality monitoring, especially with the gross pollutant removal
- Estimation of the cost benefit from switching on to the pod system compared to the conventional tree watering services including associated externalities
- Impact on tree health

These monitoring studies would be helpful in assessing the suitability of the pods for other councils with adequate soil media and flow management issues.

References

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Rosemary Leonard, Andrea Walton, Barbara Koth, Melissa Green, Anneliese Spinks, Baden Myers, Aditi Mankad, Priya Chacko, Ashok Sharma, and D. Pezzaniti, 2013, Community Acceptance of Water Sensitive Urban Design: A Qualitative Analysis, in I. f. W. R. T. R. Series, ed.

Harbrow Grove Reserve-detailed assessment

Overview

Harbrow Grove Reserve in Seacombe Gardens was a precinct level narrow undeveloped strip of land identified for redevelopment in City of Marion's 'Open Space and Recreation Strategy', due to its accessibility and size. It was redeveloped in 2011 (City of Marion 2007) with a variety of environmental and recreational design features that could attract users from a wider catchment than the local community (City of Marion 2007). The reserve, approximately one hectare in size, was previously used as a BMX track.

Figure J-11- Harbrow Grove reserve prior to the redevelopment (Department of Environment and heritage, 2007)

Figure J-12- Harbrow Grove reserve post development

Source: Google Maps 2013

The Harbrow Grove redevelopment project was mainly aimed at alleviating local flooding, reducing demand on mains water supply for open space irrigation and improving downstream water quality, along with contributing to community well-being by providing landscape amenity and recreational opportunities. Phase 1 and 2 of the project received an open space grant from the South Australian Government. This provided financial assistance to the City of Marion, to plan and develop the Reserve. City of Marion's active involvement in International Council for Local Environmental Initiatives (ICLEI)' and 'Water Campaign' programs paved the way for introducing stormwater recycling concepts into the design of the Reserve redevelopment. The project commenced in the 2009 and was completed in 2011. The total cost of the project was estimated to be about $ 1.1 Million.

Description of WSUD elements

Table J-5 represents an overview of the WSUD features in the Reserve. Flood mitigation and stormwater reuse were the main priorities for the council. However the introduction of WSUD into the reserve provided an additional benefit by improving the overall landscape amenity of the area. The system was designed as an open space rainwater detention system consisting of a swale, a sedimentation pond, a bioretention basin, a detention basin and underground 'rain vault' to store treated runoff. These elements are represented in Figure J-13.

Table J-5- Overview of the WSUD features in the Reserve

Rainfall zone (mm)	Alternative water source used	WSUD elements	Development type	Scale of development
400-600	Stormwater	Swales, Bio retention basins, storage tank, reuse	Retrofit	n/a

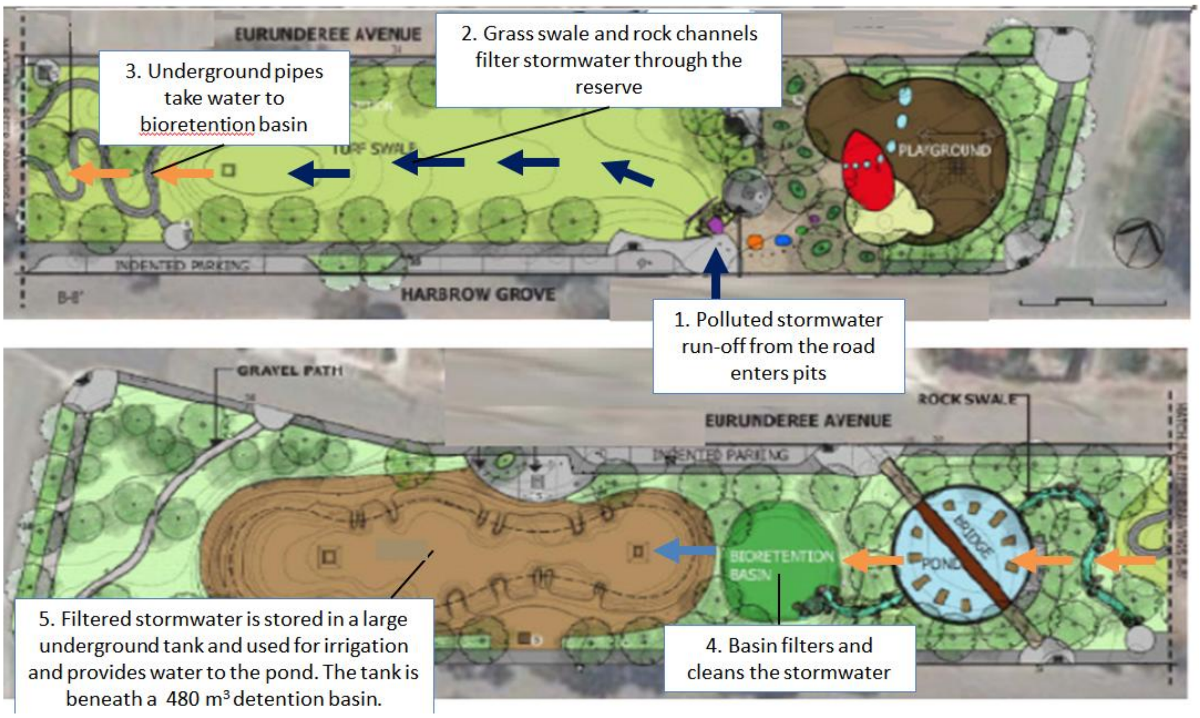

Figure J-13- WSUD elements in the reserve

Source: City of Marion, 2009.

External consultants were involved in the development of the draft Master Plan and the detailed design of the reserve. The hydrology of the catchment was analysed to determine peak flows into the Reserve for the existing surrounding catchment conditions. Preliminary site investigations revealed that the groundwater level varied between 7 m and 20 m below the surface, with a clayey soil profile and that the existing catchment had no underground drainage to the reserve (Tonkin Consulting2008a). Although the site was originally assessed as having 'low to moderate risk' due to a previous adverse environmental site history, Phase 1 assessments revealed that there was no significant soil contamination (Tonkin Consulting 2008b).

According to the project plan, stormwater runoff from the local catchment area is diverted into the reserve through a series of kerb inlets (Tonkin Consulting, 2008a), of which a part flows into the turf basin (Figure

J-14). The turf basin consists of a shallow swale and a detention basin with a storage capacity of 190 m^3 and a depth of 0.6 m (Tonkin Consulting Consulting 2008b). The transport of water through the turf basin removes some suspended impurities, and excess water then discharges via a drain into the bioretention basin.

The bioretention basin was designed to provide treatment of flows from the turf swale (the runoff from the catchment directly drains into the turf swale through the side entry pits) and overflows from the decorative pond (Tonkin Consulting, 2008b) by fine filtration, extended detention and biological uptake (Tonkin Consulting 2008a). The stormwater ponds in the infiltration basin and seeps through a filtration layer (sandy loam) and a transition layer (sand) to a series of perforated pipes below, which all drain into the underground tank (Tonkin Consulting 2008a).

The underground rain vault collects treated stormwater runoff from the bioretention basin. The stored water is used for irrigation of the park area and to top up the decorative pond. The decorative pond was designed for ornamental purposes only. Water from the rain vault is pumped into the pond via small channels from where it trickles down into the pond. The direct discharge of runoff into the pond from the turf basin or from the surrounding impermeable area was not considered due to the risk of nutrient and biological contamination (Tonkin Consulting 2008b).

Major flows have been designed to bypass the bioretention basin and discharge into a second detention basin area above the buried storage tank (Figure J-14). This detention basin is designed to assist with reducing peak flows from the surrounding catchment and has a storage capacity of approximately 460 m^3 and a depth of 0.8 m (Tonkin Consulting 2008a). The excess flow from the detention basin is conveyed to a pit in the Eurunderee Avenue. The pond, infiltration basin and the underground tank are provided with impermeable lining to prevent seepage losses (Tonkin Consulting 2008c).

(a) (b)

(c) (d)

Figure J-14- WSUD features in the reserve (a) inlet (b) turf basin (c) pond (d) detention basin

The turf basin and swale were designed to carry flows up to and including the 100 year ARI and were constructed wide and shallow to allow stormwater to be conveyed and detained without impeding on the recreational use of the area (Tonkin Consulting2008a). The bioretention basin was designed based on a hydraulic conductivity of 180 mm/hour, with an extended detention depth of 300 mm and a filter media area of 240 $m^2$and with 13underlying perforated pipes of 100 mm diameter. The design was based on WSUD Guidelines from Melbourne Water (Tonkin Consulting2008b). A land use runoff coefficient (ROC) of 0.45 was considered for the design, which is typical for low density residential areas.

Implementation

Construction site management was solely the responsibility of the civil contractor and according to Tonkin Consulting (2008b), was to comply with EPA SA guidelines for stormwater pollution prevention (Botting and Bellette, 1999). Special care was taken in acquiring adequate filtration media for the bioretention basin construction and was contracted out to Clay and Mineral Sales. A maintenance manual for the reserve (Tonkin Consulting2008d) was developed by Tonkin Consulting, specifying the required maintenance tasks methodologies and schedule. The manual focussed on maintaining vegetation, removal of accumulated sediments in depressed areas and assessment of the rate of erosion from the turf swale and infiltration basin.

Stakeholders and WSUD management

The major stakeholders in the redevelopment were local residents, the City of Marion and the South Australian Government. Harbrow Grove Reserve was identified for redevelopment in the 2006 City of Marion Open Space Strategy, while South Australian Government funding initiated the construction. External consultancies included the University of South Australia, Tonkin Consulting and Swanbury Penglase Architects.

The council is responsible for the long term management of the reserve and has plans to develop the adjoining areas of the reserve as part of the reserve redevelopment project.

Community involvement

As part of the community engagement program the City of Marion distributed letters to local residents highlighting the features and functions of the redeveloped reserve. Four local schools supported the project recognising the value the reserve in terms of environmental, science and water management studies.

The local community views the redevelopment as a net positive in creating a more liveable area. Some residents had concerns over the state of the ornamental pond, which is generally empty due to issues encountered during construction. City of Marion is aware of this and making arrangements to overcome this matter. Although one resident had some concern over pump noise, most residents had not noticed this.

WSUD performance

Some performance issues were noted once the entire system became functional. The pond system was unable to hold water, which may be due to leakage in the impermeable composite geomembrane layer underneath the pond. Currently the council is in the process of addressing this issue, by consulting with the contractors and design engineers. A likely solution is to turn the pond into a garden feature using marsh plants and creating an ornamental creek under the bridge. This will provide a longer term sustainable solution.

Modelling performance

Water balance and Water Quality Modelling

Tonkin Consulting used MUSIC software to determine the water storage requirements of the system. Based on this, the average annual volume required to keep the pond full was calculated based on the evaporation losses from the pond, assuming a surface area of 314 square meters and a volume of 200 cubic meters in concept design. The top up volume was calculated to be 840 KL/year (Tonkin Consulting2008c).

All WSUD elements were modelled by accounting for losses prior to entering the subsurface storage. Potential future increase in overall catchment area contributing to the reserve was taken into consideration and the models were developed using a projected catchment area of 7 Ha, rather than an existing area of 4.4 Ha (Tonkin Consulting2008a).

The resultant treatment train effectiveness of the system showed 100% reduction in gross pollutants, 98% reductions in total suspended solids, 83% reduction in Total Phosphorous and 60% reduction in Total Nitrogen (Tonkin Consulting2008a). The peak flow, detention requirement and upstream and underlying pipe sizes of the reserve were calculated using ILSAX software.

The Summary and implications

Review of the status of WSUD in Harbrow Grove

Harbrow Grove Reserve was designed as an open space rain water detention system consisting of swales, an ornamental pond, a bioretention basin, two detention basins and an underground rain vault to store the treated runoff. Despite the effective function of almost all aspects, the ornamental pond (sedimentation basin), which was half way through the treatment train, became non-functional due to construction issues. While this has significant issues associated with visual amenity, the effects on the performance of the system have been minimal as irrigation still occurs in addition to appropriate stormwater flow management. However it should be noted that while this has little impact of carrying flow or collecting water, it is a very visible issue with the overall development. The council is under the process of reinstating the ornamental pond reserve by working closely with the contractors. The redevelopment of the reserve and the post construction issues clearly highlights the need for coordination and oversight in the construction phase of WSUD projects.

Impediments and opportunities

Harbrow Grove Reserve was designed as a multi-functional WSUD system to reduce the demand on the mains water, alleviate flooding issues and improve stormwater quality. Despite achieving all these goals, the system is not generally considered fully functional as the ornamental pond does not hold water, which is a minor but very visible impediment to its performance. A more collaborative nature of the project would have caused a lower impact on the design and construction of the system. The maintenance burden of the ornamental ponds, especially in a scenario where the council lacked adequate funding for the maintenance of the small scale water management structures was another key issue. Council resolved this potential risk by undertaking a whole of life cost analysis and within the city of Marion costs for maintenance of all existing WSUD features are contained with the Long Term Financial plan.

According to most practitioners who contributed to the Goyder Institute WSUD project, economic justification is one among the toughest aspect of getting WSUD projects in place due to the difficulty in costing the externalities and creating a financial argument for the construction and long term operation of the system. However, Harbrow Grove Reserve could be cited as the best example of how effectively a multi-functional WSUD scheme could be incorporated into a precinct level reserve redevelopment, to reuse the stormwater runoff and at the same time create a vibrant hub and sense of place for the community, through its sustainable approach.

Monitoring and validation

The council is currently working on reinstating the reserve along with the relevant contractors involved. However, once completed the following aspects need to be monitored for evaluating the performance of the system.

- The reduction in mains water usage, once the system starts its full-fledged operation, to estimate the associated monetary benefits obtained.
- The actual quality and quantity of treated water reused to assess the system functionality and effectiveness.
- The quantity of mains water top up to the underground storage to assess the suitability of the system in meeting the irrigation demand.
- Estimating the energy and cost involved in pumping treated water for irrigation and refilling the pond to quantify the energy required to operate externalities the system.

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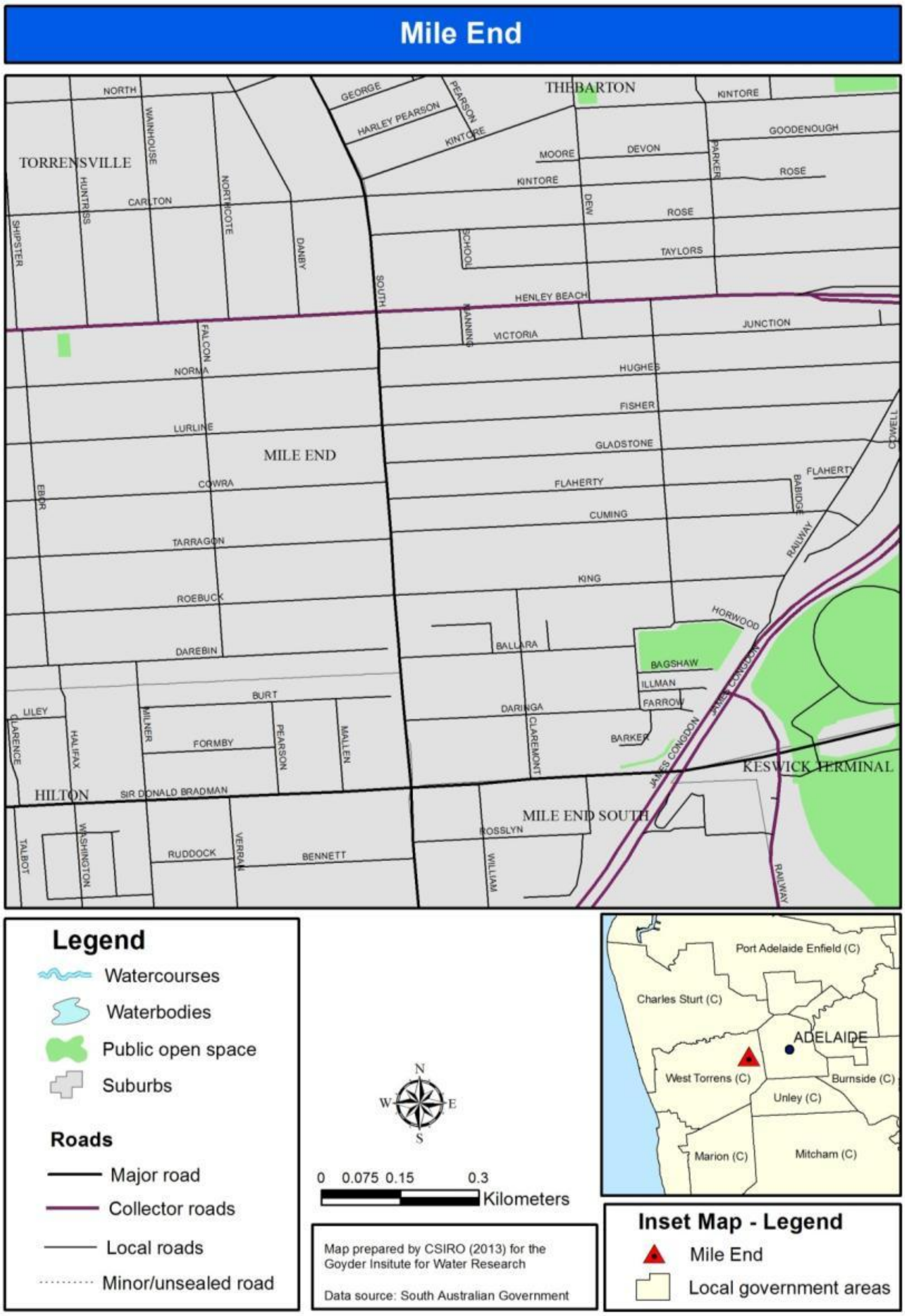
Mile-End bio filtration systems- detailed assessment



Overview

WSUD in the City of West Torrens is encouraged for new development, but is also retrofitted within existing works by council. One of the council led initiatives includes the retrofitting of raingardens systems opportunistically along road verges, which commenced in September 2011. The raingardens have been installed by the council during civil works to roads and drainage systems. The council has installed more than 90 individual raingardens over the last four years. The raingardens have been installed along road verges in several locations, including Tarragon Street in the suburb of Mile End (SIA Awards 2012). Since Mile End was already well established and lacked significant green areas (the parks and open space), it was decided that the wider streets, such as Tarragon Street, could be retrofitted with the raingardens to enhance the runoff water quality and provide a greener streetscape.

The City of West Torrens identified that there was an opportunity to incrementally improve streetscapes and stormwater management, which was a major driver for the installation of the raingardens. The raingardens were seen as step towards more sustainable development through the provision of vegetated verges with passive irrigation. The availability of funding was also an essential criterion, as most civil works for the raingardens were undertaken along with road/drainage modification works. While the total budget spent for stormwater works, road construction and new trunk drainage was approximately $ 2.2 Million/year, the cost of installing an individual rain garden was approximated to be $ 9,500 each.

These raingardens were designed to collect, store, and treat the stormwater runoff from residences (including roof runoff) and streets. Runoff is ultimately discharged into local stormwater drains. Figure J-15 shows two typical system installations in Tarragon Street, Mile End.

Figure J-15- Mile End Raingardens

In the long term, the City of West Torrens is aiming to demonstrate a working example of large scale retrofit of WSUD elements into an established urban area. Retrofitting WSUD approaches to established urban areas is a significant challenge, so the completion of the raingarden scheme (up to 40 % of the raingardens have already been installed) can provide a valuable example to other local governments, both in South Australia and nationally, on the ways and means to retrofit WSUD into existing developments.

Description of WSUD elements

Table J-9 represents an overview of the WSUD installation in Mile End.

Table J-9- Overview of the WSUD feature and location

Rainfall zone (mm)	Alternative water source used	WSUD elements	Development type	Scale of development
400-600	Stormwater runoff	Raingardens	Retrofit	Street scale

Raingardens are on site stormwater storage and infiltration facilities that use permeable soils (usually sand and sandy loam), organic matter and vegetation for detaining and treating runoff from parking lots, streets and highways without a permanent water body. The water pooling depth of these schemes generally range from 0.15 to 0.46 metres, and the bio-retention pit will typically drain over 12 hours following a rain event (Li, Dvorak et al. 2010). Figure J-39 represents a typical cross section of a raingarden from literature.

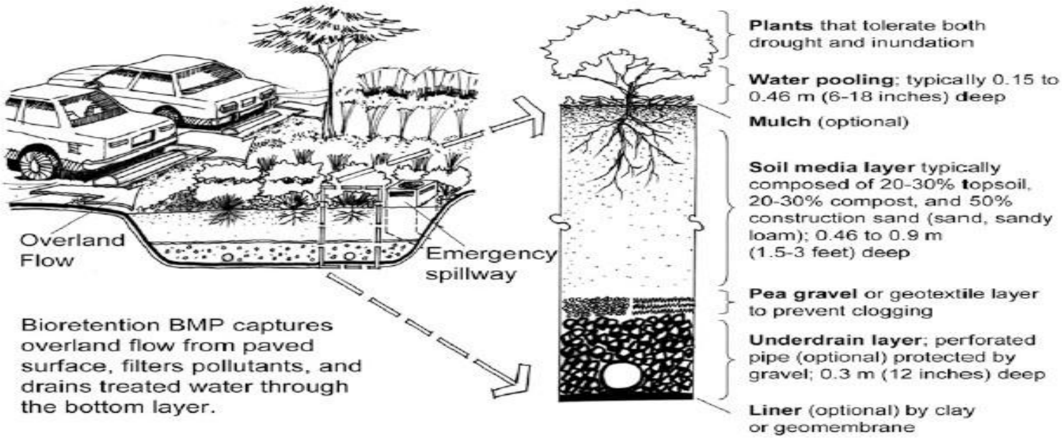


Figure J-39- Typical cross section of a raingarden (Li, Dvorak et al. 2010)

The raingarden treatment processes are represented in Table J-10.

Table J-10- Physical and treatment processes in a rain garden (Cherqui, Granger et al.)

	Hydrological processes & *outcomes* (*)					Treatment process				Scales		
Technologies	Detention (&/or Retention	Infiltration	*Flow attenuation**	*Volume reduction**	*Baseflow restoration**	Sedimentation	Filtration	Adsorption	Biological treatment	Household	Streetscape	Precinct/ Suburb
Soakaway	++	+++	+	++		+	+++	++	++	X	X	
Green roof / detention roof	++		++	+			++	++	+[2]	X		
Swale	++	(++)	+	(+)	(+)	++	(+++)	++	++		X	
Filter strips	.	+++	+	(+)	(+)	+	+++	+++	++		X	
Detention / infiltration trench	++	(++)	++	(+++)	(++)	+	(+++)[3]	(++)[3]	(++)[3]	X	X	
Rain garden / Biofiltration systems	+++	+++	+(+)	(++)	(++)	++	+++	+++	+++	X	X	X
Porous Roads	++	(+++)	++	(++)	(++)	+	(+++)[4]	(+++)[4]	(++)[4]	X	X	X
Wet pond	+++		+++			++		+	+			X
Wetland	+++		++			++	++	+	+++			X
Dry pond	+++	(+++)	+++	(++)	(+)	++	(+++)	+++	+ (+++)			X
Rainwater tank	+++		++	+++	+[1]	++				X	X	

+ low ability; ++ medium ability; +++ high ability; () only if infiltration is possible; * These are not strictly hydrological *processes*, but rather *outcomes* in terms of changes to the flow regime. [1] Only if connected to irrigation or provided with a 'trickle outlet' specifically designed to enhance baseflows. [2] if green roof. [3] if covered by topsoil. [4] if infiltration porous structure or permeable surface

The mechanism of pollutant removal in a raingarden includes physical (settling and filtration), chemical (adsorption), and biological (plant uptake) methods (Li, Dvorak et al. 2010). Unlike conventional stormwater treatment technologies which occupy the lower part of a drainage basin, raingarden act as a source control measure and are designed to treat the first flush (Li, Dvorak et al. 2010).

Mile End raingarden systems

The typical components of a raingarden installed in Mile End are shown in Figure J-40. These systems in Mile End consist of a shallow trench (30 cm to 46 cm) that accommodates filtration media and vegetation. The water well beneath supports planted vegetation within the garden bed. While the council did not specifically design the raingarden as a traffic management device, the visual impact and layout of the raingardens and paving has been found by City of West Torrens to have helped reduce vehicle speeds along streets.

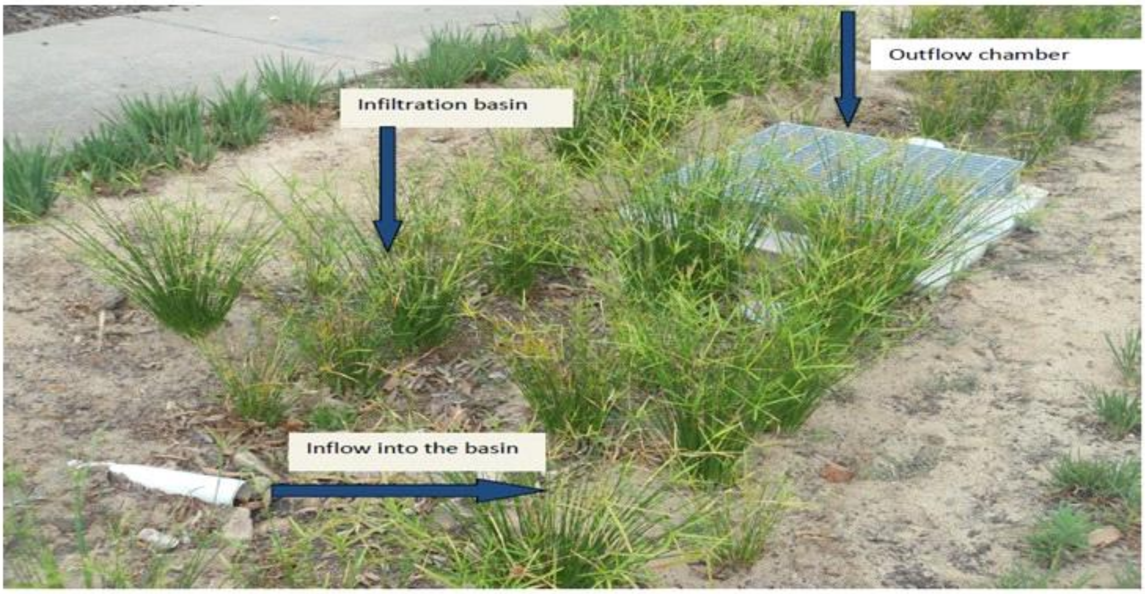


Figure J-40- Components of a typical raingarden in Mile End

Design

The design of the raingardens was undertaken with reference to guideline documents, including *Australian Runoff Quality* (Fletcher et al., 2005) and guidelines from South East Queensland by the Moreton Bay Waterways and Catchments Partnership (Water by Design 2006). The spacing between the raingardens was based on practical considerations, based on the impervious catchment area versus area of the garden bed and how the raingardens systems could be configured in the streetscape without impacting on other features like driveways, underground services and existing vegetation.

A "Lego block" design was developed for the construction of the systems, in close consultation with Tonkin Consulting, covering common arrangements of verges, service locations and road features at the point of installation. These general design arrangements were then used to implement raingardens into the surrounding area with respect to offsets from footpaths and connections into the main underground drainage line. The benefits of this generic design was the easy transferability and effective incorporation of key features such as the inlet design, kerb alignment, overflow weir, overflow pit and vegetation schedule into future road rejuvenation projects as well as the ease with which construction contractors could familiarise themselves with repeated installation requirements. Issues such as the myriad of services within the road and verge (e.g. water, electrical, telecommunications), street trees, and driveways were overcome by varying the width and/or location of the bio-filter media to ensure that a suitable offset to these elements was maintained. The design also considered the impact of garden features for on-street parking, vehicle access and spaces for residential bin pickup.

City of West Torrens has developed an overall stormwater strategy to produce catchments with a runoff coefficient equal to 0.25 for a 20 year storm event, depending on the local conditions. The raingardens are one of the strategies being used to assist in achieving these stormwater runoff flow targets. For larger storm events, a raised grated inlet pit (with an interception flow rate equivalent to approximately two standard side entry pits) was provided to allow any overflow to discharge directly to the main drainage network. The acquisition of filter media was outsourced to Adelaide based soil suppliers Clay and Mineral Sales who tried to replicate the recommendations provided by the Facility for Advancing Water Raingardens (FAWB 2009). The hydraulic conductivity of the filter material used was between 100 to 200 mm/hour and the water pooling depth was between 100 to 200 mm. The City of West Torrens Parks and Gardens department were responsible for the selection of appropriate plants in the raingarden. The department showed a preference for indigenous species due to their tolerance to the local climate, which reduced watering and maintenance requirements. The maximum height to which these species grow is 1.2 m above the kerb, thus minimising any traffic hazard via visual obstruction. Plant selection has proceeded on a trial and error basis to identify the best performing plants based on observed survival.

A limited cost benefit analysis was undertaken prior to the construction of these raingardens systems, as benefits were mostly assessed on a qualitative basis. Construction was opportunistically undertaken by the council as part of road upgrade works, bringing in economies of scale to the required civil works.

Implementation

The council followed a general construction schedule of undertaking the construction of drainage works followed by the road structure and finally the rain garden beds. The nature of works means that there has been a delay in vegetation planting, because civil works tend to be completed near the beginning of summer, and it is preferable to plant the systems after the summer dry period has passed. Because of this, there is sometimes a lag time for the raingarden projects to be completed until there is the right planting conditions.

The number of raingardens provided in each street depended on the street configuration. The raingarden overflow outlet, which is usually the first item to be laid, was constructed based on practical experience and discussions with the contractor. The slope and depth of the basin as well as the pool depth was carefully designed to maximise runoff retention, while a base was constructed at the front of affected dwellings to accommodate garbage bins. Where possible, the presence of existing stormwater drains helped the council to avoid costs associated with pipe construction which helped them to concentrate more on the filter media and the vegetation aspects of the raingardens systems.

Since the construction of raingardens systems in existing streetscapes is relatively novel in the South Australian context, a very hands-on approach was used in the early stages of construction to ensure that adequate materials were used and proper construction methodology was adhered to. There was extensive interaction between City of West Torrens staff and the construction contractors to ensure the quality of the built product. The time needed for the construction to proceed was also monitored to further refine the design and planning process. Special instructions were given to contractors regarding the need for an adequate amount of compaction of the filtration material (not greater than human foot traffic load) to preserve the filtration qualities of the material. Adjustments were also made to simplify construction; for example, the requirement to build to detailed levels was found to be unrealistic, and levels were adjusted to allow construction contractors to build and measure based on a stringline from the entry pit to the overflow pit to ensure that ponding depth was adequate. Care was also taken in ensuring proper installation of the inlets and raingarden materials without interfering with existing services.

Based on feedback from construction contractors, the impermeable liner within the basin was laid as a single layer within the raingarden trench to avoid issues created with a poor joint in the geomembrane. Since there were practical difficulties in dealing with a 450mm wide trench in terms of the pliability of laying the liner as well as the availability of providing adequate working room, a minimum width of 600 mm was adopted in further design and construction of raingardens systems. The City of West Torrens raingardens also included permanent water well (Figure J-41) at the bottom to provide vegetation with a source of water during dry weather periods.

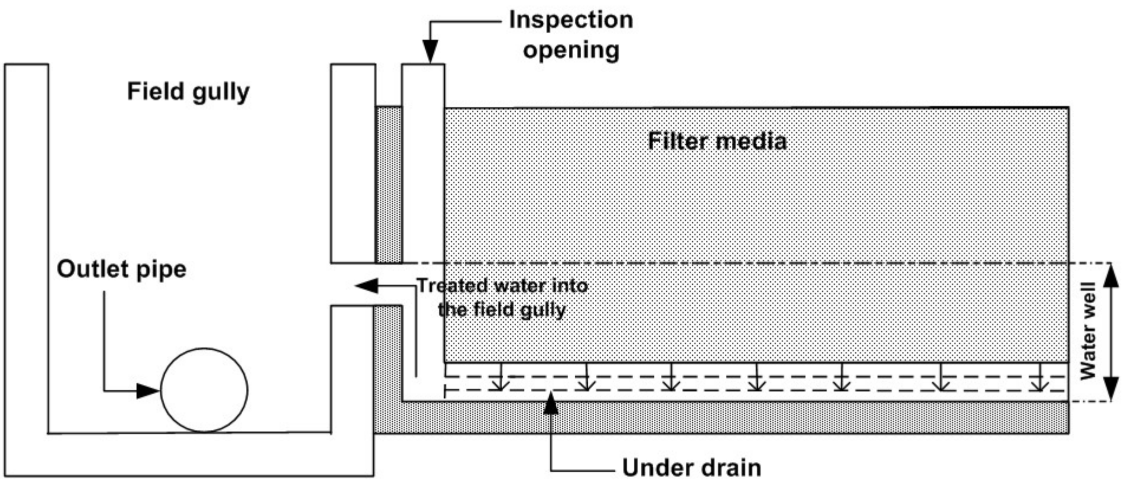


Figure J-41- Permanent water well in rain garden bed

Vegetation contractors were involved with planting the raingarden beds, which were handed over to the council once the construction was completed. Planting works were typically undertaken following the dry summer months. Planting was usually preferred at this time to prevent the plants from dying off due to lack of soil moisture. This also allowed council landscape personnel to monitor the growth of weeds in the bare filter media over the summer months and remove those using non-persistent herbicides prior to planting without affecting new plant stock. A 300 mm kerb constructed beside the raingarden prevented vehicle access to the raingarden. Fringing vegetation (Dianella), which has a limited growth and needs low maintenance, was planted along the buffer zone (near to the kerb) to provide an attractive border that discourages people from walking into the garden.

The council has tried to document all relevant information, especially direct costs, peripheral costs, the standard element drainage costs and the kerb replacement cost obtained during the construction of the raingardens. This information will be used in future to develop a budget for similar project proposals.

Stakeholders and WSUD management

The City of West Torrens, especially the Engineering Department and the Parks and Gardens personnel who were involved in the implementation and maintenance of the raingardens, represented the major stakeholders of the project. The civil contractor (Camco) and the design consultants Tonkin and Wallbridge & Gilbert were other major stakeholders due to their high level involvement in detailed design and construction of the raingardens. The local community were perhaps the most direct stakeholder in the development of the raingardens. Consultation with the local community is described in the following section.

The Parks and Garden department in the council are responsible for raingarden maintenance and they have adapted WSUD guidelines from Victoria and Queensland for the maintenance of these systems (Water by Design 2006). According to the council, maintenance for WSUD systems seems to be easier when compared to conventional stormwater treatment devices like the gross pollutant traps. It should be noted that some aspects of maintenance are undertaken informally. For example, the collection of gross pollutants at the filter surface has been undertaken by some local residents.

Community involvement

The installation of the raingardens by the City of West Torrens was designed to enhance the amenity of roadways for the community, by providing a green space in a developed area. This was considered especially important with the shift in a development emphasis from greenfield to urban infill in the *30 year Plan for Greater Adelaide* (DPLG, 2010).

Community consultation was undertaken during the initial stages of the project. Residents were informed about the installation of the raingardens along their street and the anticipated environmental benefits. The consultation was done through letter dropping at residences with the contact details of the relevant officer in the council if further information was required. The majority of residents had no objection or issues with the proposed raingardens. Communication with residents was maintained throughout the project which included more detailed explanations, education on how the raingardens systems function, final design and their locations. This interaction with the residents was important to ensure that the local community understood what to expect with the raingardens systems. The council has noticed that residents with the systems in front of their homes tend to maintain them regularly, which indicates some pride in the features.

Of those with complaints about the systems, the loss of private car parking space in front of residences was most common, especially from those who lived in high density housing. The council also received enquiries from residents regarding the fallow soil in front of the houses over the summer months, a result of the deliberate measure to ensure plant establishment was not compromised by the hot dry summer months. There were some complaints received about water ponding issues in the raingardens. The council addressed this complaint by educating residents that the water detention in the raingardens is temporary, and in most cases will recede within an hour following a rainfall event.

The knowledge and understanding of operating and maintenance costs for the raingardens systems is still developing. To quantify these more appropriately, City of West Torrens has plans to contract out the maintenance of these systems for a period of 12 to 24 months to determine the actual costs incurred per square metre. An additional outcome from this process will be a refinement of the appropriate maintenance schedule. This will also result in an appropriate budget allocation for O&M.

WSUD performance

According to the City of West Torrens the raingardens have performed well for drainage. They were found to often have a layer of black crust over the soil surface during summer, which was considered to be a build-up of pollutants caught on the soil surface. The removal of this crust has been notably difficult in other areas of Adelaide and in some of the City of West Torrens systems. However, the council noticed that the higher soil moisture in the raingardens tended to prevent the black crust from hardening. This reduced the risk of the pollutant material being discharged into the stormwater drain during heavy rain events.

There were difficulties in identifying the type of shrubs which performed well in the raingardens due to variable plant selection for each pod. Also there was uncertainty regarding the treatment potential of plants in the systems. The clogging of inlets from leaf litter and the poor performance of raingarden shrubs located under trees were other issues of concern.

Limited informal water quality monitoring was undertaken by the council from selected raingardens. This monitoring was ad-hoc at the inlet and outlet of the system, and may not adequately represent the performance.

Modelling Performance

Background studies

Numerous studies have been conducted to estimate the ability of raingardens to moderate peak stormwater discharges. A typical hydrograph at the inlet and outlet of a raingarden is represented in Figure J-42 (Li et al 2005). Hunt et.al (2007) demonstrated in a field based study that raingardens could attenuate the peak discharge flow rates by an average of 96%, (Hunt, Jarrett et al. 2006) estimated that an unlined raingardens could bring about a median peak flow reduction by 93% during summer and 44% during winter, even though the nitrogen removal efficiency for individual systems varied as per the numerous field monitoring studies conducted.

Other studies have indicated that provision of an anaerobic zone into the raingardens by adding a saturated zone at the base of a filter, can increase denitrification. This is particularly noted to occur when there is a carbon source present (e.g. newspaper) to enhance the nitrate –nitrogen removal rates (Li, Dvorak et al. 2010). The inclusion of mulch in raingardens was also found to be effective in removing pollutants including heavy metals, oil and grease. Raingardens has also been shown to reduce pathogen concentrations. Li et al (2010) indicated that the concentrations of *E. coli* at the outlet of a raingardens were reduced to about 96% of that at the inlet of the system influent (Li, Dvorak et al. 2010).

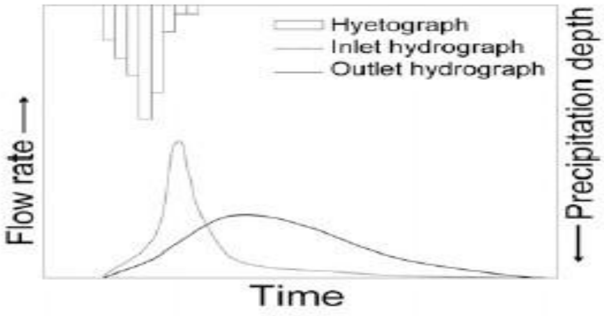


Figure J-42- Hydrograph for a typical raingardens system (Li, Dvorak et al. 2010)

(Cherqui, Granger et al.2013) provided a range of simple indicators such as the ratio of peak flow rates (peak inflow/peak outflow) or the ratio of storm event flows (inflow /outflow) for both volume and pollutant load, to measure the performance of the infiltration systems acting as a stormwater control measure.

Simulation of Mile End system

The conceptual performance of the raingardens in Mile End was analysed using MUSIC software. Six raingardens along Tarragon Street, between Bagot Avenue and Ebor Avenue, were selected to estimate the effectiveness of the water quality and quantity impacts of the systems. The location of the study area is shown in Figure J-43. The gardens have been named by the authors for the purposes of modelling.

Figure J-43- Selected stretch of Tarragon Street for modelling of rain garden (Source- Google Map)

The dimensions of each of these raingardens were measured on-site and with the findings presented in Table J-11. The layout of the simulated catchment system in MUSIC is shown in Figure J-44.

Table J-11- Dimensions of individual raingardens

Basin designation	Basin Dimensions			Filter media dimension	
	Length (m)	Width (m)	Extended Detention Depth (m)	Length (m)	Width (m)
1N	15	3	0.15	8.4	0.9
1S	15	2.5	0.15	9.8	0.45
2N	9.3	3	0.15	4.4	0.9
2S	13.3	2.5	0.15	10.9	0.45
3N	11.3	3	0.15	6.7	0.9
3S	11.8	2.5	0.15	8.5	0.45

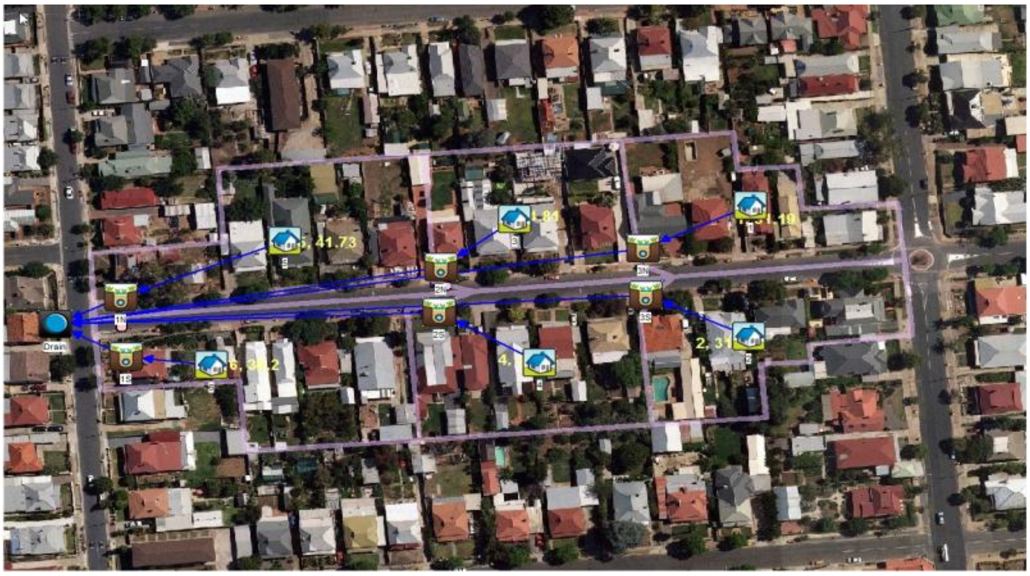


Figure J-44- Simulation of Tarragon Street raingardens using MUSIC model

For the purposes of modelling, it was assumed that the contributing catchment area to the raingardens was limited to the adjacent road and housing. The permeable and impermeable catchment area contributing to the raingardens was delineated and characterised using aerial photography within the ArcGIS software package. It was assumed that all roads and the main roof area of each allotment was directly connected impermeable area. Backyard sheds and paving at the rear of houses was considered effectively permeable (e.g. it was assumed that runoff from these area ran over grassed area prior to reaching the raingardens. The nature of each sub catchment area is depicted in Table 4. These properties were incorporated into the parameters of the 'Urban' node in MUSIC. All other parameters, including soil characteristics, were assumed to be the default parameters within MUSIC v 5.01.

Table 4- Characteristics of the urban node simulated in MUSIC

Node representation	Total area (Ha)	% impervious area	% pervious area
5	0.456	42	58
3	0.338	45	55
1	0.321	51	49
2	0.346	32	68
4	0.403	40	60
6	0.427	39	61

The raingardens were simulated using the 'raingardens' treatment node which is represented in Table 5**.**

Table 5- Raingarden node properties assigned in MUSIC based on the field measurements

Basin designation	Raingarden node properties assigned in MUSIC based on Field measurements						
	Extended Detention Depth (m)	Surface area (m^2)	Filter area (m^2)	Unlined filter perimeter (m)	Filter depth (m)	Exfiltration rate (mm/hour)	Overflow weir width (m)
1N	0.15	45	7.56	18.6	1.05	0	3.2
1S	0.15	37.50	4.41	20.50	1.05	0	3.2
2N	0.15	27.90	3.96	10.60	1.05	0	3.2
2S	0.15	33.25	4.50	20.90	1.05	0	3.2
3N	0.15	33.90	6.03	15.20	1.05	0	3.2
3S	0.15	29.50	3.83	17.90	1.05	0	3.2

The receiving node was defined as the stormwater drain at the end of the street. As per the technical drawings obtained from the council, all raingarden had a submerged zone at the base of the filter media which was 400 mm deep. The underlying collection pipes of the raingarden were therefore assumed to be 400 mm above the base of the impermeable liner around the system.

The climate characteristics for simulation were adopted based on available long term rainfall data. Rainfall was adopted from Adelaide (Kent Town) (BOM gauge 023090) between 1992 and 2002. Evapotranspiration data was adopted as the monthly aerial potential evapotranspiration data provided with the MUSIC software for Adelaide.

To provide an informative assessment of their performance, a sensitivity analysis of raingardens and catchment parameters which may affect simulated performance was conducted. Table 6 presents the assumed parameters of the base scenario (Case 1) and the sensitivity runs (Cases 2 to 6).

Table 6- Assumptions made for specific cases defined

Scenarios defined	Parameters altered			
	Saturated hydraulic conductivity (mm/hr.)	**TN (mg/kg) of filter media**	**Orthophosphate (mg/kg) of filter media**	**Vegetation properties**
Case 1 (Base scenario)	100	1000	80	Vegetated with effective nutrient removal plants
Case 2	100	1000	80	Vegetated with ineffective nutrient removal plants
Case 3	300	1000	80	Vegetated with effective nutrient removal plants
Case 4 (As per FAWB 2009)	100	1000	20	Vegetated with plants with moderate sensitivity to local conditions
Case 5a	100	500	80	Vegetated with effective nutrient removal plants
Case 5b	100	1000	40	Vegetated with effective nutrient removal plants
Case 5c	100	500	40	Vegetated with effective nutrient removal plants
Case 6 (Urban node assigned Adelaide soil parameters (Soil storage capacity 40 mm, Field capacity 30 mm)	100	1000	80	Vegetated with effective nutrient removal plants

Figure 08 summarises the results of the performance analysis in terms of the percentage reduction in annual flow volume, total suspended solids, total phosphorous and total nitrogen exported form the catchment.

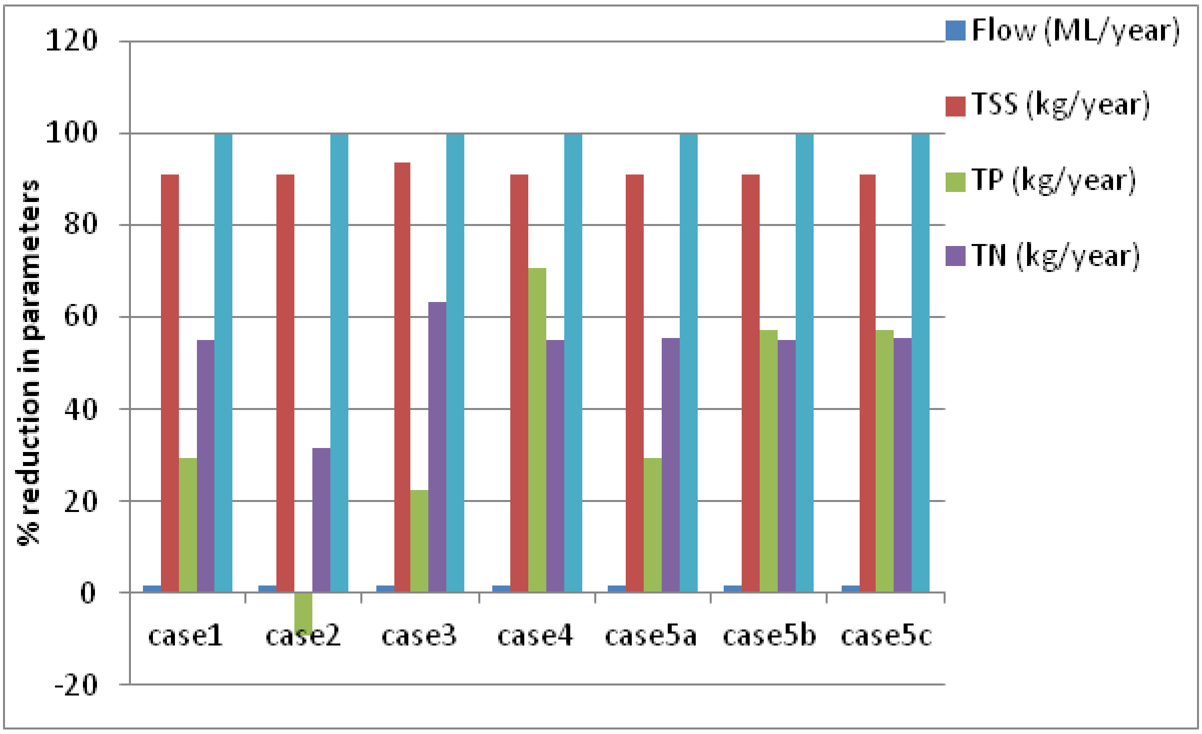


Figure 08- Sensitivity analysis results

The simulation results show that for the base scenario the reduction in annual flow volume was 1.8% and reduction in TSS, TP and TN being 91.1%, 29.4% and 55.1% respectively, even though the simulated removal of gross pollutants was 100%, indicating that they tend not to bypass the raingarden in MUSIC simulation. The percentage of flow reduction (1.8%) and Gross Pollutant Removal (100%) remained unchanged during the sensitivity analysis, except for Case 6, where the changes in soil conditions generated more runoff (5.3 ML/year to 4.72 ML/year of the base case) causing a lesser reduction in flow rate (1.6%), indicating the impact of physical parameters like the size of the raingarden as well as the quantity of runoff draining into the garden bed.

The adoption of vegetation considered 'ineffective' for nutrient removal was found to have the greatest impact on the percentage reduction of TP and TN. While comparing the base scenario with this specific case (case 2) , the TP and TN treatment were reduced from 29.4 kg/year and 55.1 kg/year to -9.2 kg/year and 31.4 kg/year respectively (where the negative value indicates a net export of phosphorous, due to the presence of TP in the soil media).The occurrence of this export has been noted in previous raingarden research and has been suggested to occur because of ineffective bio-absorption of phosphorous by unhealthy vegetation (Hinman 2009). This research also emphasises the need for routine maintenance of the raingardens.

Higher hydraulic conductivity (Case 3) seemed to improve the water quality treatment effectiveness of the system by increasing TSS removal efficiency from 91.1% (base case) to 93.6% and Total Nitrogen removal to 63.2% from 55.1% (base case).

Sensitivity analysis associated with the TN and Orthophosphate content in the filter media in Case 4 indicated that when the orthophosphate content of the filter media was increased from 20 mg/kg to 80 mg/kg (based on FAWB recommendation of 80 mg/kg), the percentage reduction in TP content decreased. The high percentage removal of TSS (91 %) indicates the efficiency of the raingardens along the street in capturing the sediments. The capture of TSS however suggest that assuming the predicted load of sediment is approximately true, there is a need for regular maintenance of the garden beds including removal and replacement of topsoil. Doing so will help to avoid potential clogging issue in future which can affect the performance of raingardens (Elliot et.al 2011). Build-up of sediment will also influence the temporary detention volume of the filter over time, in addition to plant growth. It should be noted that this analysis also assumes that TSS does not resuspend during overflow situations and proceed to the overflow weir and into the drainage system.

When Adelaide soil conditions were simulated in the urban node of the base scenario (Case 6, with field capacity of 30 mm and soil absorption capacity of 40 mm based on recommendations for Adelaide in the MUSIC manual), there was a 0.2% reduction in flow from the base case of 1.8%, 4.1% reduction in TSS removal from the base case of 91.1% and 6.6% reduction in Total Nitrogen content from an estimated 55.1%. In contrast, there was an increase in phosphorous removal by 4.1% from the base case of 29.4%. This may be attributed to the assumed clayey nature of Adelaide soils where more urban runoff would be directed to the raingardens due to lower soil moisture holding capacity resulting in lesser removal efficiencies for TSS and TN. The reasons behind the increase in performance for TN are uncertain.

Unfortunately, it was found that MUSIC was unable to accurately assess the peak flow reductions due to the installation of raingardens in the suburb. Further work will be undertaken using a hydraulic model of the catchment scenario to accurately determine the performance of the raingardens in reducing peak flows from the catchment.

Summary and implications

Review of the status of WSUD in Mile End

Upon the completion of upgrading Mile End streets with raingardens, the City of West Torrens will have provided a leading example of an extensive retrofit of WSUD features to an established urban area. The raingardens in Mile End were the result of both an opportunity to conduct a WSUD retrofit in conjunction with existing civil works programmes for road surface and drainage upgrades, as well as a desire to improve landscape amenity and water quality raingardens. The council was initially involved in the design and implementation of these systems; however the ongoing detailed design was contracted out to external consultancies. After several design iterations, a generic design template has been developed for the construction of the raingardens, which can be easily adapted to suit local conditions. This has produced benefits in reducing the amount of design detail behind every new raingarden installation.

The construction of the raingarden was perceived by the local council and the community to have alleviated flooding issues on the streets which would have otherwise experienced nuisance flooding with reasonable rainfall. This is likely because of the provision of formal drainage to the street, however some flow volume reduction is evident attributable to the raingardens (1.8% per annum in the base case). MUSIC was unable to accurately assess peak flow reductions which require a hydrological and hydraulic model for simulation of raingarden. The results for water quality however indicated that there is a considerable removal of TSS (91%), TP (29%), TN (55%) and gross pollutants (100%). This was in accordance with similar monitoring studies conducted by Hsieh and David (2005) and Bratieres et al. (2008), which indicated an overall removal of TP between 4 to 99%, 70% removal of TN and more than 95% removal of TSS by raingardens. Literature review indicated that the lower percentage of removal of TP could be attributed to lower concentration of phosphorous entering into the system due to the prior removal of sediment bound phosphorous by turf grasses and other vegetated landscapes (Elliot et.al 2011), even though simulation using MUSIC does not account for any upstream catchment impacts. The lack of any monitoring data limited opportunities to validate the modelling results obtained. The long term performance of the system will largely depend on the adherence to routine maintenance of vegetation as well as the regular replacement of the topsoil in the raingarden to avoid clogging issues.

Impediments and opportunities

The widespread adoption of raingardens as a WSUD approach is currently impeded by a perceived maintenance burden by local governments, which is compounded by the difficulty in quantifying direct economic returns and raingarden system performance in different contexts. There is a need for more validation on the long-term maintenance requirements of raingarden features. Selection of the most appropriate plant species for raingarden is another area that requires further research, particularly to understand the performance of the plant species over a number of years and climate cycles.

The City of West Torrens has proceeded with the implementation of raingardens as they see them as a cost effective opportunity to incrementally move towards a more water sensitive approach in established urban areas. There is a need to quantify the extent to which raingarden may increase local amenity. It will also be useful to determine whether any impact on local amenity is reflected by changes to property values relative to other similar areas without streetscapes with bioretention features. If there is an increase in property value attributable to raingarden, this may justify the investment needed to meet ongoing operations and maintenance costs.

Raingardens have mostly been applied as a source control measure to retain and treat runoff from surfaces such as parking lots but there is a need for further research to consider how these WSUD features can be more widely adopted and integrated into the wider built environment.

Monitoring and validation

To validate the modelling outcomes and understand the actual performance of raingardens, the following monitoring studies would be considered substantial for assessing the performance of the raingardens.

- Treatment efficiency of these raingardens systems by conducting detailed water quality monitoring studies of inflow and outflow throughout storm events

- Assessment of inflow and outflow rate and quantity during a storm to verify the performance of the raingardens in providing a temporary detention storage which may reduce peak flows raingardens from a retrofitted catchment area.

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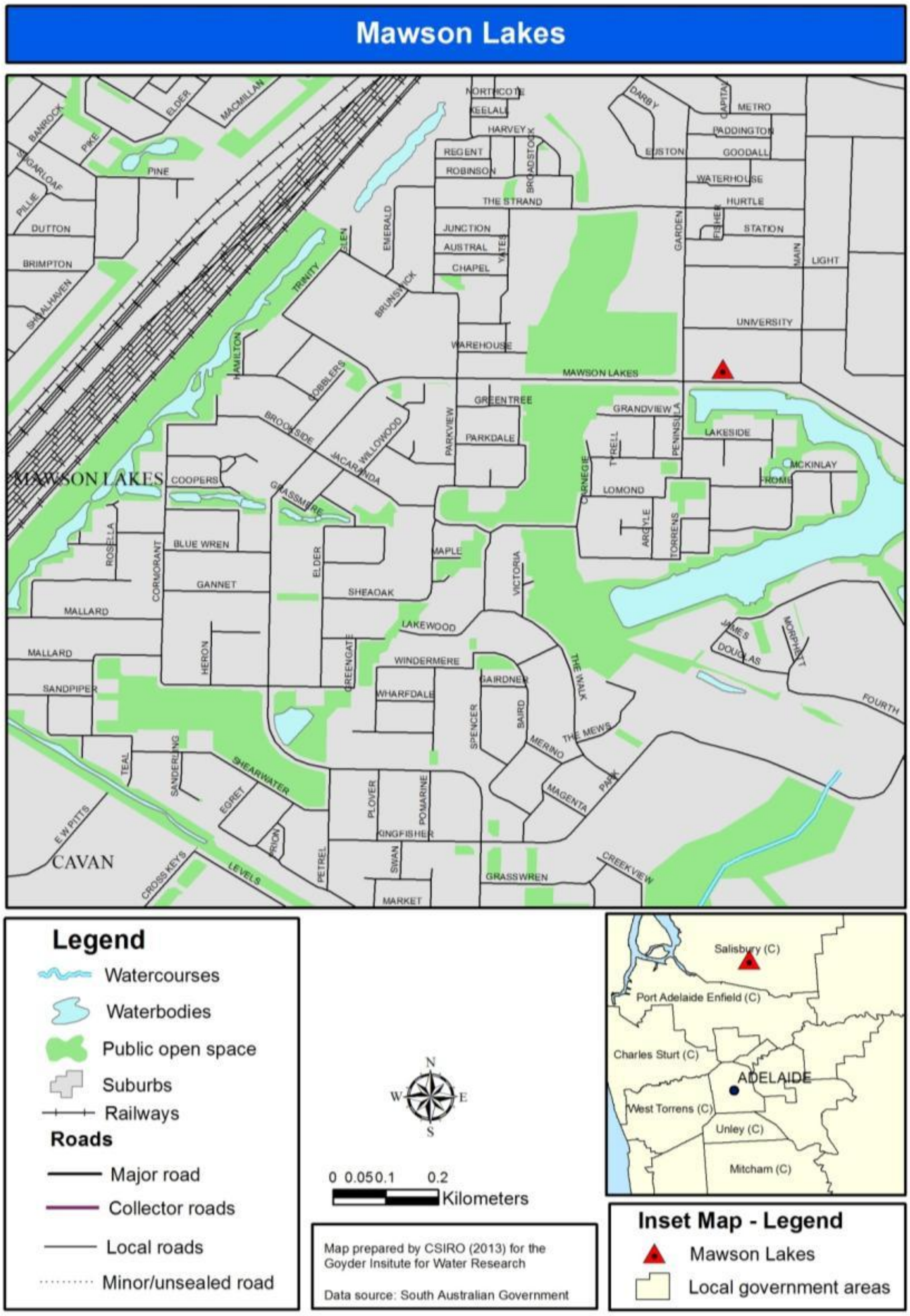
Mawson Lakes- detailed technical assessment



Overview

Mawson Lakes is a mixed urban residential and commercial development, in the City of Salisbury, characterised by distinctive water features like wetlands and ornamental Lakes as well as tracts of irrigated open space. The development houses a resident population of nearly 10,000 people, a permanent work force of 10,000 people (Technology Park) and a campus of the University of South Australia (UniSA) with nearly 5,000 students (City of Salisbury, n. d. a). Mawson Lakes was initiated from a collaborative project between the Australian and Japanese Government, named MFP (Multi Function Polis) in 1987, with a goal of achieving leading outcomes in water resources management and sustainable urban development incorporating water and energy saving measures (LendLease 2005; Tjandraatmadja 2008).

Figure J-16- Ornamental lake in Mawson Lakes Boulevard

The suburb was developed on 620 Ha of land with 70 Ha reserved for open space parks and lakes. The development features three major ornamental lakes including Sir Douglas Mawson Lake (7 Ha), which is the largest in North Adelaide, Shear Water Lake (2 Ha) and The Bridges Lake (2.2 Ha) (LendLease 2005).

Mawson Lakes was a pioneering development in Australia that introduced an integrated approach to energy and water management, incorporating mandatory wall and ceiling insulation, solar hot water systems, energy rating score card for newer dwellings and provision of recycled water for non-consumptive uses through a third pipe network (purple pipe). The project aimed at reducing domestic energy usage by 50% and achieving an annual mains water savings of approximately 110 KL per household by using a blend of recycled stormwater and reclaimed waste water for non-potable purposes (Lend Lease 2005). It was also envisaged that the non-potable water system would provide long term environmental benefits including a reduction in polluted stormwater and treated waste water entering Gulf of St. Vincent via the environmentally sensitive Barker Inlet. Every home and business (including the Technology Park and the UniSA Campus) in Mawson Lakes is connected to a 'purple pipe' system which conveys the recycled water blend. While recycled water is provided for open space irrigation in Technology Park, the newer buildings in UniSA campus have purple pipes connected to the buildings for toilet flushing (Marafioti, D 2013, pers. comm., 2 September). The overall development of Mawson Lakes cost $ 1.5 billion with the recycled water scheme alone costing about $ 16 Million (LendLease 2005). In 2003, Mawson Lakes was recognised as South Australia's best master planned development by UDIA (Urban Development Institute of Australia).

Description of WSUD elements

An integrated water management approach was adopted in Mawson Lakes with different WSUD elements (stormwater, recycled water) and landscape features (lakes and open spaces). The local runoff from the development is diverted to the wetlands (railway wetlands) on the south west of the development by stormwater infrastructure further via a culvert to the Greenfields wetlands to the west (City of Salisbury n.d. b). Prior to the entry into the wetlands the runoff is pre-treated by passing it through a series of upstream GPTs (32 no., CDS type) (Rocla 2002) consisting of a trash rack and a sedimentation basin, allowing the removal of suspended solids, litter and oil from entering further downstream. The cleansed runoff is injected under EPA Licence into a Managed Aquifer Recharge (MAR) scheme at the Greenfields wetlands.

The scheme is used to generate ‘injection credits’ in the brackish T1 aquifer. These credits are transferred under a Water Licence to enable sustainable extraction of T1 ground water from bores at Mawson Lakes for topping up the ornamental lakes as well as numerous community bores elsewhere in Salisbury for irrigation of schools and playing fields. (Naumann, B 2013, pers. comm., 29 August).

The Parafield ASR scheme, upstream of Mawson Lakes, harvests low salinity stormwater, which is used for storage and extraction in the T2 aquifer. Highly saline treated wastewater from Bolivar (provided with Dissolved Air Floatation and Filtration (DAFF) treatment and chlorination) is diverted to the Greenfields mixing tank (2.6 ML capacity)(Figure J-17a) where it is mixed with Parafield ASR scheme harvested water to mitigate the salinity impacts. Hypochlorite is automatically dosed to the inflow into the mixing tank to provide secondary disinfection to the recycled stormwater and reclaimed waste water prior to distribution as recycled water to customers in Mawson Lakes.

(a) (b)

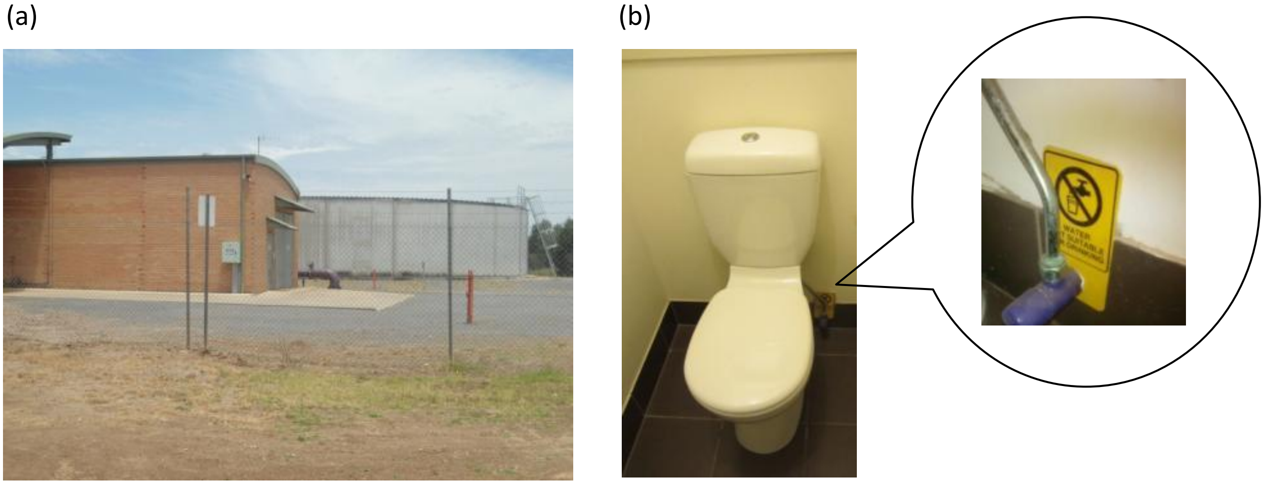


Figure J-17- (a) Recycled water mixing station at Greenfields for Mawson Lakes supply (b) the recycled water is used for toilet flushing , gardens and public open space irrigation

The dosing system is fully automated, i.e., flow paced with residual trim (Qiu, T 2013, pers. comm., 9 September). Pressure pumping system is installed which operates based on the downstream water demand and is pumped back to Mawson Lakes by SA Water through purple pipe system. Figure J-17the recycled water being used in the Mawson Lakes residences for toilet flushing. The whole process of recycled water supply into Mawson Lakes is depicted in below (Figure J-18)

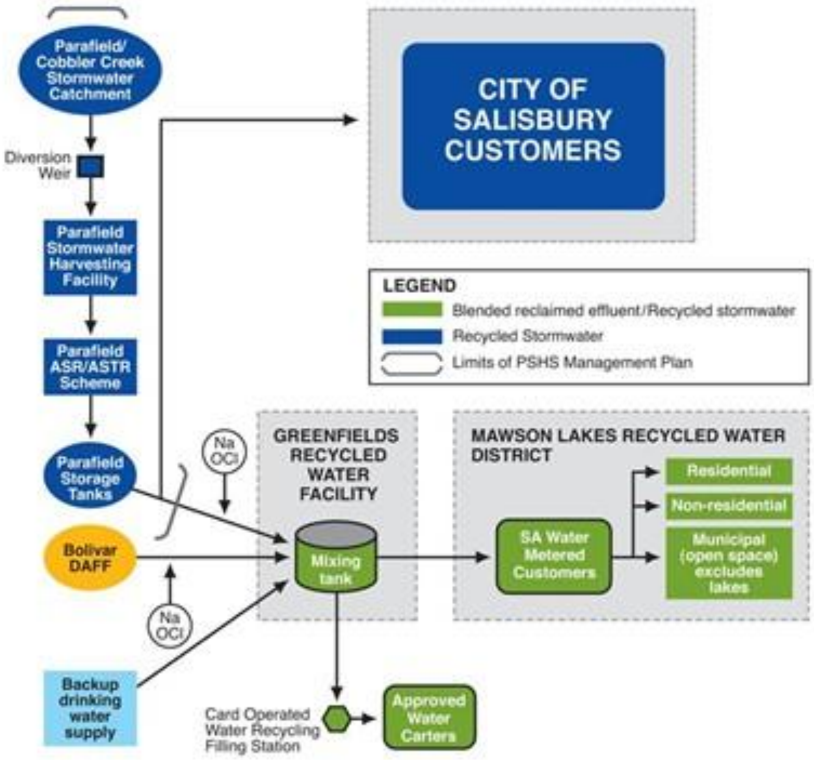


Figure J-18-Schematic version of the recycled water supply system in Mawson Lakes (Source: Declan et al., 2013)

A study conducted by SA Water on residential water usage pattern showed an average 27% increase in combined water usage for Mawson Lakes when compared to the Adelaide Metro for the period 2005-2013 (Table J-6), even though the household occupancy in Mawson Lakes (2.6 person/dwelling) was comparable to the Adelaide Metro (2.4 person/dwelling) (ABS 2011).

Table J-6- House hold water consumption data for Mawson Lakes and Adelaide Metro

Year	Av. potable (kL/yr)	Av. Recycled (kL/yr)	Mawson Lakes Av. Total water use (kL/yr)	Metro double and home unit (kL/yr)	All home units (kL/yr)
2005/2006	140	104	244	169	196
2006/2007	136	103	239	169	197
2007/2008	128	96	224	149	170
2008/2009	138	104	242	143	163
2009/2010	122	103	225	165	187
2010/2011	123	79	202	148	162
2011/2012	116	80	196	131	150
2012/2013	93	81	174	139	160
Av.(2009-2013)			199	146	165
% decrease in supply compared to Mawson Lakes				17%	27%

Source: Ingleton, G. 2013, pers. comm., 20 September

The lower water consumption rates for Adelaide Metro would have been influenced by the water restrictions imposed during the data collection period due to a drought while Mawson Lakes had the flexibility of using recycled water for non-potable residential usage, which was not restricted. Larger household size, high density housing as well as a higher socio-economic resident population in the suburb might also have influenced higher water demand in Mawson Lakes than Greater Adelaide.

Typically 400 ML/annum of recycled water is supplied into the development of which nearly 150 ML/annum is used for public open space irrigation (Naumann, B 2013, pers. comm., 4 October). Bore water is used for ornamental lake top up. Harvested stormwater is injected into stressed areas of the aquifer at the adjacent Greenfields wetlands and the injection credit is transferred by licence to unstressed bores at Mawson Lakes (Naumann, B 2013, pers. comm., 29 August). The reclaimed waste water supply from Bolivar largely depends on seasonal demand and the quantity pumped into the mixing station varies between 60 ML in summer to less than 15 ML in winter (Qiu, T 2013, pers. comm., 9 September).

Implementation

The development was designed for a demand capacity of 10,000 people (Rinck-Pfeiffer 2008). Initial plans to contract out the recycled water supply were abandoned due to the potential 'cross connection' concerns raised by SA Water. The regulatory and approvals requirements were a hurdle (like the restrictions in using reclaimed waste water in ornamental ponds), as most of them were evolving with the project (SA Water had to update standards for dual pipe installations and other associated technical elements). Issues like the lack of availability of purple pipes (required for non-potable water supply systems) and the lack of knowledge among the plumbers in installing dual reticulation pipe systems resulted in costly refits during the early stages of construction.

Operation and maintenance

Delfin Lend Lease was responsible for the overall management of the development for the first two years of operation, after which responsibility was handed over to the City of Salisbury. While City of Salisbury undertakes the operation and maintenance of the stormwater management system, SA Water manages the recycled water supply into the development. As part of the supply regime, a low pressure purple pipe system (compared to the mains water system) is maintained by SA Water, to prevent back flow and cross connection issues. SA Water also mandates that all new residents enter into an agreement regarding the appropriate use of the recycled water supply.

The maintenance of the GPTs and sedimentation basins costs the council $200,000 to $300,000 per annum which brings down the frequency of maintenance of wetlands to 5 to 7 years (Roy, D 2013, pers. comm., 19 March). Wetlands are allowed to naturally dry out (Figure J-19) each summer to reduce any anoxic conditions and assist with control of weeds and pest species such as European Carp (Naumann, B 2013, pers. comm., 29 August). The wetlands may be drained, if summer drying is not sufficient, typically every four years by the council to clear the accumulated sediments (Figure J-19). This opportunity is also used to undertake routine assessment and maintenance of weir gates. Gross pollutant traps are emptied and cleaned after rainfall events. Ornamental lakes, whose water levels are maintained through top-up, have experienced water quality issues associated with weeds, carp, turbidity, and algal blooms (Naumann, B 2013, pers. comm., 29 August).

The recycled stormwater quality is routinely monitored in accordance with EPA licences for total dissolved solids, pH, suspended solids, total organic carbon, salinity, hardness (as calcium carbonate), Lead, Zinc, Iron and Manganese and numerous other pollutants of concern.

(a)

(b)

Figure J-19- (a) Greenfields wetland during summer (b) sediments cleared off from a sedimentation basin

Recently the council had the first wetland basin (sedimentation pond) de-silted three years after installation. Nearly 400 tonnes of sediments were removed. The presence of heavy metals, especially zinc and mercury, limited the reuse potential of the soil removed.

Stakeholders and WSUD management

The major Stakeholders involved in the development and ongoing operation and management of Mawson Lakes include:

- State Government: initiated the project with the MFP partnership
- Delfin Land Lease: was responsible for planning, marketing, sales and management of the overall development
- City of Salisbury: current management of the development and the associated WSUD features)
- SA Water: manages the recycled water scheme
- Richard Marks (KBR): was responsible for the planning, water balance analysis and design of the recycled water scheme.

Community involvement

Mawson Lakes is a master-planned mixed community development, with water features and sustainable landscapes. The council has been successful in educating and training community 'champions' like the 'Mawson Lakes Environment Watch' who are involved in local water quality monitoring and spreading community awareness on the use of recycled water for non potable purposes along with updating the community with fact sheets providing the details of the recycled water scheme and its approved uses (Roy, D 2012, pers. comm., 14 November). However the council experiences a high political pressure in managing the water features in the development due to a relatively higher socio -economic and proactive community in the suburb (Roy, D 2012, pers. comm., 14 November).

Impediments and opportunities

Mawson Lakes was one of the first examples in the world of a residential development serviced with a dual reticulation water supply system. This meant there were barriers faced in the initial stages of the development due to the lack of knowledge of contractors on dual pipe systems. These barriers were overcome by initiatives such as 'green star plumbers' who are accredited for working with alternative water systems.

The existing infrastructure with spare capacity (sewer network connecting the development and the Bolivar Treatment Plant) and the costs involved in installing a treatment facility meant the initial plans for onsite treatment and reuse of wastewater was not feasible. The reclaimed wastewater from Bolivar WWTP was mixed with recycled stormwater (Parafield Wetlands ASR system) to reduce the salinity of reclaimed wastewater to be further pumped into the purple pipe network.

The reliable supply of non-potable water means that Mawson Lakes' residents are immune to the impact of water restrictions, which often limits the application of drinking water for irrigation. The regular irrigation of public open space with recycled water at Mawson Lakes has provided for improved landscape amenity when compared to nearby suburbs in northern Adelaide. The landscape amenity offered by water features such as the lakes and the recycled water scheme for irrigation, has increased the value of properties in Mawson Lakes, relative to suburbs without these features. The Mawson Lakes development may have initiated a trend among the developers in South Australia for increased acceptance of 'ornamental lakes' in greenfield developments, irrespective of the long term maintenance burden as well as the water demand generated in topping up the lakes, which can bring in to question the sustainability of the approaches and its alignment with the principles of WSUD. The high levels of water use at Mawson Lakes highlight the influence of factors such as socio-economic status, dwelling patterns and lot size on water demand. Lack of awareness regarding the purple pipe systems among new residents, resulted in the usage of recycled water in private swimming pools and overuse of potable water for non-potable uses (irrigation), when recycled water supply was offline. There have been issues with the recycled water quality (odour and discolouration) and the low pressure of recycled water supply system.

To overcome the excessive sedimentation issues in wetlands, the council has developed an extensive upstream treatment train methodology. The council emphasise bank stabilisation options incorporating soft engineering concepts like vegetated banks which reduce the rate of sediment erosion into the water ways (Roy, D 2013, pers. comm., 19 March). However according to the council, lack of adequate maintenance guidelines for green infrastructures make the maintenance tasks for WSUD features more difficult (Roy, D 2013, pers. comm., 19 March).

Monitoring and validation

Being operational for nearly 15 years, the following aspects of Mawson Lakes could provide valuable information on the performance of the WSUD systems and the impact of maintenance on the treatment effectiveness of these systems.

- Percentage reduction in mains water usage per annum;
- The frequency of maintenance of the WSUD elements in a fully functional system;
- The practical implications of a dual reticulation system and the maintenance issues (type of complaints, frequency of complaints, effectiveness in attending to the complaints etc); and,
- Biodiversity impacts of wetlands and amenity and recreational aspects of lakes.

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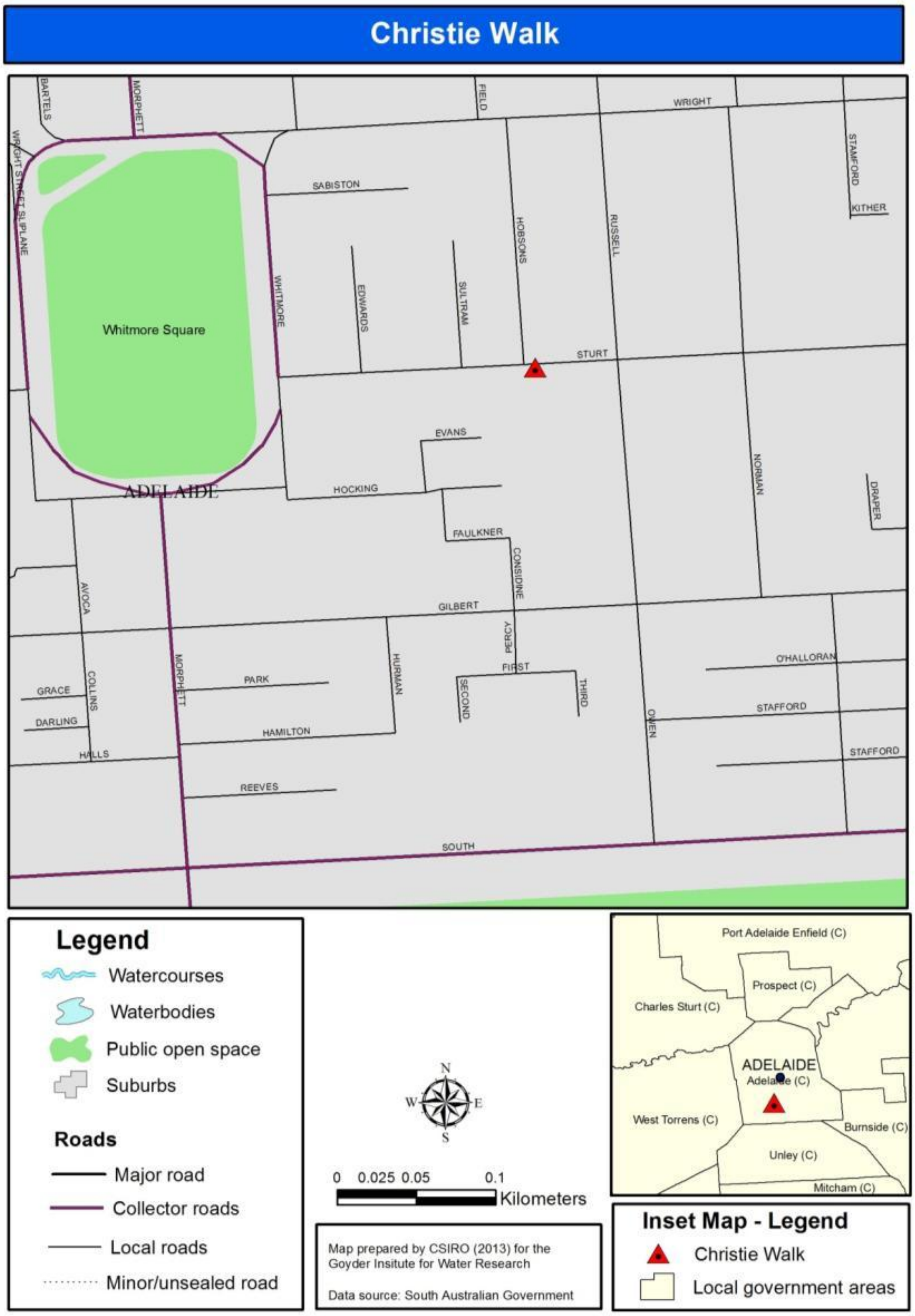
Christie Walk Detailed Site Assessment



Overview

Christy Walk is a brownfield medium density residential development, located in Adelaide's central business district. The development was initiated in 1999 and completed in 2006. The development is situated on a 2,000 m^2 lot, which was formerly used as waste recycling depot and now contains 27 dwellings of varying types that house a population of 44 people. Christie Walk was designed and is now managed to demonstrate a sustainable approach to urban development and living using the concept of an ecocity. The principles that underpin the concept of an ecocity have the purpose of (Urban Ecology Australia, 2013):

- Minimising ecological footprint (biophysical) and
- Maximising human potential, in order to;
- Repairing, replenishing and supporting the processes that maintain life.

At Christie Walk these principles have been realised through a design that includes the use of sustainable building materials, passive heating and cooling, renewable energy generation, spaces to encourage and enhance community interaction, and community gardens. However, this assessment only focuses on those aspects of Christie Walk related to WSUD features and their management. There are range of other reviews and papers that provide a broader perspective of sustainability initiatives at Christie Walk and how the project was conceived and realised (see: Downton, 2010a; Crabtree, 2006; Reid, 2005). Figure J-20 depicts a typical house at the Christie Walk development.

Figure J-20: Christie Walk development

The environmental performance criteria that were used to guide the development of the Christie Walk covered energy, water, land, health and pollution. The performance criterion specific to water was:

> "*Both in construction and in its on-going life, to maximise on-site both the retention and usage of storm water, and the retention and recycling of waste water*." (Urban Ecology Australia Inc., 2013).

The following assessment was based on a site visit to Christie Walk, which included interviews with Paul Downton – Project Architect, and members of the community who are living and managing WSUD features at the site. The detailed assessment was also supported by review of available literature and water balance modelling.

Description of Christie Walk WSUD elements

The water supply, wastewater and stormwater services at Christie Walk were designed to be water efficient, minimise environmental impacts, and enhance the local ecological processes and liveability of the development. The layout of water system is shown in Figure J-21. The following sections describe the different elements of the Christie Walk water system.

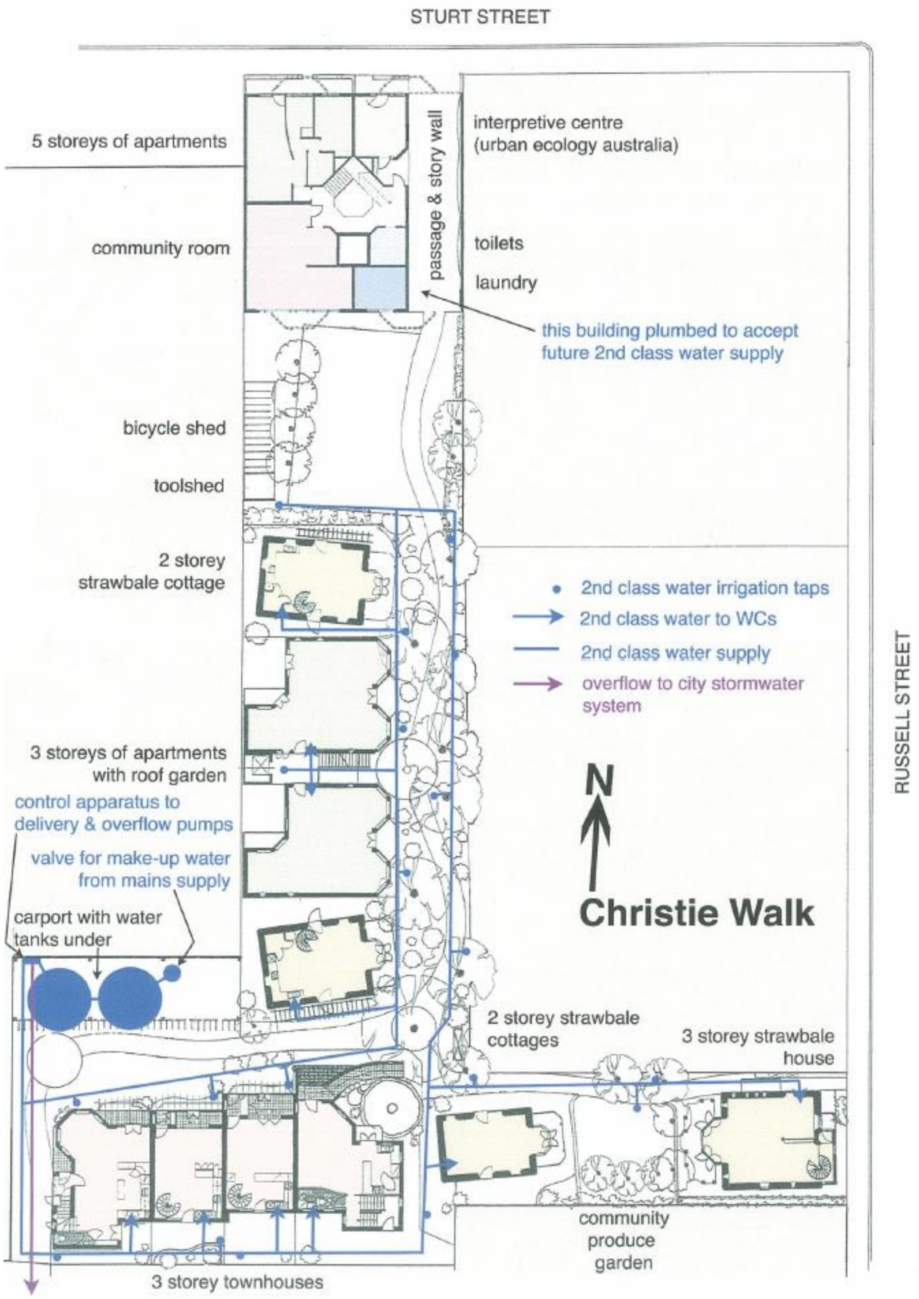


Figure J-21 – Christie Walk layout

Source: Christie Walk Community

Stormwater and rainwater

The runoff from impervious surfaces (roofs, paving, balconies, etc) is collected via downpipes and grates to a stormwater collection pipe that drains to two underground concrete storage tanks (40 m^3 total capacity). The impervious collection area is approximately 1,300 m^2, which is around 65% of the total site[1]. The harvested runoff is reticulated back to the development via a ring main pipe, which provides non-potable water for toilet flushing and garden taps for irrigation. The harvesting scheme only provides water to the around half the residents (20 people) who live in the original small apartment block and separate dwelling

[1] This is based the fact the vegetated area is 700 m^2 of the 2,000 m^2 site.

at the rear of the development. It was originally envisaged that the large apartment block at the front of the development would also be serviced by stormwater harvesting scheme but this did not go ahead. While the large apartment block was plumbed for the reticulation of stormwater the costs of additional underground tanks in the courtyard were considered prohibitive.

The supply of water through the non-potable pipe is guaranteed with mains back-up supply to the tanks. The mains top-up is controlled by high and low level sensors, which control the overflow pump and mains water back-up respectively. The system is fitted with non-return valves to prevent the risk of backflow and cross-contamination of mains water pipelines.

Excess stormwater flow (i.e. overflow) that cannot be captured in the storage tanks is directed to a spoon drain at the rear of the development.

Wastewater

It was originally envisaged that Christie Walk would include an onsite wastewater treatment plant to enable the recycling of treated effluent. Onsite options for treatment and reuse of blackwater and greywater were explored. A chlorine-free sewage treatment process was originally planned but it was found that the running costs, particularly for energy, were prohibitively high which led the Body Corporate to the decision not to proceed with the onsite water recycling system (Downton, 2010a). The challenge of treating and recycling wastewater was revisited with the support of Adelaide City Council and SA Water. The recycled water from this proposed scheme was to be used for irrigation of nearby Parkland (Whitmore Square). However, it was still considered that the cost for the treatment system was too expensive to justify the scheme. The wastewater from the development flows to SA Water sewerage network.

Green Roof

A unique feature of the Christie Walk development is the green roof. The green roof was designed to provide amenity to residents, while improving the site biodiversity. The green roof was constructed on a 200 mm thick concrete base and a bituminised water proof layer, which was overlain with a 400 mm soil layer (Figure J-23). The downpipes are discharged to subsurface soakage as the developers were unsure of the quality of the roof water that would be discharged, which inhibited the use of the green roof runoff for the stormwater harvesting scheme. This highlights the need to validate the quality of runoff discharged from the green roof to ensure it is compliant with water quality requirements for discharge to the stormwater system. The discharge from the green roof could also be used at Christie Walk to augment the stormwater harvesting and reuse scheme. There have been no problems with discharge of runoff from the green roof to subsurface soakage. Irrigation is managed, during low rainfall periods, to minimise runoff from the green roof.

Figure J-22: Green roof at Christie Walk

The green roof serves a number of purposes. It provides a significant amenity value for residents and also local biodiversity benefits. Downton (2010b) put forward that the performance benefits for green roofs include the retention of stormwater flow.

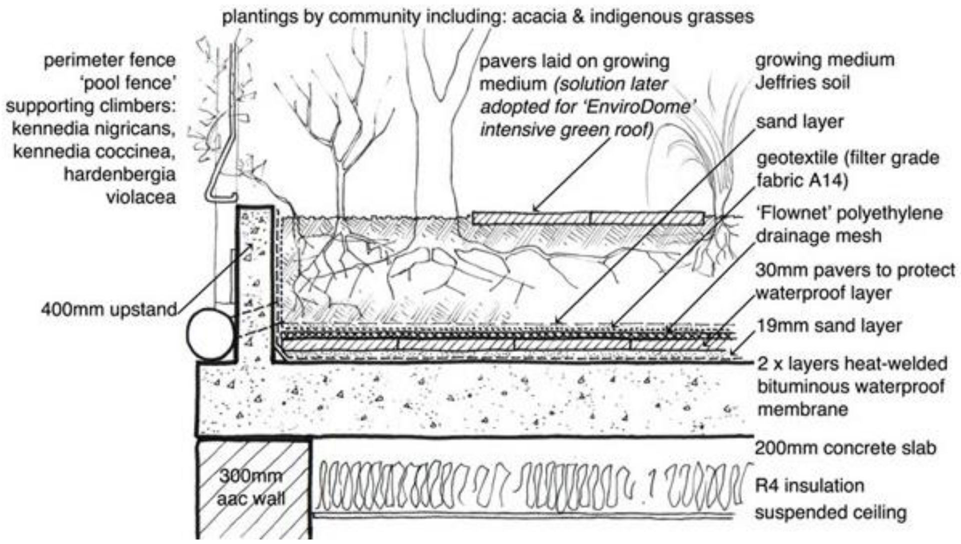


Figure J-23 - Christie Walk green roof cross-section

Source: Urban Ecology Australia, http://www.urbanecology.org.au/eco-cities/roof-gardens/

Landscaping

Native and indigenous plant species have been used widely in the landscaping for Christie Walk. The plants were selected to both reduce demand for irrigation, while providing local benefits to biodiversity. There was also selective planting of exotics and other plant species for food production. The exotic deciduous species were used selectively to allow winter solar and provide shade in summer (AILA, 2007). These plants are watered from the harvested runoff to reduce mains water demand. Irrigation to produce garden and green roof is automated with a timer but it is monitored and adjusted to meet seasonal demands or recent rainfall. Other irrigation is manually operated according to plant needs and climate conditions

Stakeholders and WSUD management

Christie Walk was initiated by Urban Ecology Australia, a non-profit educational association, which then set up Wirranendi Inc to deliver the development and sell apartments (Downton, 2005). The project didn't receive any government funding and construction was financed by a combination of private capital and a loan to the development cooperative (Sustainability Victoria, 2011).

Christie Walk is managed according to the South Australian Community Titles Act, so has a standard body corporate arrangement comprised of owners. The Body Corporate makes formal decisions based on a voting system, although discussions we had with residents revealed that issues are often resolved through informal negotiations and decisions. These informal processes are aided by the commitment and passion of the residents to the ecological city principles that underpinned the development of Christie Walk. This commitment was observed during the site visit at Christie Walk where residents are actively involved in managing and promoting the sustainable urban living features.

There are a range of resident committees that have been formed to manage the development, such as the Works & Maintenance Committee. The WSUD features are managed by a working group of two residents who have a technical background but no specific expertise in managing urban water systems. The management of the WSUD schemes, in particular the stormwater harvesting systems, was formalised with a users' guide. This guide provides the technical details of the systems and also trouble-shooting steps in case of system failure. The stormwater system users' guide will allow for management of the scheme to be passed in future to other residents by documenting current knowledge. This guide was initially developed as it was found that managing the systems was impeded by a lack of information, such as the location of pipes. While, developing this information the WSUD working group found a number of problems with how the stormwater system had been constructed. In particular, it was found that some drainage downpipes were not connected to the rainwater/stormwater storage tanks, so this harvested runoff was just being discharged into the soil profile. These problems have since been rectified. The maintenance of the WSUD scheme is funded from the yearly financial contribution that owners make to the Body Corporate. The funds are actually handled by an external organisation to avoid the potential for mismanagement and possible perceptions of conflict of interests.

Crabtree (2006) highlighted that the reliance at Christie Walk on a volunteer workforce can lead to concerns about workload on some people, and also there are concerns if this commitment can be maintained into the future. However, as Christie Walk was designed to enhance cooperative communal urban living therefore the type of people likely to be attracted to living in this type of development are more likely to be altruistic with their time. Furthermore, the active residents' committees and regular monthly working bees is likely to create a sense of ownership of the rainwater/ stormwater harvesting scheme that would encourage participation in managing and maintaining the scheme.

WSUD Performance

Mains Water Demand

The mains water demand at Christie Walk is significantly lower than for other small households in Adelaide. Mains water use is monitored by two SA Water meters. One for the front building (without recycled stormwater scheme supply) and one for small apartments and separate dwellings that do have access to this recycled water for toilet flushing. At the request of the committee SA Water divides the overall bill for both meters evenly amongst all residents. This was done for equity reasons.

Figure J-24 depicts the quarterly water demand as the daily average per household. This shows that water use for Christie Walk households is significantly lower than the average recorded for one person households in SA Water's service area. This is despite the average household size at Christie Walk being closer to 2 people (average household size of 1.85 people). The much lower than average water demand can be attributed to the following factors at Christie Walk:

- The built form and landscaping at Christie Walk was designed to be water efficient. This included efficient appliances and also the extensive use of native plants that are adapted to dry conditions;
- Discussions with the residents also revealed that they were highly motivated for sustainable behaviour both promoting and in practice, which is likely to partly explain why they would move to a development such as Christie Park. Millock and Nauges (2010) found that the household adoption of water efficient appliances was strongly related to environmental attitudes; and,
- The stormwater/rainwater harvesting and reuse scheme at Christie Walk was designed to reduce mains water demand by supplying non-potable water from this scheme for garden irrigation and toilet flushing.

It can also be noted in Figure J-24 that there was very little seasonal fluctuations in water demand. This indicates that mains water use has mostly being supplied to indoor potable demands, while seasonal demands (outdoor irrigation) is likely to be satisfied by the stormwater/ rainwater harvesting scheme.

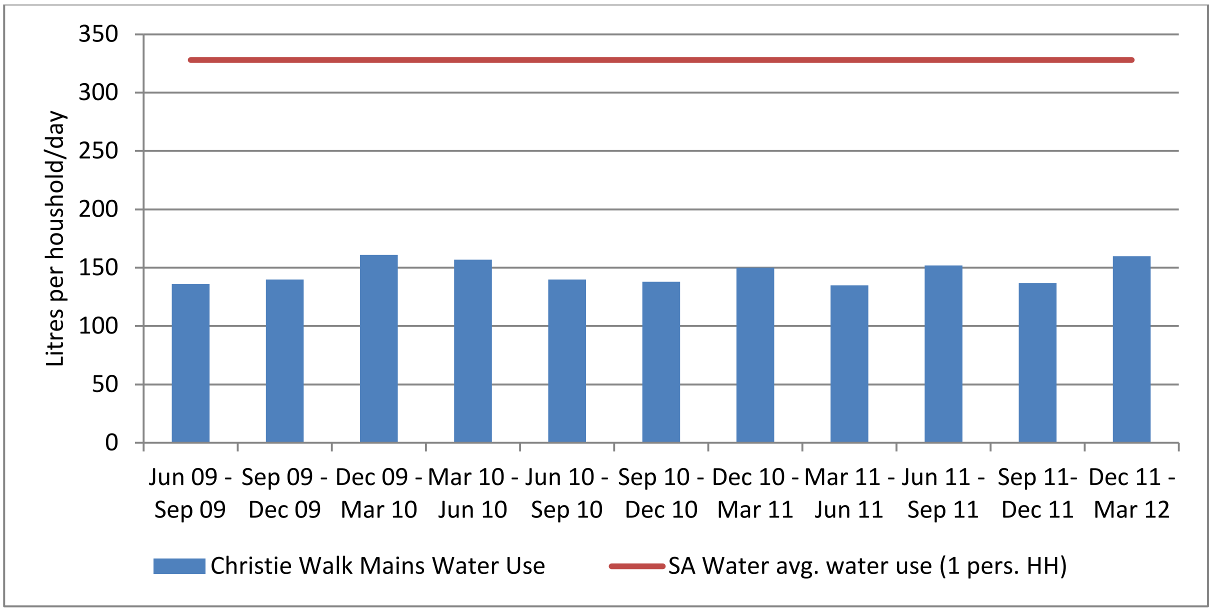


Figure J-24 – Christie Walk daily household water use vs. Average 1 person household water use in SA Water service area (litres/hh/day)

Modelling performance of stormwater/rainwater harvesting scheme

Modelling was undertaken to explore the likely performance of the stormwater/rainwater harvesting scheme at Christie Walk in reducing mains water demand and retention of runoff on site. The modelling has also enabled the performance of the Christie Walk scheme to be explored under different operating configurations and climate conditions. The long term reliability of the communal rainwater system was modelled using the Urban Volume and Quality (UVQ) model. The UVQ model quantifies urban water and contaminant balance; enabling the user to track flow paths and contaminant concentrations through the urban water cycle (Mitchell and Diaper, 2006). In the UVQ model imported water supplies and rainwater are the major inflows to the urban water cycle; while wastewater, stormwater and evaporation are the main outflows. Water sources can be used for indoor and outdoor end-uses. Specific end-uses are: kitchen, bathroom, laundry, toilet, garden irrigation and public open space irrigation. UVQ operates on a daily time step and can run from a minimum period of one year up to one hundred years. In order to account for climate variability at different temporal scales it is best for the simulation period to run over a period of decades.

The non-potable water demand for the Christie Walk stormwater system was estimated based on Australian end use studies. In particular, estimates were based on an end use study conducted by Roberts (2004) in Melbourne. Roberts (2004) recorded that on average the frequency of toilet flushing was 4.2 per person a day. Roberts (2004) found that, based on an average 7.8 litre flush volume (with a slightly higher proportion of full to half flushes), the per capita daily volume for toilet flushing was 31 litres. We have applied the frequency of toilet flushing recorded by Roberts (2004) but reduced the flush volume based on the assumption that more water efficient toilets have been adopted at Christie Walk. There was a limited trial of ultra low flush toilets at Christie Walk, but as this was only trialled in a few apartments we have assumed an average toilet flush volume of 3.5 litres, which gives a per capita daily volume for toilet flushing of 15 litres. This was based on a 4 star dual flush toilet with a 4.5/3 litre volume. This was founded on information from the Australian Government Water Efficiency Labelling Scheme (WELS) website (http://www.waterrating.gov.au/). Garden irrigation in UVQ was calculated based on antecedent rainfall, potential evaporation, percentage of garden irrigated, soil hydraulic properties, and the soil moisture that the irrigator wants to maintain. For Christie Walk there was no information on the irrigation demand, so we estimated irrigation demand (Figure J-25) on the basis that around 30% of the pervious area is irrigated.

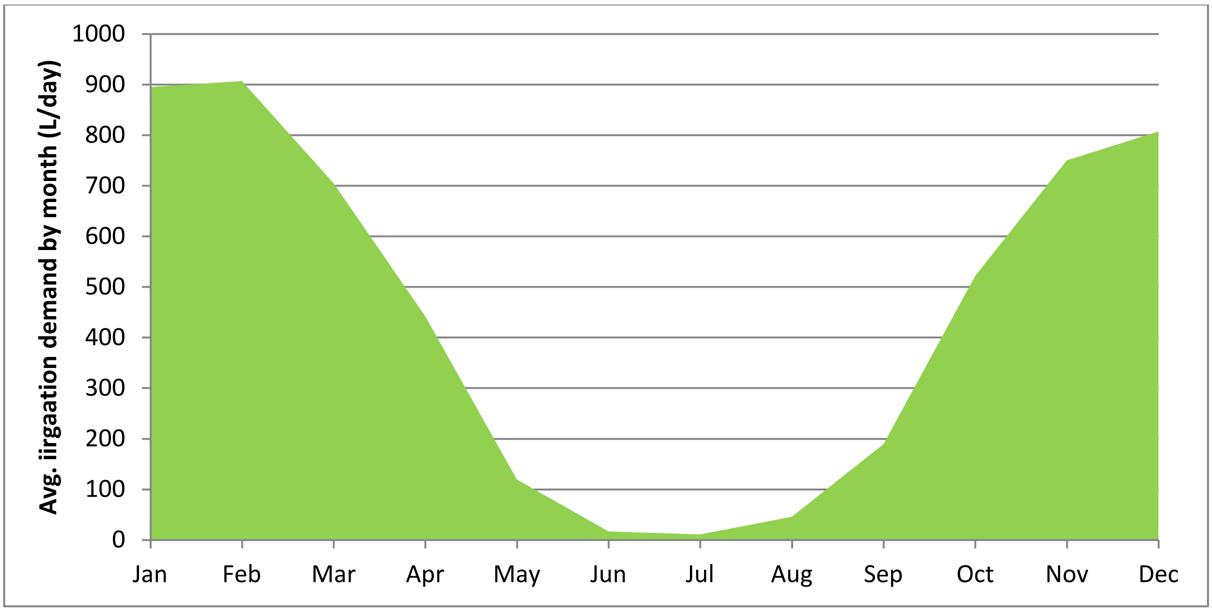


Figure J-25 - Estimated Christie Walk irrigation demand by month (litres/day)

In assessing the performance of the Christie Walk stormwater scheme there was a need to account for inherent climate variability. A thirty year climate record (1983 – 2012) was obtained from the Bureau of Metrology station from the nearby Kent Town monitoring station. Figure J-26 depicts the annual and average annual rainfall over this period. This shows that average annual rainfall depth was 548 mm, with one wet year in 1992 and a very dry year in 2006 with only 288 mm of rainfall recorded during the peak of the Millennium drought.

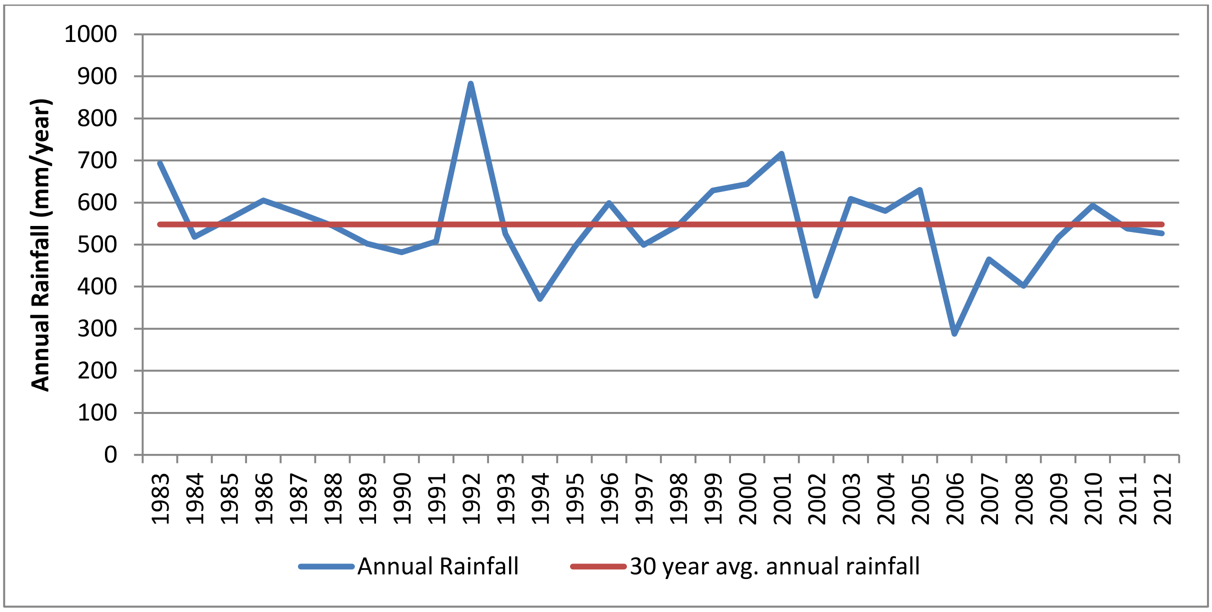


Figure J-26 - Annual Rainfall (Kent Town)

Table J-7 shows the estimated demand for non-potable water, with the majority of the demand estimated to be for toilet flushing.

Table J-7 –Estimated demand for harvested stormwater at Christie Walk

Demand	Avg. Daily capita demand (litres/person/day)	Avg. annual development demand (kL/development/year)
Estimated toilet flushing demand	15	274
Estimated irrigation demand	9	163
Total non-potable demand	24	437

The modelled performance of the system at Christie Walk showed the stormwater/rainwater harvesting scheme could satisfy demand for toilet flushing and garden irrigation on 67% days annually, when averaged over the thirty year simulation. Figure J-27 depicts the average monthly inflow to the stormwater storage against the monthly demand for stormwater at Christie Walk. This shows the challenge of meeting seasonal irrigation demand that peaks during the drier months of Adelaide's summers. Removing garden irrigation, which is a seasonal demand, would increase the reliability of Christie Walk's stormwater/ rainwater scheme to 93%.

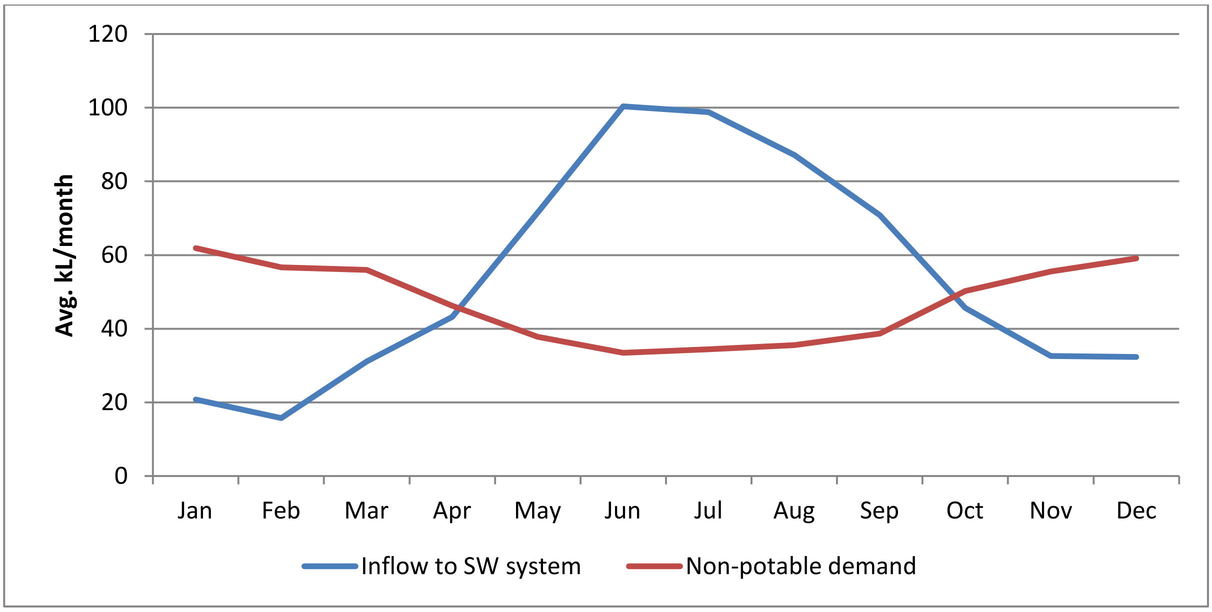


Figure J-27 - Monthly average stormwater inflow and demand

Figure J-28 shows the modelled impact of increased storage size for the Christie Walk stormwater/ rainwater scheme and annual reliability (red circle denotes current storage size). While, Figure J-29 depicts the effect on reliability of reducing the catchment area of the harvesting scheme at Christie Walk to less than the current 100% of available impervious area. These figures show that around 97% reliability might be achieved with a storage volume four times greater than currently available, but that reducing the harvesting catchment area would only have very marginal implications for the reliability of the scheme. This indicates the limiting factor for the scheme is the storage available to meet seasonal irrigation demands during the drier summer months.

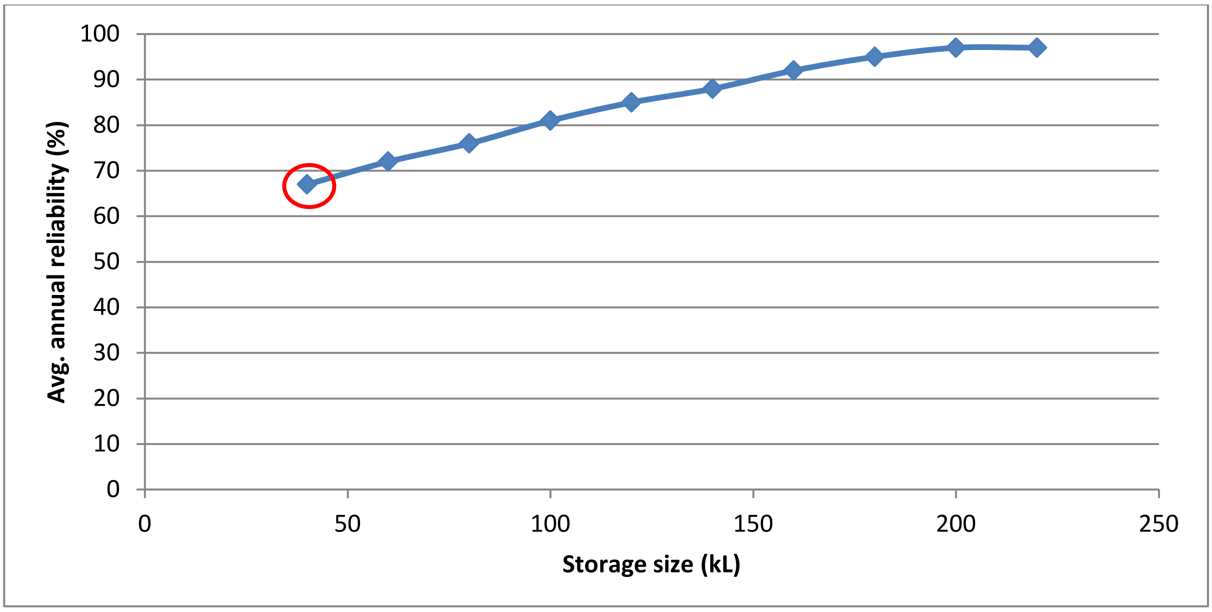


Figure J-28 - Increased storage size and reliability

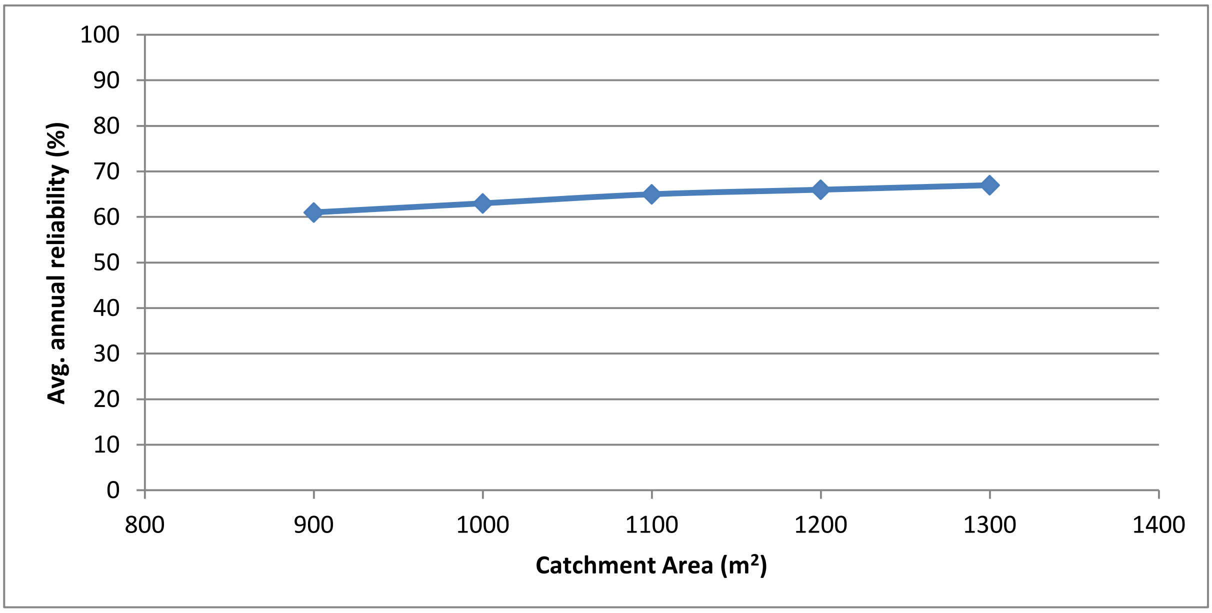


Figure J-29 - Decreased catchment area and reliability

The harvesting and reuse of stormwater at Christie Walk also has an impact on the discharge of stormwater. The UVQ model can estimate the amount of avoided stormwater discharge due to harvesting and reuse, but due to the daily time step is not useful for considering impact on peak stormwater flows. The modelling results indicated that the harvesting and reuse of stormwater at Christie Walk could reduce average stormwater discharge by around 47%. Figure J-30 shows the average monthly impact of the harvesting and reuse scheme on stormwater discharge. In the drier summer months, when the storage level would be low from high seasonal irrigation demand, the majority of the stormwater flows are captured by the harvesting scheme. However, in winter months with lower demand and higher rainfall there is less impact on stormwater discharge.

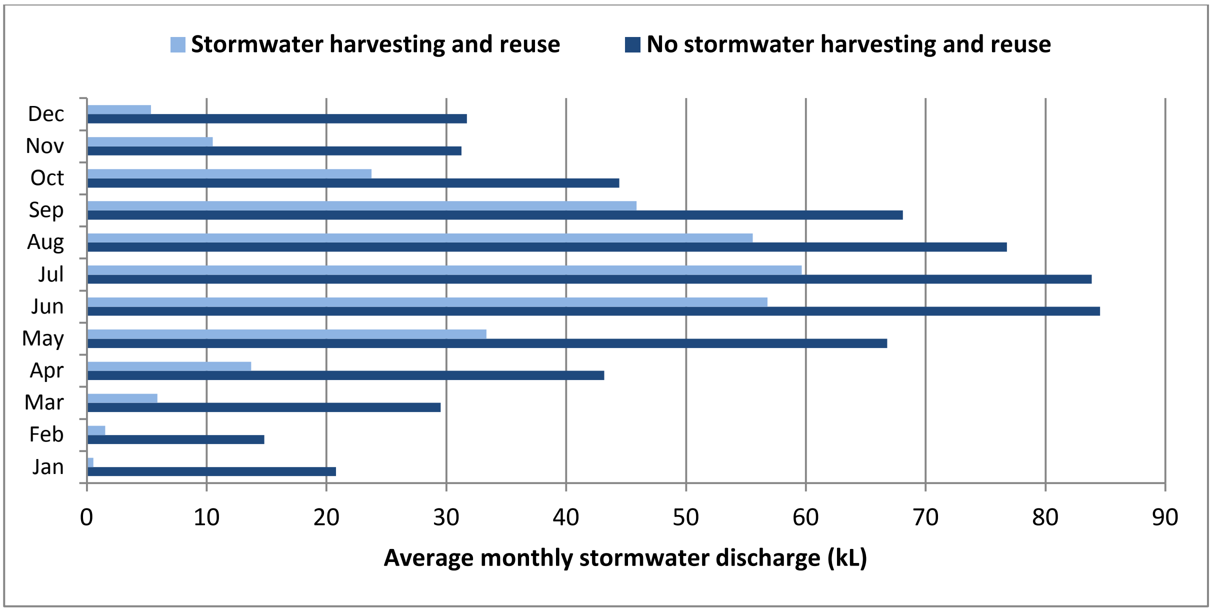


Figure J-30 - Impact of stormwater and reuse on stormwater discharge

Summary and Implications

Review of Christie Walk WSUD Planning and Implementation Process

The planning and implementation process for Christie Walk was atypical in that the purpose for the development, as outlined by during the site visit by Paul Downton (the site architect) was to push the boundaries of what could be achieved in terms of sustainable development for high density urban living. This meant that the development considered options that were not mainstream practice at the time, or even covered by the regulatory framework. The purpose of the Christie Walk development has implications when considering the potential for replicating the WSUD approaches more widely in urban infill developments across South Australia. In terms of WSUD initiatives the particular innovations explored at Christie Walk were:

- A green roof to provide amenity to residents as well as benefits to managing stormwater quality and quantity;
- A scheme to harvest stormwater and roof runoff, which is then reticulated back to residents for non-potable applications; and,
- Onsite wastewater treatment and recycling.

As has been outlined in the preceding sections each of these initiatives faced some impediments during implementation that meant that the performance of these WSUD did not always achieve the benefits nominated during the planning of the development, or there was a delay in fully achieving these benefits.

In the case of the green roof there was uncertainty in the quality of the exfiltrating water. This uncertainly in water quality means that water in excess of evapo-transpiration rates and soil water holding capacity is discharged to sub-surface soakage instead of contributing to the stormwater harvesting scheme. The uncertainty in the quality of green roof runoff highlights the need to validate the likely quality and quantity of water being discharged from green roofs. This validation could be achieved through event based monitoring to determine if the green roof has a significant impact on stormwater detention, and subsequently peak stormwater flows. Also, understanding the likely quality of exfiltrating water, and possible practices (such as application of fertiliser and pesticides) that may contribute to poor water quality would enable the development of guidelines for managing green roof water quality either though treatment or improved practices. This knowledge would enable the exploration of the potential to reuse green roof overflow for non-potable applications, or for discharge to stormwater drains.

The initial implementation of the stormwater/rainwater harvesting scheme was later found to be faulty in that all of the downpipes were not connected to collection and storages. This was discovered during a post-implementation assessment by resident committees and meant that the not all potentially harvestable water was being captured. It was thought by the project architect that the problem was likely to have resulted from contractor error. The identification of this problem highlight the need for post-implementation validation of WSUD elements to ensure that they are operating as planned. Also, the scheme did not proceed to the newer larger apartment block at the front of the development due to costs associated with additional storage being considered prohibitive. The use of harvesting schemes in a high density urban development raises the issue of configuring storages that are both optimal for demand but also cost effective given the need to install tanks underground where space is limited.

The previous sections highlighted that there were difficulties with implementing the onsite wastewater treatment and recycling scheme that led to it being abandoned. The primary reason for the shelving of the onsite wastewater treatment and recycling scheme was high capital and operating costs of the proposed treatment system. For the first wastewater treatment and recycling option explored at Christie Walk, it was found that the energy requirements and associated costs were too high. Another approach was explored in collaboration with SA Water, where the treated effluent would be recycled for irrigation at a nearly public park. However, the treatment costs associated with this scheme were also considered prohibitive by the body corporate. The recycling of blackwater requires a much higher level of treatment than other potential non-potable water sources such as stormwater runoff or greywater, which raises the costs of implementing a scheme to reduce mains water demand. The blackwater treatment and recycling also requires a higher level of technical skills to adequately manage and operate the scheme. These specialist skills are likely to have to be provided by a contractor external to the resident community. The higher costs, regulatory requirements and management complexity associated with non-potable water scheme where blackwater is recycled means that there may need to consider a hierarchy of recycling opportunities for small scale developments where non-potable demand is firstly satisfied by sources requiring minimal or no treatment, such as rainwater, then subsequently moving to poorer quality water sources such as stormwater, greywater and blackwater.

Impediments and opportunities

The review of Christie Walk has identified that there are a number of opportunities and impediments when considering the potential for more widespread uptake of the WSUD approaches in similar urban developments across South Australia. In some cases factors that are impediments also carry some opportunities. For example, at the Christie Walk development uncertainty around the quality of exfiltration from the green roof was an impediment in maximising the reuse of stormwater onsite but the development also provides an opportunity to validate the impact of green roofs on quality and quantity through a monitoring study. This information could be used in developing improved guidelines for green roofs that highlight their likely performance and required management. Improved guidelines are likely to be important in gaining more widespread acceptance in the South Australian development industry by understanding the potential benefits and costs, and the development contexts where green roofs might be a suitable WSUD approach.

Other specific impediments for realising the full benefit of WSUD elements at Christie Walk were:

- Implementation problems, with the downpipes not connected to the harvesting collection system. This may have been due to building and plumbing contractors not being familiar with these systems at the time, as water harvesting schemes have become more common over the last 6 years the skills and experience for implementing such systems is likely to have improved, but it does highlight the need for project designers and planners to have an ongoing involvement in the construction to ensure design intent is achieved. It also raises the need for post-implementation validation of WSUD schemes.
- The difficulty of realising the onsite wastewater scheme at Christie Walk highlighted the challenges of commissioning these decentralised approaches to water recycling. The main challenge faced at Christie Walk was cost. Small-scale onsite wastewater treatment and recycling for urban infill

developments are potentially costly and just as importantly impose a management and operating complexity that might not be justified by the reduced mains water demand. These management costs and complexity may be appropriate for larger scale schemes that have the oversight and direct involvement of local authorities and service a large number of households, but it may be difficult at smaller schemes that do not necessarily have access to the required skills needed to maintain and operate these schemes appropriately.

- In the case of the onsite wastewater treatment and recycling the costs were found to be prohibitive. There is a need to ensure that the costs of WSUD schemes are justified by the expected benefits, and that lower cost and complexity WSUD options for reducing mains water demand or improved onsite stormwater management are exploited first.

The Christie Walk development has highlighted a number of opportunities, which include:

- The analysis of the stormwater harvesting scheme showed that the communal stormwater harvesting and reuse for meeting non-potable demand, in combination with water efficiency, has reduced mains water demand at Christie Walk by around 55% when compared to similar households in South Australia.
- In addition the capture and use of stormwater has significantly improved the retention of onsite stormwater. The analysis showed that reliability could be improved through larger storage at Christie Walk, but that a decrease in the catchment area would only have a marginal impact on yield. The use of increased storage size in similar high density urban infill developments would need to be considered in respect to the feasibility given limited space and costs associated with putting storages underground.
- At Christie Walk runoff is harvested of all impervious surfaces. In general, roof runoff provides better quality runoff when compared to runoff collected from other urban impervious surfaces, such as driveways and paths, which are subject to more contamination sources. Therefore, there is the need to consider the benefit of extending harvesting beyond roof catchments if the improvements in yield and reliability are only marginal as there may be additional risks associated with the reuse of this water. These risks could be managed by treatment and monitoring but this would place additional costs and complexity on the water harvesting and reuse scheme. While, harvesting runoff from roads and pavements may assist with onsite stormwater management this objective could be satisfied with other WSUD elements such as infiltration pits that don't present the public health risks associated with reuse.
- The success of WSUD elements at Christie Walk have been due to the strong vision and commitment from the original project designers to delivering a sustainable high density urban development. This meant that the original design was progressive in exploring all feasible options to deliver sustainability objectives. The ongoing success has been due to the motivation and engagement of residents to participate in the community management of the development. In considering the broader applicability of a WSUD approach, such as that demonstrated by Christie Walk, to other urban infill developments in Greater Adelaide there is the need to consider if these approaches could be adopted as a mainstream development practice.

Monitoring and Validation

The review of the WSUD features implemented at Christie Walk have made clear the need for some monitoring studies to validate the performance of the approaches implemented, and therefore more accurately quantify the costs and benefits of such approaches. The specific monitoring that could be undertaken at Christie Walk includes:

1. Monitoring of water quality and quantity exfiltrating from the green roof to understand the impact on stormwater management.
2. Monitoring of rainwater and stormwater usage to estimate likely non-potable demand, and potential mains water savings.
3. Monitoring of mains water back-up supply to rainwater / stormwater tank to understand the reliability of the system in meeting demand.
4. Estimation of energy in the rainwater supply to better quantify environmental impacts and costs of rainwater/stormwater harvesting system.
5. Monitoring of rainwater tank quality as stormwater is mixed with rainwater to understand the impact of runoff quality from different urban impervious surfaces.

The knowledge is critical for:

- Understanding the potential to replicate these approaches in similar developments across South Australia;
- Informing improved guidelines and regulatory requirements for successfully implementing these WSUD approaches; and.
- Providing the development sector with the evidence base that can be used to build more mainstream acceptance of the need to invest in these WSUD approaches

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Lochiel Park – Detailed Site Assessment

Overview

Lochiel Park is a small residential development on a 15 hectare site that is located 8 kilometres from the Adelaide CBD. The master-planned development was designed to showcase sustainable living for medium-density urban development (Edwards and Pocock, 2011). The development was first announced in 2004 when the Premier Mike Rann announced a vision for Lochiel Park to provide a nation leading green village. It was hoped that experiences and knowledge developed through the Lochiel Park development which would provide a nationally significant example of Ecologically Sustainable Development (ESD) to encourage adoption as a mainstream practice (Blaess, et al., 2007). The South Australian Land Management Cooperation (now part of Renewal SA) was tasked with delivering the vision for Lochiel Park to be a leading example of sustainable development. The development was planned to accommodate 106 medium density dwellings and is now largely developed.

Figure J-31. Lochiel Park streetscape

Renewal SA developed a Masterplan and Urban Design Guidelines to guide the development of Lochiel Park, and ensure that all services were aligned with sustainability principles including WSUD. Two main approaches were undertaken to deliver the overarching sustainability objectives for Lochiel Park which were: a) the development of community level infrastructure; and, b) the development of design guidelines for individual home (Berry, 2013). The community infrastructure initiatives were developed by expert consultants and formalised in the Development Masterplan. The Development Masterplan for Lochiel Park included the physical design and layout of the stormwater harvesting scheme. While, sustainability initiatives at the household level were developed in the Urban Design Guidelines, which communicated how sustainability principles and practices should be incorporated into each dwelling. The Lochiel Park set out the mandatory elements that needed to be included in the design of each home, and also the advised actions, which would assist in achieving the overall objective of reducing potable water demand by 80%.

Renewal SA has set the following sustainability objectives, relative to current Adelaide housing stock:

- Overall energy saving target of 66% reduction compared to the average for Adelaide households, and
- Potable water saving of 80% compared to the average for Adelaide households.

All houses were designed with a range of energy and water saving technologies in addition to the community level infrastructure specified by the Masterplan. This review focuses on assessment of the approaches implemented at Lochiel Park to achieve the potable water saving target.

To achieve the targeted water savings a range of initiatives were implemented, which included:

- Demand management;
- Rainwater tanks for hot water supply; and,
- The use of harvested stormwater and ASR for non-potable uses.

The WSUD elements at Lochiel Park, introduced above, are described in more detail in the following sections.

Description of Lochiel Park WSUD elements

Wetland and ASR Scheme

A consultant report identified that stormwater harvesting in wetlands with subsequent Aquifer Storage and Recovery (ASR) could be used to meet non-potable demands at Lochiel Park. Lochiel Park is located in a hydro-geological zone that contains: 3 Quaternary aquifers, 2 Tertiary aquifers and a deeper fractured bedrock aquifer. It was determined by desktop analysis that the fractured bedrock aquifer had the most potential for an ASR scheme (Australian Groundwater Technologies, 2006). Testing was undertaken to determine the likely extraction and injection capacity of the aquifer. It was found that well yield of 7 L/s was sustainable, which was the same as the maximum sustainable injection rate. This testing also found that the Recovery Efficiency (the volume of the extracted water which is suitable for the intended use, expressed as a % of the water injected) was 55% (Australian Groundwater Technologies, 2006).

The Southern Wetland at Lochiel Park (which has been used in the stormwater harvesting scheme) has an urban catchment of 189 hectares. Figure J-32 depicts approximate extent of this catchment relative to Lochiel Park. Prior to the development of the Lochiel Park stormwater harvesting scheme, runoff from this catchment was discharged, untreated to the River Torrens.

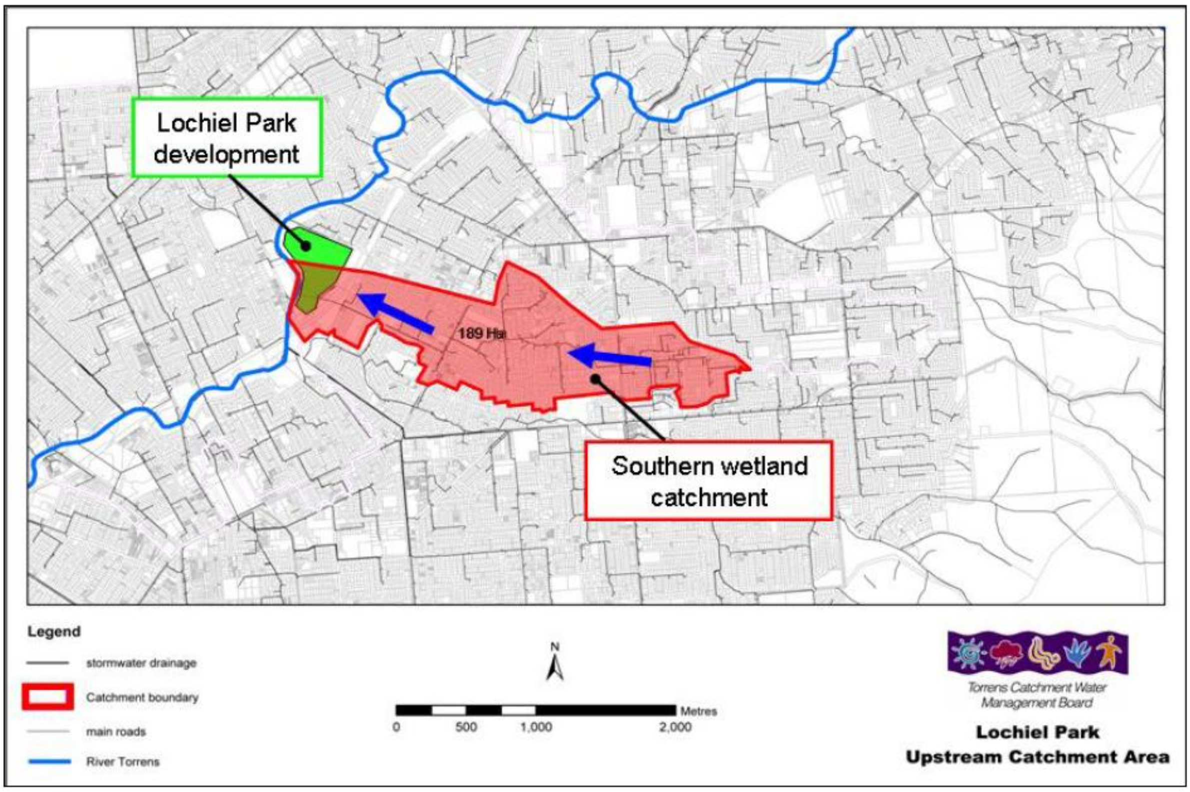

Figure J-32. Lochiel Park Wetland Catchment

Source: Ecological Engineering (2006a) p. 6.

The design of the wetland at Lochiel Park had the following objectives (Ecological Engineering, 2006a):

- Ensure the water from the wetland is of a suitable qualify for aquifer injection;
- Reduce pollutant loads to the River Torrens;
- Design diversion structure to maintain the existing peak pipe capacity (i.e. that is no increase in flood risk to properties in the catchment; and,

- Provide an attractive, accessible landscape feature.

The wetland was designed to reduce pollutant loads in stormwater by filtering through shallow vegetation and allowing sufficient residence time for sedimentation, and other chemical, physical and biological processes. Prior to entering the wetland stormwater runoff passes through a Gross Pollutant Trap (GPT) using a Continuous Deflective Separation (CDS) system. The GPT was designed to remove debris, sediment, and oil and grease prior to runoff reaching the wetland. There have been issues commissioning this GPT, which are described in subsequent sections.

The wetland was designed for a minimum of 3 days detention time prior to aquifer injection via the well. The diversion structure means that during high rainfall events stormwater flows can bypass the wetland system and be discharged directly to the River Torrens. The intake capacity of the GPT (0.8 m^3/s) corresponds to 3 month ARI flow from the catchment based on hydrological modelling (Ecological Engineering, 2006a). Runoff events above the 3 month ARI result in flows being diverted via a weir directly to the River Torrens by a stormwater drainage pipe.

The selection of plants in the wetland was designed to not attract waterbirds due to the potential for increased pollution due to waterbird activity. Figure J-33 shows the southern wetland at Lochiel Park where the selection of plant species mix and density was based on the likely hydrologic conditions in the wetland to ensure optimal treatment performance (Ecological Engineering, 2006a).

Figure J-33. Lochiel Park Southern Wetland

Modelling was undertaken to determine the likely impact of the wetland treatment and ASR harvesting scheme using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC, Version 3). The modelling used historical climate data (1980 – 1990) from the Adelaide Airport weather station, which had a mean annual rainfall of 436 mm for the time series modelled (Ecological Engineering, 2006a). The modelled improvements in water quality are shown in Table J-8.

Table J-8. Modelled impact of Lochiel Park Wetland and ASR scheme on water quality

	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Pollutant Loads from 189 ha urban catchment with no treatment (kg/yr)	60,400	127	915
Pollutant loads from 189 ha urban catchment with proposed treatment (kg/yr)	29,900	69	634
Reduction in pollutant loads (%)	50	46	35

Source: Ecological Engineering (2006a), pg. 25.

Prior to injection to the aquifer stormwater from the aquifer is treated by UV disinfection, and the water extracted from the aquifer is chlorinated prior to reticulation to houses and public open space irrigation. A 129 kL buffer tank is available to hold water from the wetland or aquifer; this tank can also be topped up by mains water supply if required.

The reticulated water from the ASR scheme is used to supply the following end use demands at Lochiel Park: toilet flushing, outdoor taps, cold water tap in the laundry, and irrigation for public open space.

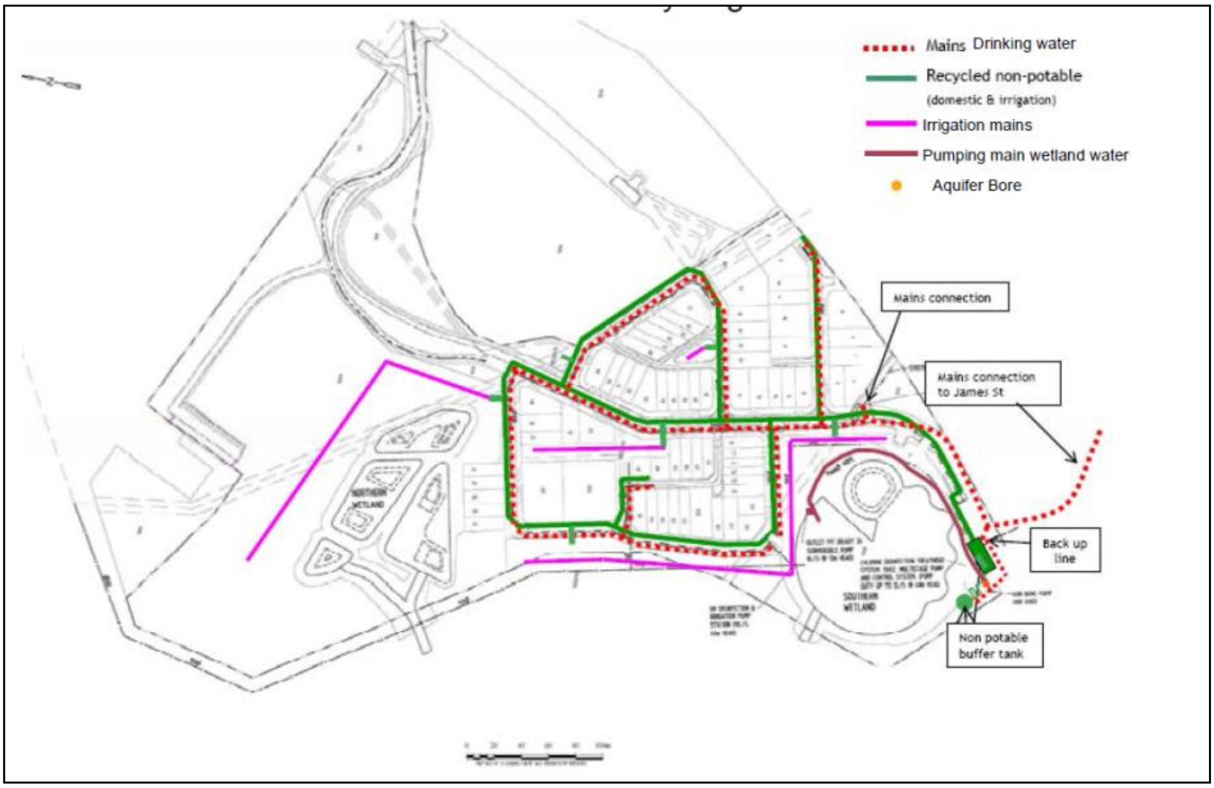

Figure J-34. Layout of reticulated water supply at Lochiel Park

Source: (Bishop, A. 2013, pers. comm., 11 June).

Bioretention pits and swales

Runoff from Lochiel Park is directed through streetscape bioretention systems. Bioretention pits and swales are used at Lochiel Park to both treat stormwater before it reaches the wetland, and also to provide a landscape feature. Figure J-35 provides a schematic of the bioretention pit design used at Lochiel Park, while Figure J-36 shows a bioretention pit at Lochiel Park. A total of 250 m^2 of bioretention systems was recommended by Ecological Engineering for the 4.25 ha of urban area at Lochiel Park.

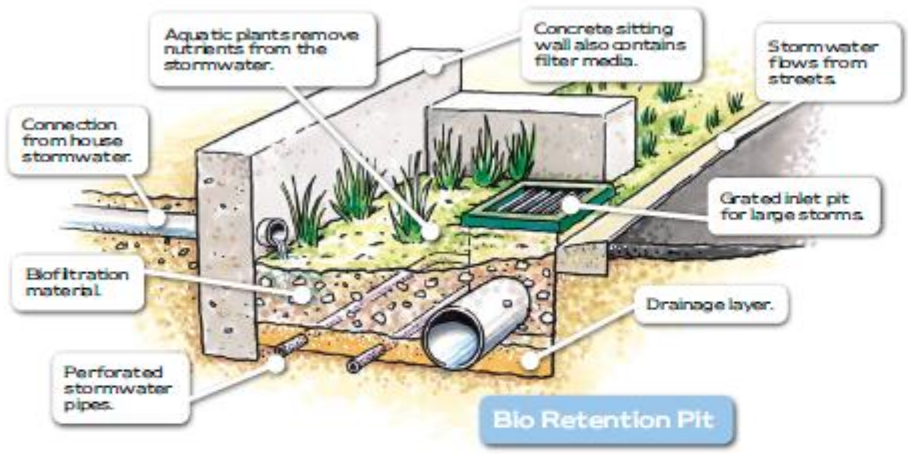

Figure J-35. Diagram of Bioretention Pit at Lochiel Park

Source: http://www.lochielpark.com.au/lochielpark/water.htm

Figure J-36. Lochiel Park streetscape with bioretention pit

Rainwater tanks for hot-water supply

Ecological Engineering (2006a) put forward the concept of using rainwater tanks for hot water demand. The presence of a recycled water scheme meant that under current legislation Lochiel Park residents were exempt from the requirement for a rainwater tank to be installed at new homes. However, it was decided to use rainwater tanks for the supply to hot water systems to maximise the total water savings and demonstrate both rainwater harvesting and the recycled water scheme.

All homes at Lochiel Park are required to have a minimum 1.5 kL rainwater tank connected to 80% of the roof area. The system supplies solar heated hot water services, which treat water to a minimum of 60 °C. Research has shown that pasteurisation through heating water between 55 and 65 °C kills bacteria. Spinks et al. (2006) demonstrated that heating harvested rainwater to a minimum of 60 °C was critical for the effective removal of enteric/pathogenic bacteria loads. Ecological Engineering (2006b) undertook a modelling study determine the optimal configuration of rainwater systems at Lochiel Park. Demand for the modelling was based on 2.3 persons per dwelling, while it was assumed that 80% of the roof area (120 – 200 m^2). This modelling found that demand for the hot water system could be supplied two thirds of the time from the rainwater tank, with remaining water supplied from mains drinking water supply.

The Urban Design Guidelines for Lochiel Park (Land Management Cooperation, 2009) provides the specifications for the installation of rainwater tanks. This includes a number of controls to manage the risks of contamination of rainwater tank water. Controls include: roof material selection, guttering and screening to reduce solid matter entering tanks, first flush devices, pump and controller for top-up with mains water, and backflow prevention. .

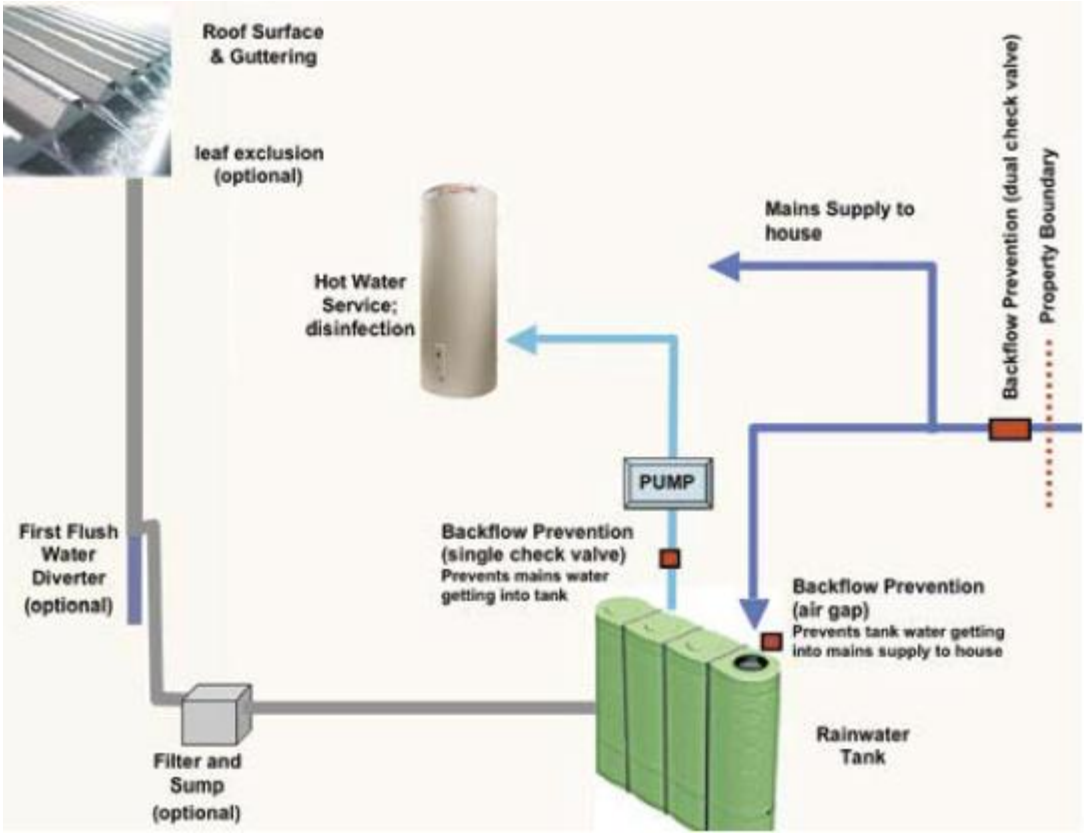

Figure J-37. Schematic of rainwater system at Lochiel Park

Source: Land Management Cooperation (2009) pg. 17.

Demand Management

The Urban Design Guidelines for Lochiel Park (Land Management Cooperation, 2009) specifies the minimum water efficiency for fittings and installed appliances. The Guidelines use the Australian Government Water Efficiency and Labelling Scheme (WELS), which can be seen at: http://www.waterrating.gov.au/. Under this scheme all homes at Lochiel Park must have a 4 star toilet, 3 star showerhead, and 4 star dishwasher where one is installed.

In addition to water efficient appliances and fittings, Lochiel Park homes have been fitted with Ecovision monitors that allow for real time monitoring of household energy and water consumption (Edwards and Pocock, 2011). It is envisaged that these monitors will lead to more sustainable use of water and energy, as the feedback from the system on consumption patterns will influence their behaviour. Interviews with those residents who have an Ecovision monitor showed that they found it easy to use. Also, 80% of the residents interviewed said that they checked their Ecovision monitor at least once per day (Edwards and Pocock, 2011). However, the long-term impact of these monitors on changing residents' behaviour at Lochiel Park to conserve water is not yet known. Willis et al. (2010) did find that visual display monitors with real time water demand data did reduce the household water demand. For example, households with water consumption monitors on average reduced their shower event volume by 27%.

Evaluation

Carrard et al. (2008) undertook a cost benefit analysis of the sustainability initiatives that were implemented at Lochiel Park. Carrard et al. (2008) developed a methodology for undertaking a Cost Benefit Analysis (CBA) that considered multiple perspectives. The justification for this approach was that Lochiel Park has a range of public and private agencies that have a stake in the investment and returns from the development, while in addition there is the need to include residents and the broader community. This study found that residents would use on average 75% less mains potable water supply than an average Adelaide household. This was mostly as a result of replacing mains water with recycled stormwater for all non-potable uses. Also, the water bills for Lochiel Park residents are expected to be around 40% lower than the average for Adelaide homes, which was mostly attributed to demand management strategies, such as water efficient fittings and appliances.

Carrard et al. (2008) also undertook a cost effectiveness analysis of the Lochiel Park water initiatives (Figure J-38). The analysis found that demand management strategies, such as water efficient appliances, were the most cost effective costing only $0.15 per kL of mains water saved. The rainwater tanks for meeting hot water demand were relatively expensive at $18/KL. The cost of stormwater recycling unit was estimated at $6/kL of mains water saved, however this would rise significantly if the scheme was not used for park and open space irrigation. The analysis showed that demand management was the most cost effective option for reducing mains water use. However, the target of an 80% reduction in mains water use compared to the average Adelaide household could not be met with demand management alone. Therefore, the reduction in mains water use due to the stormwater harvesting is also important, and it must be recognised the additional benefits this scheme can deliver including the treatment of runoff through constructed wetlands (Carrard et al. 2008).

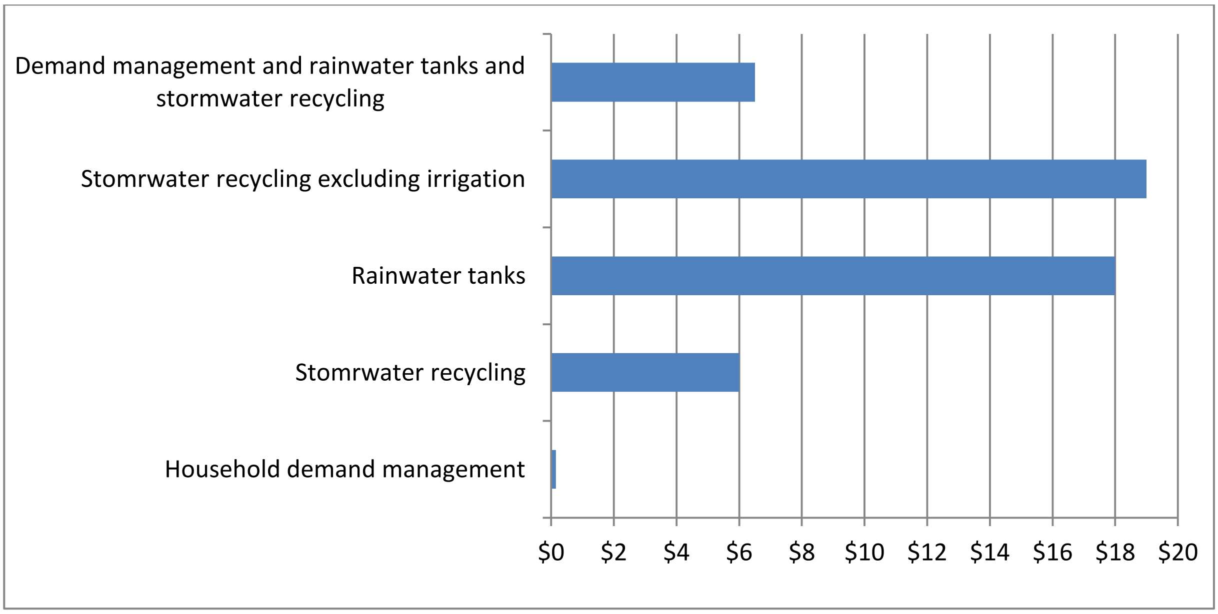

Figure J-38. Cost effectiveness of mains water savings initiatives at Lochiel Park

Source: Carrard et al. (2008)

Implementation

The research team met with the key organisations involved in the delivery and management of WSUD elements at Lochiel Park (see below for description of organisation's role in the development). The research team also visited the Lochiel Park development, where a Renewal SA officer guided them through the key features of the site, and experiences gained through the implementation.

A critical problem faced in the delivery of WSUD at Lochiel Park has been the defective installation of the GPT. The contractor responsible for the installation of the GPT did not align the inlet pipe correctly, which is critical for the effective functioning of the CDS system. This problem has meant that Campbelltown City Council have not assumed responsibility for the GPT as anticipated, as this will only occur once they are satisfied the system is operating to specification. The malfunctioning GPT has also meant that water is not yet being harvested from the wetland system for ASR, which means the non-potable reticulation network is using mains drinking at present. Considerable effort is being spent now to rectify the GPT but the delay in the system could be as much as 12 months. Those involved in the design of the system attributed the problems to poor coordination among the different organisations involved in the design and construction phases of the project. Effective project management was complicated by the range of consultancies that were assigned to delivering the WSUD elements. There may be the need for an overseeing organisation that can coordinate input from different consultancies to ensure the design intent is realised in the construction.

The aquifer being used for the ASR is a fractured rock and there is still some uncertainty on the fate of water injected. Also, there is some concern on the salinity of the groundwater, with testing showing that salinity was around 1,000 mg/L. For both these reasons only around 40 - 55% of the water injected into the aquifer will be recovered. The community has expressed some concerns regarding the impact of the ASR scheme on the aquifer. Approval from the EPA was required prior to injection of water from the wetland to the aquifer. The Department of Health was responsible for providing approvals for the reticulation of treated water to households. There were initially some concerns with the scheme due to the risk of pesticide and insecticide contamination of stormwater in the urban catchment. However, approval was granted for the scheme with monitoring controls.

Costs

The capital costs associated with constructing WSUD elements at Lochiel Park were provided by Renewal SA. The bioretention pit systems cost a total of \$113,000 for 26 pits, which is around \$4,300 per pit (Bishop, A. 2013, pers. comm., 11 June). Around 45% of this cost was associated with the construction of concrete walls, while another 30% of the cost was for the grated inlet pits. The bioretention swales had a capital cost of \$38,000, with the most significant cost items being for the supply and fill of drainage and filter material (44% of the cost). The landscaping with 'instant' turf following construction of bioretention swales was also a notable cost (18%). The costs provided by Renewal SA only covered capital costs, as the systems have only recently been commissioned. However, it is also useful to consider the ongoing operating and maintenance costs of these WSUD features. It was found in discussions with local government representatives in South Australia that uncertainly in these costs can lead to reluctance for local government to assume responsibility for the management of WSUD features.

South East Queensland Healthy Waterways Partnership (2007) developed recommendations for the frequency of inspections and regular maintenance of WSUD features. The recommended frequency for bioretention systems and wetlands (in a temperate climate) was 3 months, which excludes mowing for grassed swales. Water by Design (2010) based on case studies provided estimates on maintenance costs for WSUD features. This indicated that for bioretention systems for the first 2 years of operation the annual maintenance cost would \$15/m^2, which subsequently reduces to \$5/m^2/year as the system becomes established. This means that for the 250 m2 of bioretention systems at Lochiel Park the ongoing maintenance costs would be \$1,250 once the systems are established. While for a detention storage, such as the Southern Wetland at Lochiel Park, the estimated maintenance cost is \$2.5/m^3/year (Water by Design, 2010). Based on this estimate the annual maintenance cost for the 1 hectare (0.5 m average depth) Southern Wetland macrophyte zone would be approximately \$12,500. However, these generic costs are only an estimate of the maintenance costs for WSUD elements at Lochiel Park. The actual costs will be influenced by factors specific to the Lochiel Park development.

Table J-9. Capital costs for Lochiel Park Wetland and ASR scheme

Cost item	Cost
Wetland and GPT (portion attributed to recycled water scheme)	$210,661
Reticulation system (dual/lilac pipe network)	$135,375
Total ASR bore drilling incl. Testing	$109,067
Recycled water system headworks (estimate)	$1,074,000
Total Capital Costs	$1,529,103

Source: (Bishop, A. 2013, pers. comm., 11 June).

The Lochiel Park scheme led to a change of the cost structure for recycled water relative to mains drinking water. Previously, recycled water had been charged at 75% of the tier 2 water use charge for mains water ($2.58 at 2012/13 prices). However, now recycled water will be charged at 90% of the tier 1 water use charge for mains water ($2.17 at 2012/13 prices). The previous charge was seen as a disincentive for the adoption of recycled water, as household using less than 328 litres per day were previously paying more for recycled water than mains drinking water (Caica, 2012). Renewal SA petitioned for this change with SA Water based on the experiences at Lochiel Park.

Stakeholders and WSUD management

The following summarises the main organisations that have had a stake in the design and installation of WSUD elements at Lochiel Park, and also the ongoing maintenance of these elements:

- Renewal SA (Formerly: Land Management Cooperation) – Developer and interim manager of the development
- Campbelltown City Council – Responsible local government who will assume responsibility for streetscape WSUD features
- Ecological Engineering – Conceptual design OF WSUD elements
- Design Flow – Functional design of WSUD elements
- SA Water - manages the stormwater wetland, ASR and the supply of treated non-potable water in addition to conventional mains water supply and wastewater services
- Rossdale Homes – Builder
- Charterhouse by Hickinbotham Homes– Builder
- Institute for Sustainable Futures (University of Technology Sydney) - Undertook cost benefit analysis of sustainability initiatives
- University of South Australia - Ongoing monitoring and validation of the performance of water and energy initiatives at Lochiel Park.

Community involvement

A qualitative research project was undertaken with residents of Lochiel Park, or those people who planned to become residents shortly (Edwards and Pocock, 2011). The focus of this research was to determine the factors that influenced household 'green' behaviours, and if moving to Lochiel Park had shaped these behaviours in any way. This research found that 75% of residents moved to Lochiel Park as they wanted to live more sustainably. This demonstrates that the sustainability initiatives, including the WSUD elements, were a major drawcard for residents. Another important driver for residents moving to Lochiel Park was the location, as residents were attracted by the proximity to the city and the aesthetic appeal of the surrounding area. This indicates that sustainability initiatives alone might not be enough to attract new residents, as locality will also influence if people think the area aligns with their needs (Edwards and Pocock, 2011).

Renewal SA placed considerable effort in facilitating the development of a cohesive community, which included: urban design to encourage interaction through medium density dwellings and public open space, and community website and community-based groups (Edwards and Pocock, 2011). The research found that sustainability help to develop a sense of community at Lochiel Park, as residents came to terms with the unconventional systems (Edwards and Pocock, 2011).

Monitoring and Evaluation

A unique feature of Lochiel Park, when compared to other urban developments that are designed with WSUD approaches is that at Lochiel Park there will be a focus on ongoing monitoring and evaluation to determine the in situ performance. The comparison of actual performance in the field with that of estimated during conceptual design will provide a valuable knowledge base with which to refine future design and guidelines for WSUD implementation.

Berry (2013) highlighted that the experience gained through the Lochiel Park sustainability initiatives will enable many organisations to gain a more detailed and practical understanding of how sustainable urban development can be implemented, which will provide the confidence to change industry practices, government policies and regulatory standards. The monitoring and dissemination of experiences with a leading-edge example of WSUD development, such as has been provided at Lochiel Park, can enable niche innovations that eventually lead to broader change and a socio-technical transition in mainstream practice (Berry, 2013).

Opportunities and Benefits

The purpose behind Lochiel Park was to provide a nation leading example of sustainable development. Therefore the development set ambitious objectives for sustainability performance relative to average households in Adelaide, which included the 80% reduction in mains water use. The approach taken to WSUD has incorporated a range of leading edge approaches, such as the use of rainwater tanks for hot water supply. The demonstration of WSUD approaches and the ongoing monitoring (e.g. 50 rainwater tanks being monitored for flows and energy) is providing opportunity to test modelled performance against actual performance. There are a range of detailed research projects underway that are investigating the actual performance of the WSUD systems, including demand characteristics and energy requirements. Garnaut (2008) highlighted that a development such as Lochiel Park provide leadership and to the development and construction industries on practical ways to deliver more ecologically sustainable developments. Also, Lochiel Park will provide an incubator for research that can assist in setting targets and guidelines for WSUD development, which will move urban development in South Australia beyond a business as usual approach (Garnaut, 2008).

Impediments and opportunities

Berry (2013) reported on semi-structured interviews that were undertaken with a number of industry experts, policy makers and members of the Lochiel Park community. The focus of the interviews was to ascertain the barriers to the achievement of sustainability initiatives at Lochiel Park, including WSUD elements. The following points highlight some of the barriers for innovation in sustainable development at Lochiel Park that were identified in these interviews.

- The allocation of costs was seen as an economic barrier. WSUD initiatives at Lochiel Park are aligned with wider government policy objectives, yet full costs of implementation were assigned to the project and not to the agencies implementing the polices. Berry (2013) made the point that the stormwater recycling scheme provides benefits to the City of Campbelltown and the users of the Rover Torrens but all costs were allocated to Lochiel Park, which are ultimately passed on to home buyers.
- Another barrier noted by interviewees was that for the consistent achievement of water saving targets there is the need for feedback between households and technologies. It was believed that low levels of technology literacy may limit the potential of in-home monitors to change water consumption behaviour.

Garnaut (2008) noted that sustainability initiatives, such as the WSUD approaches demonstrated at Lochiel Park, are expensive due to the fact that water prices are too low to limit consumption and externalities are not considered.

Problems with the commissioning of the recycled water scheme due to the faulty installation of the GPT highlight the need for further capacity building. There is the need to develop the capacity of organisations to manage the design and installation of WSUD features, as often there are often many organisation involved in delivering different aspects of a WSUD scheme such as Lochiel Park.

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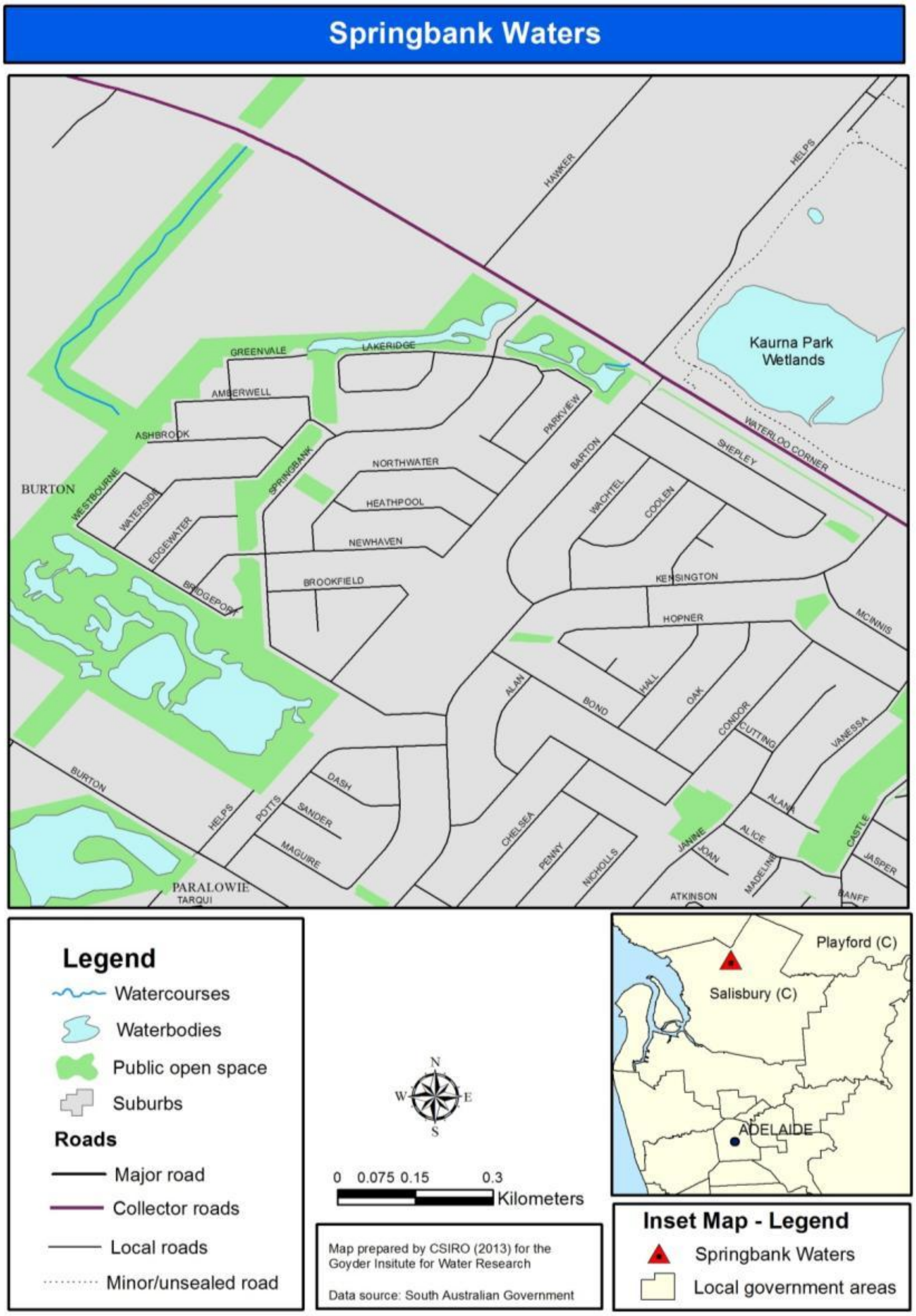
Springbank Waters – Detailed Site Assessment



Overview

The Springbank Waters residential development is located in the northern Adelaide suburb of Burton. The greenfield development is part of Adelaide's northern growth corridor in the City of Salisbury. Springbank Waters (SW) was developed in 2007 and is now largely completed. The development is predominately separate homes on large lots (circa 600 m^2), with around 407 lots. The nearby Edinburgh RAAF weather station has an annual average rainfall of 432 mm compared to the 547 mm annual average rainfall recorded for Kent Town, which is close to the Adelaide CBD (BoM, 2013).

SW was developed as a joint venture between AV Jennings and Opthummell with a number of investors including Defence Housing Australia. The public open space that surrounds the development, including wetlands, is administered by the Salisbury Council.

Background

The City of Salisbury covers an area that extends from the foothills of the Mount Lofty ranges to the flat plains that meet the Gulf of Saint Vincent. The flat coastal plain, prior to European settlement, was marshy and poorly drained. The City of Salisbury created stormwater detention basins in the 1970s to help control flood waters (Haines, 2009). The stormwater basins were also designed to create a native habitat for bird species and an area for passive recreation. Runoff from the City of Salisbury drains to Barker Inlet, which is an ecologically sensitive area, with the estuarine mangrove swamps providing an important habitat and breeding ground for many marine species. In the 1990s there was a growing awareness of the environmental impact that pollution from runoff was having on Barker Inlet (Haines, 2009). Investigations into the ways this environmental impact could be mitigated found that the stormwater detention ponds also provided for efficient reduction of pollutant load (Haines, 2009). There were also concerns at the City of Salisbury about the availability and costs of irrigation water, which led to interest in harvesting stormwater (Haines, 2009).

The first trial of stormwater harvesting from the Salisbury Wetlands using was aquifer storage and recovery was undertaken at the *Paddocks* wetland in 1994 (Haines, 2009). This trial was successful as it demonstrated that the aquifer could be used to store water that could be extracted for reuse during drier months when irrigation demand peaked. The storage and reuse of water in the aquifer also provided benefits in reducing discharge of stormwater to the Gulf.

The overall capital investment in City of Salisbury stormwater harvesting scheme is shown in Figure J-39. This shows that a majority of the funding for capital investment has come from Government funding, which in the case of State Government investment has mostly been through its land development agency, while Commonwealth funding has been through program such as the *National Water Security Plan for Cities and Towns* and the *Water for the Future* program.

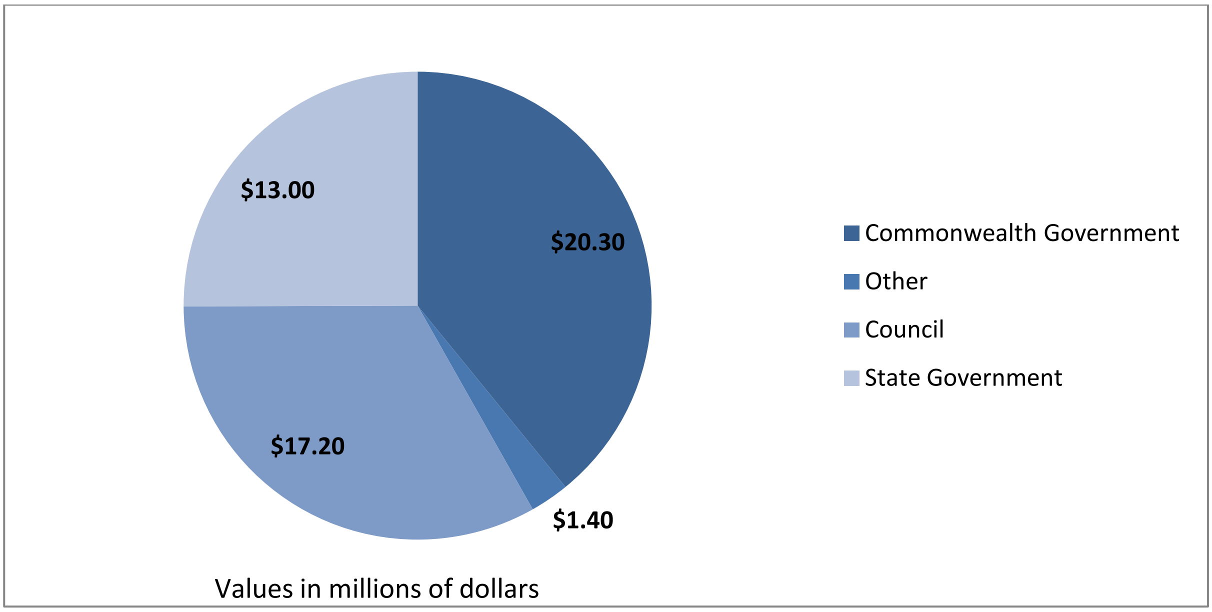


Figure J-39. Capital investment in City of Salisbury Stormwater Harvesting Scheme (as of 2009)

Source: Haines (2009).

Description of WSUD elements

SW is located near the Kaurna Wetland, which forms part of the City of Salisbury stormwater harvesting scheme. Specifically, the Kaurna Wetland is part of the Helps Road Urban Stormwater Harvesting System. This system is a component of the Integrated Water Cycle Management Plan for the City of Salisbury, which includes the Salisbury Stormwater Harvesting Project. This project was initiated to deliver both environmental improvements and to provide a sustainable source of recycled water for non-potable uses in the community.

The WSUD features at SW were designed to achieve the following objectives:

- Reduce dependence on mains water;
- Enhance the amenity of public open space;
- Reduce the downstream environmental impact of stormwater discharge; and,
- Provide opportunity for increased harvesting of water for the Salisbury Stormwater Harvesting (SSH) Project.

The constructed wetlands, which are part of the stormwater harvesting scheme, also provide a way for the City of Salisbury to manage and improve water quality and establish natural ecosystems to enhance biodiversity. Native birds, lizards, frogs and fish have been found to inhabit the wetlands (City of Salisbury, 2013). Within the City of Salisbury there is a system of more than 50 constructed wetlands that assist in treating stormwater prior to reuse or discharge to sensitive receiving environments such as the Barker Inlet.

Treatment features of the Salisbury wetlands include:

- Gross pollutant traps and trash racks, which remove large floating debris and some sediments;
- Sedimentation or detention ponds, which slow the water down to allow the sedimentation;
- Reed beds, to filter slow moving water; and,
- Weirs, and flow and diversion structures, which respectively are used to control the level of water in different parts of the wetland and to regulate inflows.

The City of Salisbury constructed wetlands also enable other natural processes to improve water quality, such as solar radiation and oxidation of pathogens, flocculation of heavy metals and sediments, and filtration of suspended particles by aquatic vegetation.

Stormwater is harvested and treated using a standard Aquifer Storage and Recovery (ASR) practices. The harvested stormwater for SW comes from the Kaurna Wetlands ASR scheme (Figure J-41), which is located to the north east of the Springbank Waters development. The wetland has a storage capacity of 52 ML and helps to detain stormwater to improve quality and reduce flooding risk. Harvested stormwater is pumped to the aquifer during the wetter months and then extracted during the warmer, drier months to meet irrigation demand for local parkland and grounds of the school. The stormwater is reticulated through a purple pipe network but there are no service connections to individual households. Runoff from the SW development is managed with a mix of traditional stormwater pits and pipes, and also vegetated open swales.

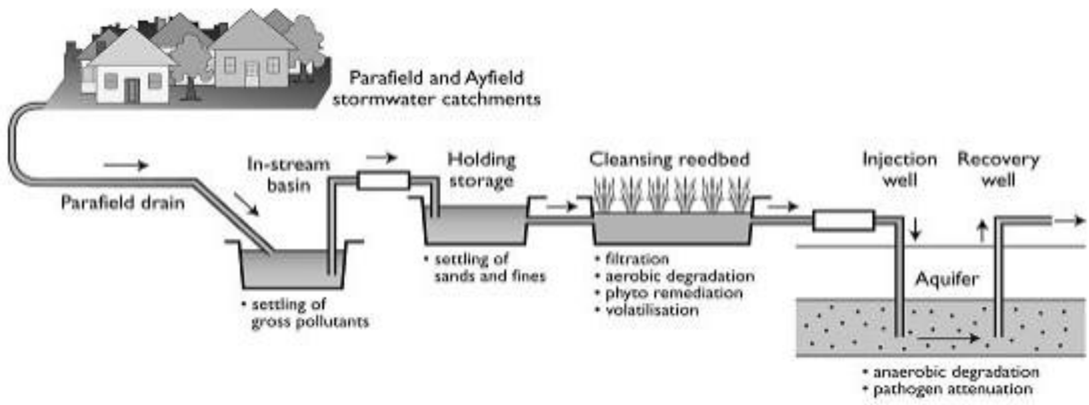


Figure J-40. Aquifer Storage and Recovery

Source: City of Salisbury (2013)

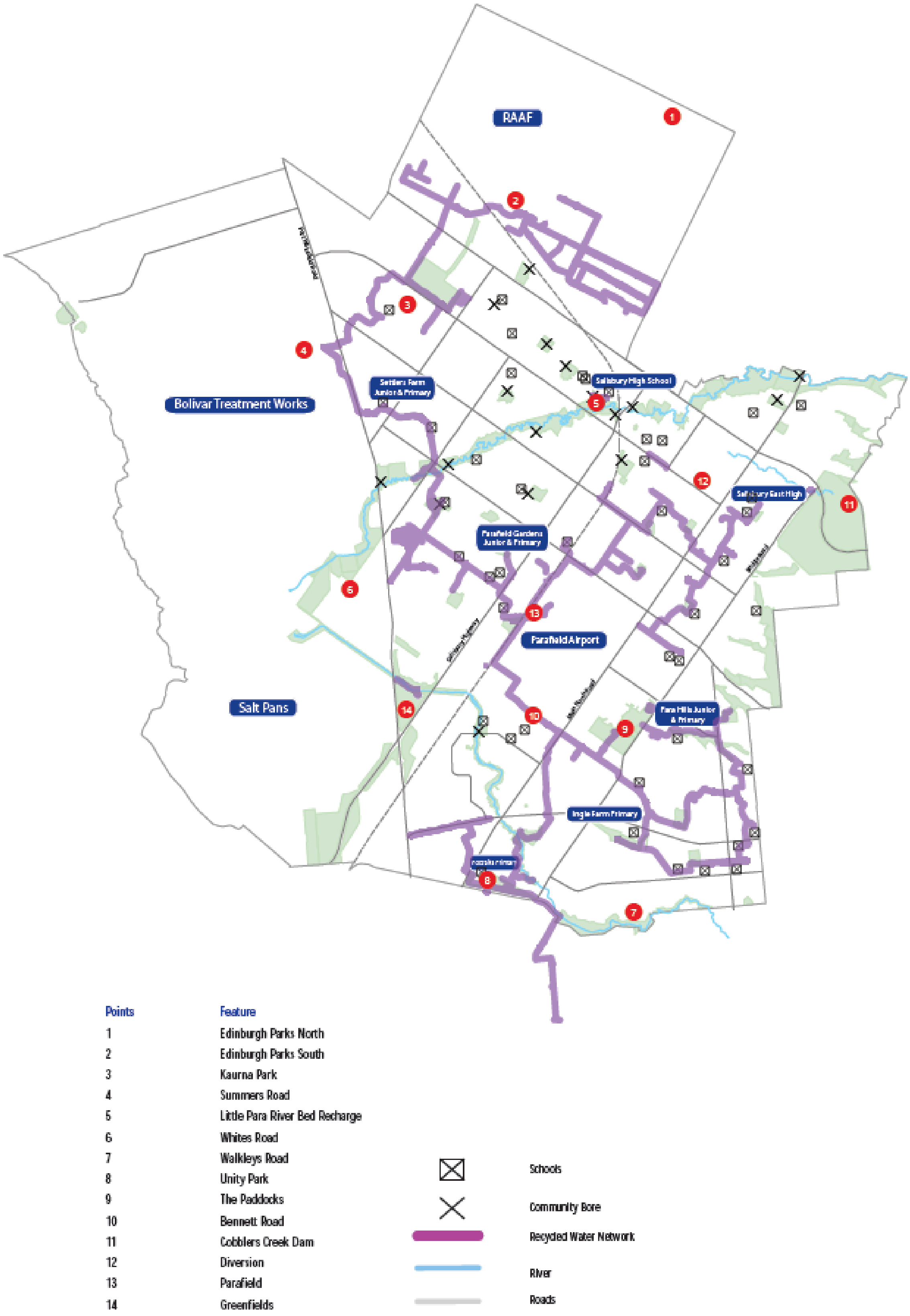


Figure J-41. City of Salisbury Stormwater Harvesting and ASR Projects

Thomas et al. (2007) developed a simulation tool to assist management of the Salisbury stormwater harvesting scheme. The conceptual model of the Help Road Drain, which includes Kaurna Park, is shown in Figure J-42. In the model it was assumed that stormwater runoff from the urban catchment is diverted to the first dam via a weir in sequence. Once this dam is full the dam spills over the levee bank to the next dam. The simulation of this tool was able to highlight periods where demand outstripped supply. Simulation tools such as the one described by Thomas et al. (2007) may be useful in assisting managers gain insight to the implications of different configurations, demand patterns and runoff on the system reliability. However, the application of such tools is limited without the input of monitoring data from the system to be simulated. The monitoring data can assist in calibrating and adjusting model parameters to more realistically simulate system performance.

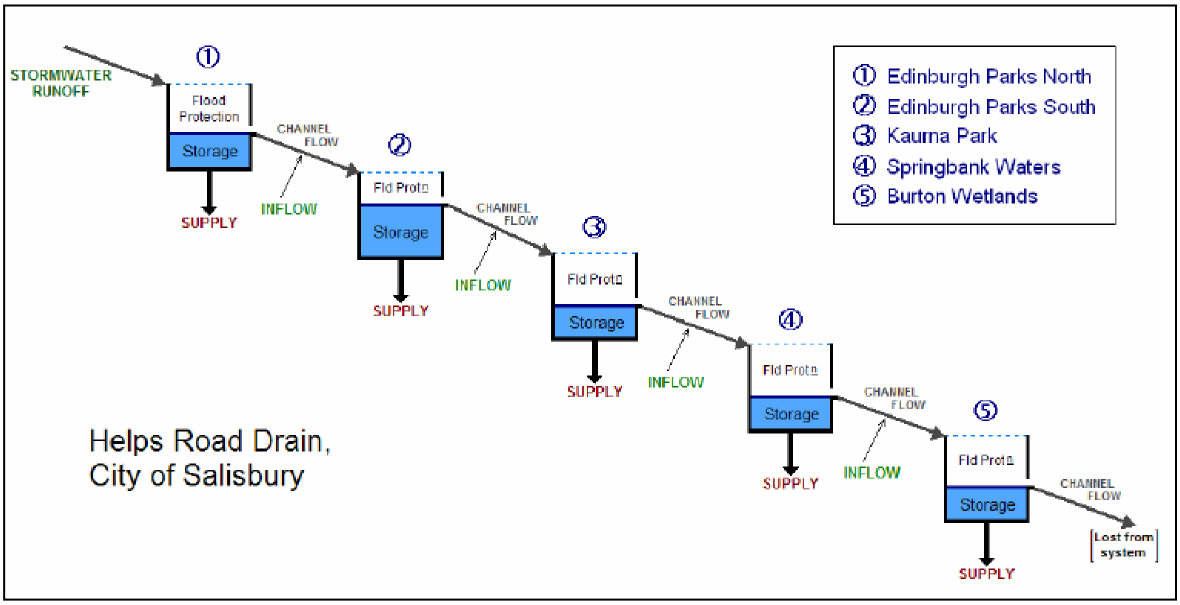


Figure J-42. Schematic of Help Road Drain stormwater harvesting system

Source: Thomas et al. (2007)

Stakeholders and WSUD management

The WSUD features at SW are managed by the City of Salisbury. The City of Salisbury established Salisbury Water, as a business arm of the council to manage and operate recycled water schemes throughout the Council area. Salisbury Water is governed by the Salisbury Water Management Advisory Board. The Advisory Board is made up of two external independent experts and senior members of the Council. Some of the issues that are handled by the Advisory Board include: setting the strategic direction for Salisbury Water, consideration of legal and regulatory issues, community considerations, capital investment, performance against indicators, setting of price and reporting to Council Executive. The price for water supplied by Salisbury Water is $2.48 per kilolitre (current as of 1 July 2012), which is nearly $1 cheaper per kilolitre than mains drinking water. Both internal (or Council) customers and external customers are charged the same rate for recycled water supply. Residential customers are also charged a $12.50 connection charge per quarter.

The business unit for the Salisbury stormwater harvesting scheme was established to separate out the capital and operational costs associated with the production and distribution of recycled water from more general Council functions of drainage and flood risk mitigation. This was to avoid cross-subsidisation that could occur between normal council operations (e.g. flood management) and the retailing of recycled water where the price of water needs to reflect the costs of supply.

Figure J-43. Inlet to water pond at Springbank Waters

Community involvement

Community focus groups undertaken at SW revealed householders' perceptions of the WSUD features. Local residents viewed the lack of a third pipe reticulation system as a limitation, as there is no opportunity to access non-potable water for household uses such as toilet flushing and garden irrigation. The residents also felt that the maintenance of the WSUD features was important, and that there was the need to ensure that maintenance was kept up so that the appearance and function of the WSUD features does not degrade over time.

WSUD performance

Figure J-44 shows the breakdown of how water harvested from the Kaurna Park ASR system is used. Email correspondence with the City of Salisbury indicated that the water levels in the SW lakes are kept topped up during drier months with runoff from a nearby plant nursery. This plant nursery uses around 105 ML per year of recycled water, and 50% of the supplied water drains from the nursery to the lakes at SW. The supply of nursery runoff to the SW lakes prevents the need to directly provide top-up to the lakes during the drier months. The potential drying of the lakes during summer can be viewed unfavourably by the local community due to perceived loss of landscape amenity and odour issues. There was only once occurrence, during a particularly dry period, when around 20 ML of water from the ASR system was pumped directly into the lakes to prevent them drying out.

It was noted in discussion with the City of Salisbury that wetlands that *are* allowed to naturally dry out over summer months do not have problems with meeting EPA water quality guidelines for aquifer recharge during winter harvest. However, there was a perception that amenity lakes that have water levels maintained during summer months are more likely to have issues with pest species such as carp and weeds, high turbidity and algal blooms. Also, it was thought that odour issues are more likely when artificial ponds are infrequently drained for maintenance compared to ephemeral wetlands that seasonally dry out.

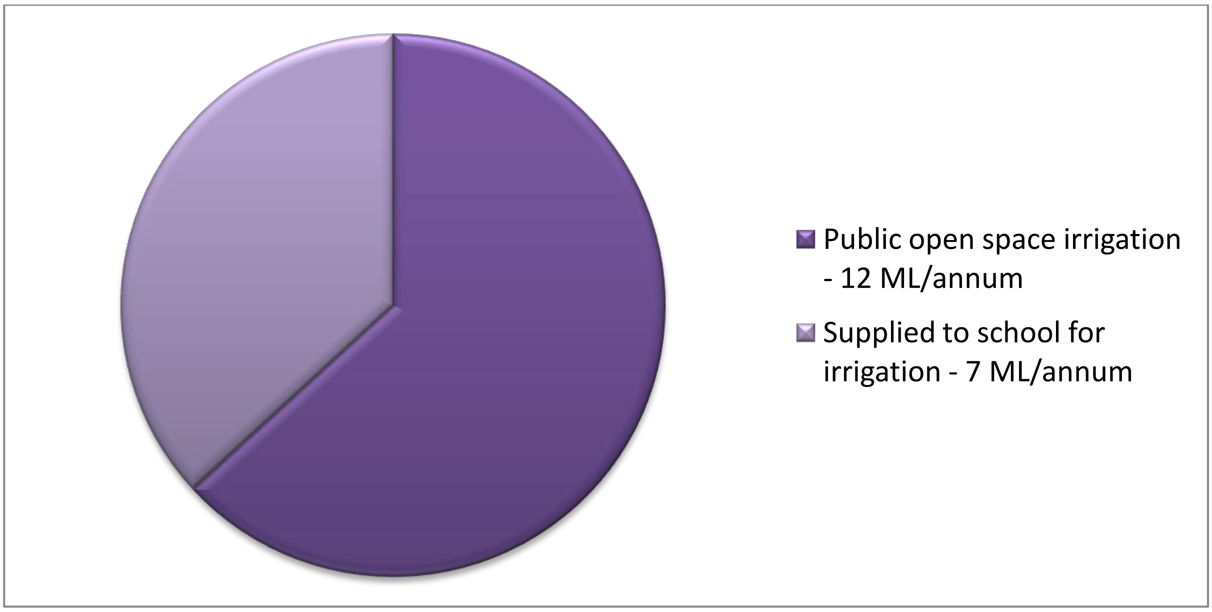


Figure J-44. Use of harvested stormwater water from ASR system

It was noted in discussion with officers from the City of Salisbury that there had been issues with commissioning of the system at SW. In particular, the water entering the main pond has had no pre-treatment and can have a significant sediment load. The slowing of the water as it enters the pond area results in sediments dropping out. While this provides a useful function in reducing sediments in downstream flows it does require regular draining and dredging to remove the sediment build up. The proximity of this pond to residences can lead to complaints due to the perceived odour and unsightliness of routine de-silting of the pond.

An objective of the Salisbury Stormwater Harvesting scheme was to mitigate the impact of runoff on Barker Inlet. While it is difficult to directly attribute the impact of the harvesting scheme on the ecological health of the Inlet the scheme does reduce stormwater discharged by around 6 GL per year.

The Summary and implications

Impediments and opportunities

The Salisbury City Council has implemented a large number of stormwater harvesting projects. The Salisbury Stormwater Harvesting System was made possible by the land availability and the need for drainage system to be constructed to manage flood risk. It was found that the directing urban stormwater to wetlands not only mitigated flood risk but improved water quality. The suitability of the underlying aquifer for ASR meant that it was possible to inject harvested stormwater during the wetter months, which could then be recovered during drier months to meet peak irrigation demand. The potential for this type of WSUD scheme to be adopted more broadly in South Australia would be limited in areas that don't have large areas of land available. The interviews with Salisbury Council revealed a reluctance to invest in small scale stormwater harvesting systems. This was due to perceptions of poor economies of scale in terms of the cost of building and maintaining the system relative to the value of the stormwater yield from a small scale system.

Discussions with Salisbury Water also revealed there have been some problems with maintenance costs associated with the regular removal of sediments in the wetlands and ponds. The management of the wetland has been impeded due to difficulties in securing the operational budget needed to regularly de-slit the ponds. While, securing the capital investment needed for the scheme was often made possible by the availability Federal and State government funding programs there is less certainty in how to secure the significant operational budget needed to adequately maintain the systems.

There is also community and political pressure to maintain water levels in ponds and wetlands that would naturally dry up during the drier months. It is thought that not letting the ponds dry out can result in water quality issues due to wetlands turning anoxic and the proliferation of pest species such as carp. This issue highlights the tension when WSUD systems are managed for what can be competing objectives, which in the case of SW included landscape amenity, water harvesting, flood mitigation and improvement in the quality of runoff.

The use of harvested water from the ASR scheme at SW is limited to the irrigation of the school and public open space, with no reticulated supply to households for non-potable uses. SW was developed prior to legislation required developers to provide an alternative water source, with individual rainwater tanks being the most commonly adopted source. However, it's likely for a development proximal to a recycled water scheme that non-potable reticulation network may be more economical for a developer than installing a rainwater tank system at each household.

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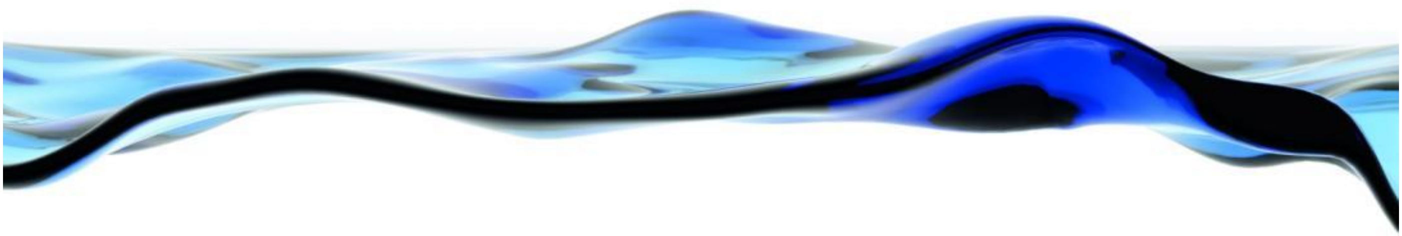

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