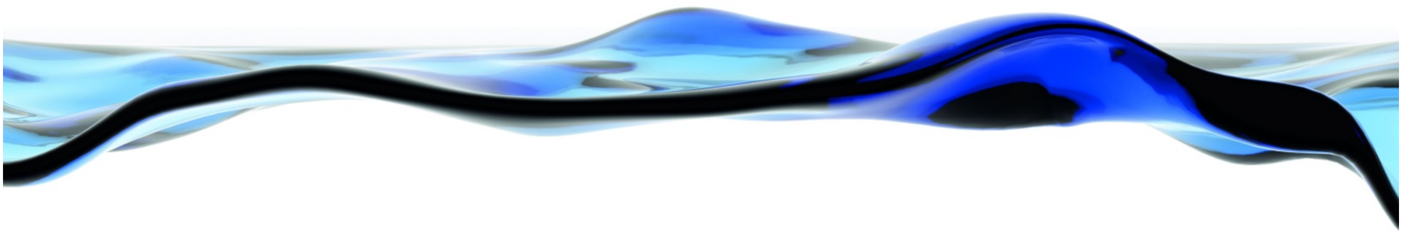
The Status of Water Sensitive Urban Design Schemes in South Australia

Myers B., Chacko P., Tjandraatmadja G., Cook S., Umapathi S., Pezzaniti D., Sharma A.K.



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Enquires should be addressed to: Goyder Institute for Water Research
Level 1, Torrens Building
220 Victoria Square, Adelaide, SA, 5000
tel: 08-8303 8952
e-mail: enquiries@goyderinstitute.org

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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, aims to identify and address the factors impeding water sensitive urban design (WSUD) uptake in South Australia. The outputs will identify the benefits of WSUD, and the opportunities and strategies that can be used to encourage the adoption of WSUD as a cost effective mainstream practice in the urban development sector.

This document summarises the status of WSUD in South Australia as per December 2012. This was achieved by: (a) Developing an inventory of existing and planned WSUD sites across South Australia; (b) an analysis of the literature and legislation relevant to WSUD in South Australia; and (c) an evaluation of the drivers and barriers for WSUD based on the experiences of local government WSUD practitioners across 23 local government areas.

To identify WSUD sites for the inventory, a thorough literature review was undertaken in addition to a process of stakeholder interviews which for the present have largely concentrated on local government representatives. At the time of preparing this report, 176 sites with WSUD features were identified by this procedure. Whilst the inventory covers the whole of SA, the majority of WSUD sites were located in the Greater Adelaide region and only 7 of the sites were located beyond those boundaries. The process of identifying WSUD sites will continue with further literature review and interviews, and an updated inventory will be provided with the final report. It is important to acknowledge that the catchment area managed by the WSUD systems may influence the number of individual devices implemented. For example, the implementation of large scale “end of pipe” WSUD systems in some areas (such as constructed wetlands for treatment and harvesting) may discourage the implementation of small scale systems upstream. This may have had an impact on the number of WSUD devices in South Australia.

The inventory of WSUD sites showed that the uptake of WSUD in South Australia has historically been characterised by the predominance of stormwater management features implemented by local councils. Flow management is one of the primary drivers for WSUD uptake in councils, with WSUD elements designed to control flooding and reduce peak flows. The trends in urban form for increased dwelling density, with associated increases in impervious surfaces, means source control of runoff will continue to be a key driver for WSUD adoption.

In addition to flow management, WSUD has been adopted to achieve multiple direct benefits such as producing alternative water resources (to reduce drinking water demand) and stormwater quality improvement. WSUD also offers indirect benefits such as reduced costs for providing urban water services by alleviating capacity constraints on centralised infrastructure, and enhancing public open space for recreational and environmental benefits. The adoption of harvesting type WSUD measures in South Australia has been influenced by exposed limitations on the mains water supply system. In addition the need to reduce the environmental impact of urban development on receiving waterways and coastal waters was identified as a significant driver for WSUD adoption in South Australia.

Interviews conducted with practitioners so far have also revealed that the configuration of WSUD features is site specific, as the design of WSUD elements is influenced by multiple factors, including (i) physical constraints, such as restrictions on the availability of open space and physical conditions (suitable geology, slope); (ii) the technical capacity and expertise of proponents and (iii) policies (either council policy or policy support).

Information gathered when compiling the inventory of WSUD measures showed that WSUD uptake has been driven by councils, with a few notable exceptions. A large number of the WSUD features in the inventory were located in public open space and managed by local councils. For this reason practitioners surveyed were predominantly from local government. The limited WSUD uptake by private developers (residential and commercial) reflected the lack of incentives and capacity for them to adopt such practices unless required by local government. Councils across Greater Adelaide were observed to differ regarding their WSUD requirements in the development approval process. Further investigation of the barriers for WSUD uptake from the developers' perspective, and the effectiveness of strategies to provide incentives or regulate for WSUD, is planned.

The interviews with local government representatives, supported by the literature, confirmed the fragmented nature of WSUD implementation across councils. WSUD adoption across local government appears to be influenced by the in-house capacity and commitment to WSUD. Differing levels of expertise from consultants engaged in projects also seem to influence the uptake of WSUD. Consequently capacity for WSUD planning and implementation, whilst evolving, varies across Greater Adelaide, and also among consultancy firms and within State Government departments. The capacity and drive for adopting WSUD approaches in organisations was found to still be influenced by individual champions. This is also reflected in the processes for WSUD implementation. Councils which have had a longer history with implementing WSUD have typically learnt from their past experiences, 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. Access to resources or funding for implementation is a challenge for local governments, and is particularly required to ensure the on-going maintenance of WSUD features. In particular, local governments identified difficulties of managing street scale distributed WSUD infrastructure, whose performance and impact is not as well characterised.

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1 Introduction

In 2009 the South Australian government released the *Water for Good* plan (Government SA, 2009). *Water for Good* outlined a range of actions aimed at reform of the water sector to increase water security and transition South Australia towards a water sensitive State by 2050. Actions proposed in the plan covered all facets of water management from integration of alternative water sources, water allocation and planning to infrastructure development and institutional reform. One of the needs identified by the *Water for Good* plan was the development of 'master plans' for the management of stormwater and wastewater in Greater Adelaide. As a precursor to this master plan, the South Australian Minister for Water released the *Stormwater Strategy* (2011) with further actions specific to urban stormwater, including the development of a 'blueprint for urban water' which will:

> *'…summarise investigations relating to the costs and benefits of various water sources and document projected demands for alternative water resources in the Greater Adelaide region. It will also analyse current land use and strategic infrastructure planning to determine future infrastructure requirements.'*

In addition to these water specific plans, the *30-Year Plan for Greater Adelaide* (the Plan) has been produced which seeks to create an efficient planning system for Adelaide up to 2040 (DPLG, 2010). The Plan projects a steady population growth of 560,000 people and the development of an additional 258,000 homes in the greater Adelaide region by 2040. It aims to provide for population and economic growth, whilst protecting the environment, heritage and character of Greater Adelaide by creating vibrant and liveable communities resilient to climate change impacts. One of the key principles of the Plan is the emphasis on the protection of natural resources and the engagement with community (DPLG, 2010).

Achieving the goals of *Water for Good* and the *30 Year Plan for Greater Adelaide* will require careful consideration of water management, supply and demand, which are key facets of Water Sensitive Urban Design (WSUD). In the South Australian *Water Sensitive Urban Design Technical Manual*, WSUD is defined as:

> '*an approach to urban planning and design that integrates the management of the total water cycle into the urban development process' (Government of South Australia 2010).*

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 water (Government of South Australia 2010). Traditionally, Australian water supply, stormwater and wastewater infrastructure systems were planned, designed and constructed separately to satisfactorily deliver service requirements of potable water supply, efficient wastewater treatment and disposal, and flood risk mitigation through drainage management. However, over the last 25 to 30 years water policy makers and managers recognised that there was a need to manage the urban water cycle in a way that minimises changes to natural catchment hydrology and move towards achieving the objectives of ecologically sustainable development. JSCWSC (2009) identified that the impacts of urban development extend 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 of stormwater and treated wastewater to downstream receiving waters; and
- The significant modification of natural hydrological regimes and associated processes in waterways upstream and downstream.

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, which is driving the need to 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 or a whole subdivision (Lloyd, 2001).

The Intergovernmental Agreement on a National Water Initiative incorporated the concepts of WSUD into its urban water reform agenda, and defined WSUD as (NWC, 2004):

> "*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 the concept of WSUD fundamentally 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 which has led to some scepticism in the scientific community regarding the ability of WSUD to deliver 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.
- Preserving the hydrological regime of catchments.

Elements that can be used to achieve WSUD objectives are flexible to the needs of the 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*, which included guidance for the implementation of the following 12 WSUD tools in the greater Adelaide region:

- 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 depicts the framework for WSUD as developed by Wong (2006). It captures the interactions of the 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.

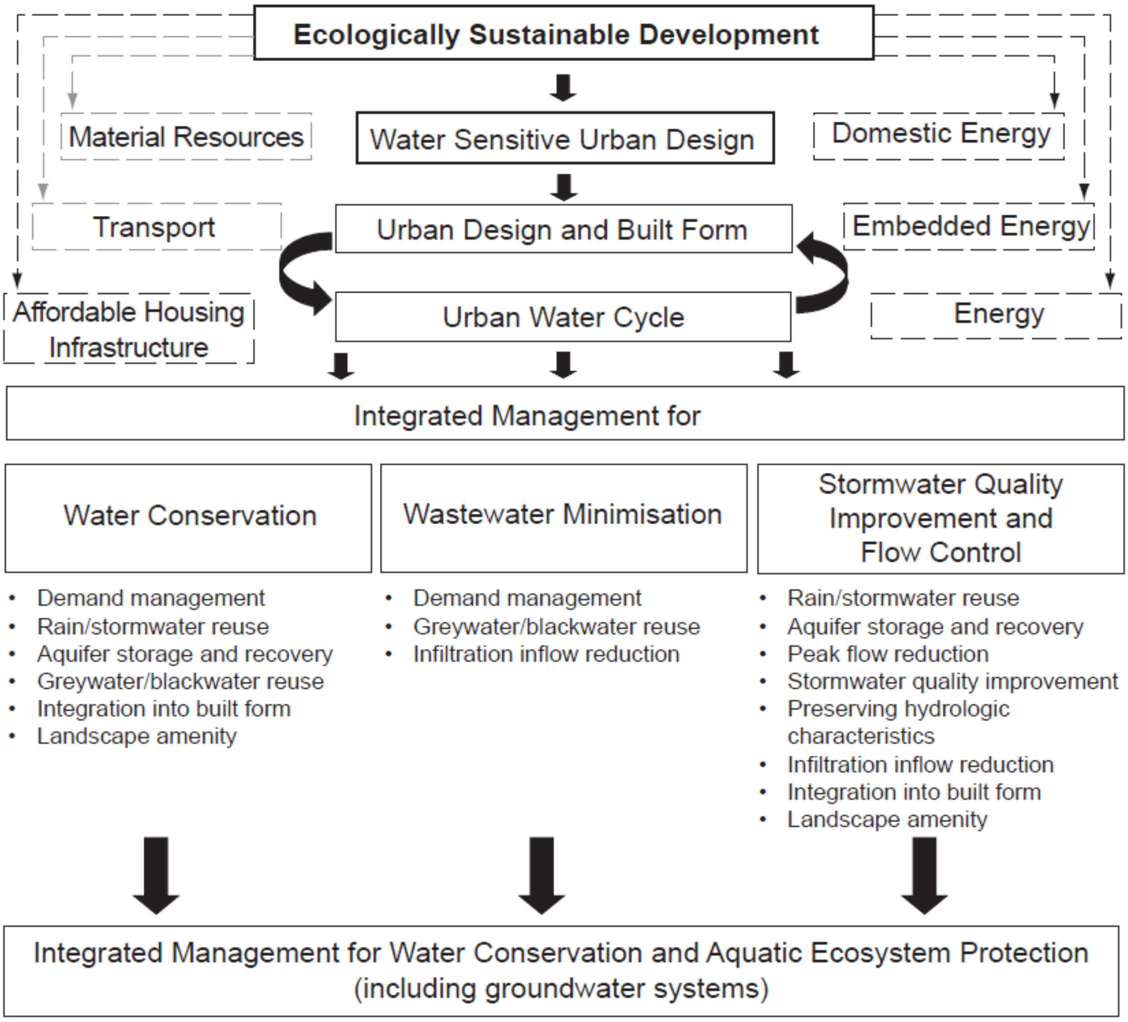

Figure 1 - The water sensitive urban design framework (Source: Wong, 2006, pg. 1-3).

The strategic adoption of WSUD in South Australia can play a major role in the SA Urban Water Blueprint and in addressing actions and directions in the Water for Good Plan and 30 Year plan. In particular, effective and specific WSUD adoption strategies tailored to local conditions are required where there is additional load on existing infrastructure from greenfield and infill development. The 30 Year Plan indicates at least half of the projected number of new dwellings in greater Adelaide is expected to occur within the existing metropolitan area. There will be a need to examine the performance of WSUD systems to minimise the impact on existing streams, as well as water supply and stormwater management infrastructure.

To date South Australia has not experienced uptake of WSUD systems to the same extent exhibited in other Australian states and this may be attributed to local impediments and constraints. These constraints include but are not limited to local conditions as well as issues associated with gaps in knowledge and capacity for planning and implementation.

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

In addition, the primary objectives of the WSUD project are to address the knowledge gaps that will support the WSUD capacity building project and the Blueprint for Urban Water, which would ultimately result in strategic uptake of WSUD in South Australia. The WSUD capacity building project is a collaboration between state and local government agencies, industry groups and research organisations, led by the Adelaide and Mount Lofty Ranges Natural Resource Management Board (AMLRNRMB). The WSUD capacity Building project has support from the Environment Protection Authority (EPA SA), the Department for Environment, Water and Natural Resources (DEWNR), local and state government agencies and industry groups[1] (for a full list, see Alluvium and Kate Black Consulting, 2012). The capacity building program will be strongly driven by the emerging needs outlined in the Blueprint for Urban Water, currently being developed by DEWNR.

1.1 Report Objectives

This document outlines Task 1.1 of the Project. Task 1.1 examines urban developments with WSUD features in South Australia (SA) in the context of research on WSUD implementation in SA. This review is the first output of a comprehensive assessment aimed at determining the enabling factors and drivers where WSUD implementation has been successful, and the opposing factors where impediments were exhibited in SA.

1.2 Report Structure

The report is sub-divided as follows:

Chapter 1: Introduction and background
Chapter 2: Methodology
Chapter 3: The status of WSUD legislation in South Australia
Chapter 4: Analysis of Inventory of WSUD developments in South Australia
Chapter 5: References
Appendix A: Interview guide
Appendix B: Inventory of WSUD sites in SA

1.3 Background

The major focus of the first task of this Goyder Institute project was to undertake a post-implementation assessment of WSUD sites in South Australia. However, it was considered appropriate to begin this task by compiling a list of existing WSUD sites across South Australia. Such a list is intended to be used to identify sites for which a post-implementation assessment may provide the greatest benefit to practitioners. It can also be used to build an understanding of how WSUD is being implemented across South Australia to the present, including the types of approaches implemented, functions provided by the WSUD features, and the location and types of developments where WSUD has been implemented.

[1] Adelaide and Mount lofty Ranges NRM Board, South-Australian Murray-Darling Basin NRM Board, Stormwater Industry Association (South Australia), Institute of Public works and Engineering Australia, Local Government Association of South Australia, SA Water, Renewal SA, Universities, Councils, Private enterprises and other practitioners.

With the exception of water harvesting projects, there was limited information regarding WSUD implementation available during the data collection phase for the inventory. Existing and future water harvesting schemes have been documented previously in reports (Wallbridge and Gilbert, 2009) and in an online mapping tool last updated in August 2010[2]. These sources also provided an estimate of the water yield per annum of each scheme where data was available. However there was little information available on the implementation of WSUD projects which were focussed on stormwater runoff management or water quality improvement. While such information has been made available in other states, such as the Melbourne Water online case studies tool[3], the nature of WSUD being applied across South Australia has not been well identified. The nature of WSUD in South Australia was considered important to explore because the factors may be different to other states due to differences in the local conditions, policy and individual practice. For example, it is acknowledged that SA has greater Aquifer Storage and Recovery (ASR) capacity compared to other states because of favourable geological characteristics.

The identification of WSUD developments in SA was therefore proposed and has been undertaken as an initial step in the post-implementation assessment process. The following sections outline the methodology and data collection and current progress in this endeavour. It should be noted that that the process of gathering site information was not yet complete and the results presented should be considered preliminary.

In addition, to gain a better understanding of the context in which the WSUD implementation is currently taking place we examined the legislative and policy framework currently in place in South Australia and we provide a preliminary summary of the status of WSUD in Australia according to the current scientific literature.

[2] See http://maps.google.com.au/maps/ms?ie=UTF8&oe=UTF8&msa=0&msid=113099579503916349953.000484b557a1f480c80af

[3] See http://wsud.melbournewater.com.au/content/case_studies/case_studies.asp

2 Methodology

The status of WSUD in South Australia was evaluated by analysis of the uptake of WSUD in the State and also of the legislation enablers that promoted WSUD uptake. A further analysis is planned that will be compared to the trends in implementation of WSUD across the country to gain greater understanding of the overall national context.

2.1 Inventory of developments with WSUD features in South Australia

An inventory of developments with WSUD characteristics in South Australia was conducted through analysis of the literature, information from the internet, consultation with local government via interviews and the solicitation of WSUD development information from natural resource management boards and practitioners in South Australia via email.

To compile a list of WSUD sites, the project team has conducted interviews with WSUD practitioners across urban precincts in SA. An outline of the interview process is provided in Section 4.1. At the time of writing, this interview process was ongoing, having completed interviews with representatives from local government, state government departments and other WSUD practitioners. It was assumed that local government areas would be best informed of WSUD implementation, and the project team have interviewed 23 of 26 local governments in the Greater Adelaide region. A further two representatives from other local government areas declined a meeting request on the basis of no known WSUD features in their area of operation. During and following the interview process, existing and in-progress WSUD sites and their characteristics were documented in accordance with the details in Section 2.1.2. The location of each site was also placed into two new geospatial databases – firstly, a GoogleEarth layer was created which enabled coordinates to be determined. Locations were then used to create a new layer (shapefile) in ArcMap 10. It is intended that the completed version of this shapefile will be made publically available at the conclusion of Task 1 (June 2013) subject to the approval of the Goyder Institute and the interest of public authorities. Some assumptions were made in the compilation of the list which are outlined in Section 2.1.3.

2.1.1 Interviews

Meetings were initiated with practitioners in a face to face manner wherever possible. In some circumstances, meetings were arranged via telephone. Meetings commenced with a brief overview of the aims of the Goyder Institute WSUD Project. The interview then discussed the nature of WSUD developments known by the practitioners, which may be known sites in a particular area (in the case of local government) or sites which the practitioners have knowledge of or a database of (in the case of state government and other practitioners). For each site the information described in Section 2.1.2 was discussed during the interview or in subsequent communication. In some circumstances, online literature was also reviewed to collect this information. Following discussion of particular sites, general discussion was also encouraged regarding the success or failure of known WSUD projects, as well as any implementation and post-implementation issues, maintenance details and the presence or absence of impediments during the design and construction process. Where information was considered sensitive, such as in cases of design or maintenance issues which may reflect negatively on an organisation or person, the information was considered to be from an anonymous interviewee. The meeting concluded with general remarks and suggestions from the practitioner(s) regarding opportunities for capacity building and for increasing the implementation of WSUD in SA. Appendix A provides a copy of the guide for interview questions adopted for this task.

In some circumstances, details of project history such as drivers and completion dates were not easy to identify due to turnover of staff and lack of time to explore records of these sites. In such cases this information has been approximated.

2.1.2 Inventory List Characteristics

The following information was documented for each site:

a) Site name
b) Organisation: The organisation responsible for building or currently maintaining the project (generally a local government, state government department or private entity recorded as 'other')
c) Rain zone: Rain zone was allotted based on the location of the system based on four rainfall categories across the greater Adelaide region. A map indicating these categories is shown in Figure 2 based on gridded climate data from the Buereau of Meteorology.
    a. 200 - 400 mm/annum
    b. 400 – 600 mm/annum
    c. 600 – 800 mm/annum
    d. 800 + mm/annum
d) Source water: Source water indicates the source water of any water harvested by the project; 'sw' indicates stormwater, 'ww' indicates wastewater and 'rw' indicates rainwater.
e) WSUD types: The type of WSUD employed was documented based on key terms for a range of WSUD technologies – these included: Aquifer Storage and Recovery (ASR), wetlands, permeable paving, bioretention, wastewater reuse, stormwater reuse, infiltration, passive irrigation and combinations of the above.
f) Function/Driver: The main function or driver of the project was documented using key words. Generally, the main drivers are split into one or a mix of the following three drivers: 'flow' representing flow/flood management, 'quality' representing water quality management or 'conservation' representing water conservation measures. 'Other' was adopted for other reasons such preservation of amenity or vegetation.
g) Date completed: The year that the development was completed.
h) Development type: The development type was characterised as 'greenfield, 'infill', 'retrofit' or 'other'. 'Greenfield' represents sites where WSUD has been incorporated into new development of open space, typically on the urban fringe. 'Infill' represents sites where WSUD has been incorporated into renewal development of an existing site, or subdivision of a vacant or unused parcel within the urban landscape. 'Retrofit' describes renovation of existing development or infrastructure with WSUD features; this includes the incorporation of WSUD into streetscapes or downstream of developments but which were independent of the greenfield or infill urban development processes. 'Other' represents WSUD sites which are not directly attributable to these categories – such sites include those incorporated into schools or infrastructure projects.
i) Land use: Land use for each development was classified as residential, commercial, industrial, mixed use (i.e. a combination of two or more of the three previous options) or public land. Public land applies to land managed by local government such as parks, roads verges and sidewalks and other public spaces.
j) Scale: Indicates the size of a development in the form of a residential subdivision with WSUD features. This is based on a single allotment development (1 dwelling), cluster (up to 50 dwellings), medium (between 50 and 1000 dwellings) and large (1000 + dwellings). Not applicable (n/a) indicates that the WSUD feature is not instituted as part of a residential subdivision i.e. it is a retrofit, infrastructure or commercial development location.

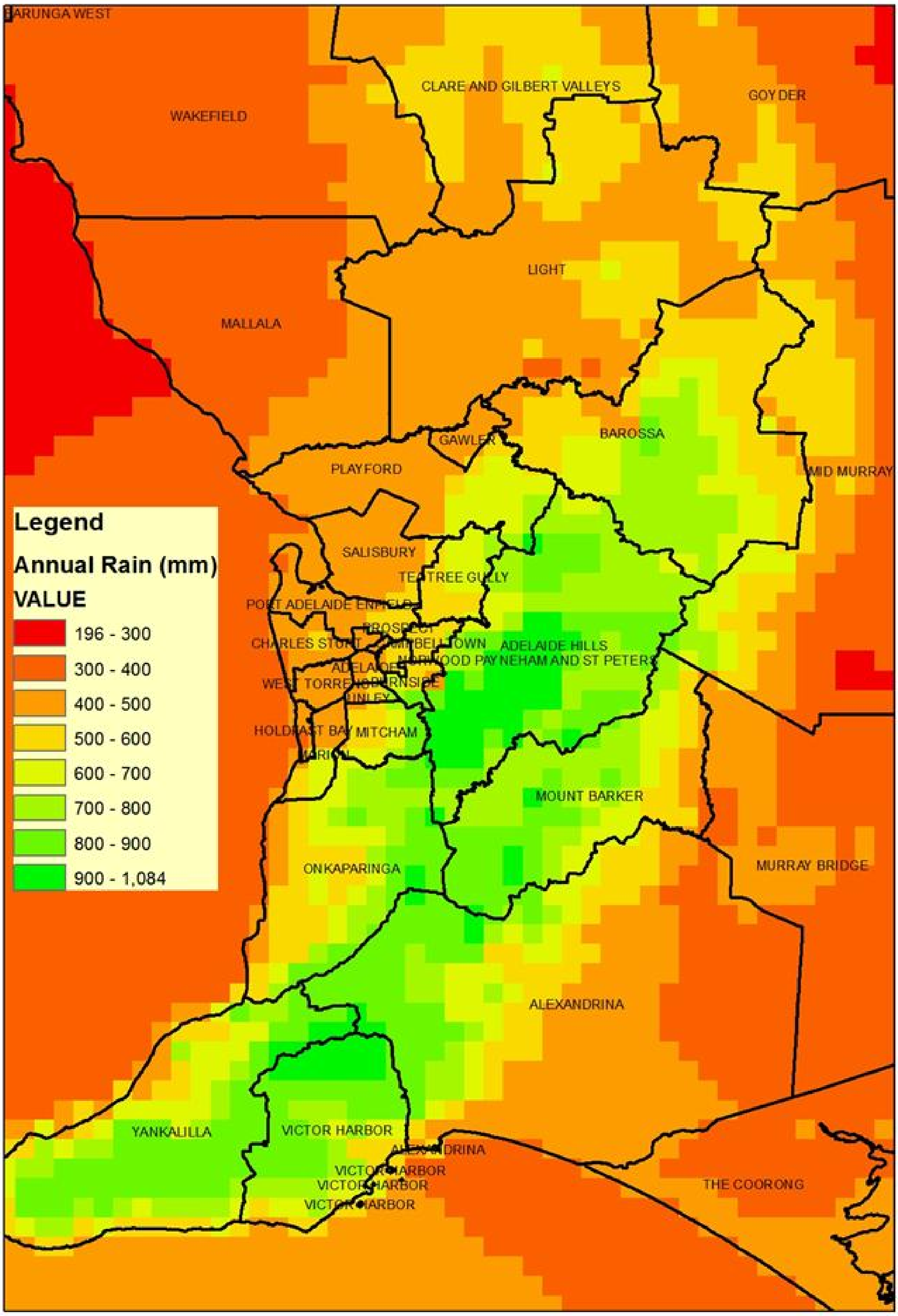

Figure 2 - Rainfall Zones in Greater Adelaide

2.1.3 Assumptions

The following assumptions have been made in the compilation of the WSUD site list:

- At the present time, the list is limited to structural best management practices, and does not document non-structural WSUD schemes. Non-structural WSUD schemes include programs aimed at behavioural change in the community, and community awareness and education programmes into the use and fate of mains water, wastewater and stormwater resources. Such schemes are acknowledged to be an important part of WSUD.
- The list excludes gross pollutant trap (GPT) and 'trash rack' devices. During interviews, it was apparent that most local governments maintain a log of GPT devices under their control for managing the emptying and maintenance requirements. There was acknowledgment that an additional number of GPT devices are deployed on private development sites, for which the maintenance history is unknown.
- The list was constructed to exclude detention basins. Detention basins are a common method of controlling flows from a development but were not considered WSUD sites for the purposes of this study. Exceptions to this rule include situations where flows were controlled using detention basins which were intended to be, or retrofitted to become, functional wetlands and/or stormwater harvesting basins. In some circumstances, the difference may be considered marginal, and where site visits were impractical the definition of a site as a wetland or detention basin was dependent on personal communication.
- To minimise repetition, the list of sites was assembled in such a way that schemes are 'grouped' wherever reasonable. For example, high volume stormwater and wastewater reuse sites with multiple customers (such as a wastewater reuse pipeline from a wastewater treatment plant) are documented as a single entity. Similarly, some local governments, such as the City of West Torrens, are implementing a large number of streetscape flow management and water quality improvement devices. These retrofit projects were documented on a street or suburb basis, rather than separating every site. In contrast to this, some practitioners are beginning to implement demonstration sites of isolated streetscape entities, and these were documented on a per-site basis. Based on feedback from the Goyder Institute WSUD project reference committee, a future iteration of this list intends to include a definitive count of smaller scale infrastructure such as bioretention systems and wetlands, so that organisations can maintain a tally of these grouped technologies. At present, this figure has been estimated based on available data.
- Based on the grouping of technologies described above, it is important to note that this list is not suitable for quantitatively assessing the level of WSUD implementation across local government areas.
- Although the "Driver" item was intended to highlight the main impetus which pushed the development to go ahead, this was in reality a difficult measure to determine. In most cases, a WSUD outcome was mainly driven by flood management requirements, with local council or the developer embracing a water sensitive approach in an attempt to achieve a better quality ecological outcome. In such cases, the WSUD development would likely not have been undertaken without the flow management driver, but was adopted with water quality improvement, amenity and water conservation considered to be additional benefits.
- Harvesting schemes are defined as those sites which collect and store water for use in a deliberate and planned fashion. They include sites such as ASR, runoff collection for storage/reuse and wastewater reuse. WSUD sites where stormwater runoff is collected and infiltrated on site as a means of passive irrigation are not documented as harvesting schemes, despite the legitimate claims to water conservation and reuse, albeit in a non-managed fashion.
- The definition of infiltration systems and bioretention systems is heavily dependent on how practitioners refer to their system in the interview process and subsequent communication. In some circumstances, bioretention systems may not be collecting water in an underdrain and may rather be designed to be vegetated infiltration systems.

3 The status of WSUD legislation in South Australia

At present, there is little formal legislation specific relating to WSUD at the state and local government level.

The South Australian Environment Protection Authority (EPA SA) 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 obligations to not contravene water quality criteria in waters.

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. These apply to a range of soil conditions.

Under the current South Australian legislation, the *South Australian Planning 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).

The implementation of WSUD requirements at development level falls under the jurisdiction of local councils, which assess development applications against the Council's development plans (DP) and policies. Development plans and council policies are formulated according the individual needs and strategies of each council, and whilst the Planning Library is available as an overarching framework for development, the incorporation of the various modules into the DP is subject to the discretion of each council.

Water ownership is determined by a system of rules that define the rights of access to water by various users (*NRM Act 2004*). The State has the authority to prescribe water resources and controls the rights of access to those prescribed resources through licences, permits and/or allocations. 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.

3.1 Guidelines and Policies for WSUD in South Australia

In recognition of the importance of stormwater runoff quality, the EPA SA 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). EPA SA has also implemented WSUD targets on a regional basis. For example, in the South East of South Australia, the EPA SA presented the *EPA Guidelines for Stormwater Management in Mt Gambier* (SA EPA, 2007). These guidelines were developed to 'help landowners and developers meet their environmental duty of care under section 25 of the *Environment Protection Act 1993* and their obligations under the *South Australia Environment Protection (Water Quality) Policy 2003* (WQEPP).

The *EPA Guidelines for Stormwater Management in Mt. Gambier* indicate that development shall incorporate stormwater treatment systems that achieve a minimum standard for treatment, as reproduced in Table 1. 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'.

Table 1 - Treatment objectives for stormwater management in Mt Gambier, SA (SA EPA, 2007)

Pollutant	**Stormwater treatment objective**
Suspended solids (SS)	80% retention of the average annual load
Total phosphorous (TP)	45% retention of the average annual load
Total nitrogen (TN)	45% retention of the average annual load
Litter	Retention of litter greater than 50 mm for flow up to the 3-month average recurrence interval (ARI) peak flow
Coarse sediment	Retention of sediment coarser than 0.125 mm for flows up to the 3-month ARI peak flow
Oil and grease	No visible oils for flow up to the 3-month ARI peak flow

Local governments in the Greater Adelaide region have also applied water quality targets to encourage implementation of WSUD. At the time of writing, City of Onkaparinga had implemented WSUD targets for runoff quality for all new developments, which were equivalent to those for TSS, TP and TN in Table 1. WSUD targets for water quality were administered by the council as an engineering condition and were adopted based on the successful implementation of targets from the *CSIRO Urban Stormwater Best Practice Guidelines* which are administered by Melbourne Water (Victorian Stormwater Committee, 1999).

In situations where WSUD was not practical, or where targets could not be achieved, a fee based offset scheme was being implemented by the City of Onkaparinga. A water quality levy was applied to non-compliant development which was effectively a contribution to larger WSUD systems being planned by the City of Onkaparinga for retrofit of WSUD infrastructure downstream or elsewhere in the council area. At the time of writing, the levy was $19,000 per hectare. However, the adoption of a water quality levy is discretionary and is not a practice adopted widely across other LGAs in SA.

The City of Salisbury has also applied water quality targets as a condition for new developments, although the targets are not currently presented in a written form. The targets are equivalent to those in Table 1 for TSS, TP and TN, and were also established based on the successful implementation of water quality targets from the Victorian Stormwater Committee (1999) administered by Melbourne Water (Melbourne Water, 2005). At time of writing, there were two developments which had proceeded in the City of Salisbury on the basis of these targets. In each case, bioretention systems were used to achieve the targets.

In 2010 *The Water Sensitive Urban Design Technical Manual* (SA Government 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. It was considered the first major attempt at mainstreaming WSUD in South Australia.

Regarding alternative water supply, the South Australian building rules (Building Code SA) require new dwellings and extensions (with a roof area greater than $50m^2$) to have a supplementary water supply other than mains water. This supplementary supply must be for supply to the toilet cistern, water heater or all cold water laundry outlets. This requirement may be fulfilled by adoption of rainwater, recycled water or stormwater (Government of SA 2006).

The *South Australian Recycled Water Guidelines* (Government SA 2012a) outline the key legislation, agencies and 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. For such schemes a risk management approach forms the basis for approvals. The validation of schemes and the roles and responsibilities for agencies in pre-development evaluation of schemes are clearly outlined.

Under the *Environment Protection Act 1993* the EPA licenses discharges of stormwater to underground aquifers (injection) when the discharge is from a catchment area greater than one hectare and the stormwater drains to the aquifer from a stormwater drainage system in metropolitan Adelaide or in the city of Mount Gambier; and discharges of wastewater into aquifers. The discharge must comply with the criteria in the WQ EPP and the operator of a scheme is obliged to monitor before they can discharge to the aquifer and to report the monitoring results to the EPA.

Schemes that extract groundwater from prescribed areas and which import water or treated wastewater require approval from DEWNR. When the recycled water is intended for stock watering or pasture irrigation, approval also needs to be sought 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 (greywater, mixed source), and the water provider (most often SA Water) consulted for the development of a recycled water supply agreement (Government SA 2012a).

Greywater schemes require consultation with the DHA, local government and SA Water or equivalent prior to installation. Up to 2012, SA Water administered the *Sewerage Act 1929* in proclaimed drainage areas (where SA Water provides mains sewerage). Non proclaimed areas were under the responsibility of local government and/or the DHA. The DHA approves 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.

With the introduction of 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 any licensed operators. In principle, this opens the right of water supply and sewage services to new entities besides SA Water, increasing competition. Approximately 56 licences have been issued to water and wastewater service providers in South Australia by ESCOSA (excluding SA Water).

However, 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 and requirements developed on a case by case basis. One of the particular areas not clearly defined is the post-implementation and management of WSUD schemes. Depending on the disposal location and water use, stormwater recovery and recycled water schemes may require monitoring and reports to the EPA or the Department of Health. Hence large scale schemes that inject into or extract from aquifers are required to provide monitoring reports in compliance with EPA requirements. However, information on other type of stormwater related WSUD schemes is scarce.

3.2 WSUD uptake in South Australia

South Australia has been a leader in the adoption of some WSUD approaches in the Australian context and has a diverse range of installations such as constructed wetlands that have been operating for more than 20 years. This included the adoption of recycled water for non-potable water demand. Well documented examples of water recycling have been provided by the Mawson Lakes and New Haven developments (Marks, 2006; Marks, and Zadoroznyj, 2005).

New Haven Village emerged from South Australia's involvement in the Multi-Function Polis (MFP) project, which sought to promote and demonstrate leading edge examples of sustainable development (Parker, 1998). A key element of New Haven Village was the on-site treatment and reuse of household wastewater with the scheme designed to have no wastewater leaving the site. 'V' shaped roads direct stormwater runoff to a single underground stormwater pipe that channels it to an adjacent reserve. Mawson Lakes used an integrated approach to provide water services that include provision of recycled water for non-consumptive uses, source control and treatment of stormwater.

Argue (2009) provided practical guidance on the source control of stormwater using WSUD approaches. South Australian examples of implementation of WSUD for on-site retention of stormwater included:

New Brompton Estate Stormwater Management Plan (constructed in 1992) – Roof runoff from 15 townhouses is directed to a small reserve where it is collected via a trench and then conveyed to a bore for storage. In drier months the stored water in the aquifer is extracted for irrigating the reserve to save mains water.

Parfitt Square Stormwater Management Project (constructed in 1997) - Another example of a small scale ASR technology, where runoff from an urban area is directed to a sediment trap and gravel reed bed for treatment, prior to being distributed to recharge bores. The stored water is again used for public open space irrigation.

St Elizabeth Church Car Park (constructed in 1998) – All the runoff from paved areas is directed to a grassed area that has ring matrix to allow for parking while still allowing runoff to infiltrate to gravel filed soak-away. Again the treated runoff is recharged to the underlying aquifer for subsequent extraction for irrigation of a neighbouring reserve.

Plympton Church Outdoor Community Garden (constructed in 1999) – Runoff from roofs and paved areas is treated by sedimentation and filtration, and provides passive irrigation of a garden area. Monitoring has shown that even despite the hot, dry summers in Adelaide this approach can maintain a garden planted with native vegetation with only minimal additional irrigation.

Barton and Ague (2007) provided a review of WSUD approaches in Australian residential developments, which included some of the examples cited above: New Brompton Estate, New Haven Village, Parfitt Square and Mawson Lakes. This included a post-implementation assessment that documented impediments or difficulties faced in achieving the desired performance intended by the WSUD elements.

In New Brompton Estate the water stored in the aquifer was intended for park irrigation. However, the local council did not fund the implementation of this part of the scheme and therefore no water has been recovered from the aquifer. The infiltration and recharge components of the scheme have functioned as intended.

In New Haven Estate, it was originally intended that treated stormwater, as well as recycled wastewater, would be used to provide a non-potable water supply, with an anticipated reduction in drinking water use of 60%. However, stormwater was not recovered for treatment and therefore potable water was used for toilet flushing and garden irrigation. Furthermore, a range of operational issues with the wastewater treatment plant led to its removal and for much of the time the non-potable supply system has been offline and potable water supply has been used to meet all household water demands. Barton and Argue (2007) found that problems with the operation of the wastewater treatment plant were due to a lack of in-house expertise at the local council who assumed responsibility for managing the system. A recent site visit also revealed, through passing conversation, that some long term residents were still under the impression that wastewater and stormwater recycling were being undertaken at the site.

At Parfitt Square, it was found that stormwater collection, treatment and infiltration are operating successfully. However, again the reuse of the water stored in the aquifer has not been implemented. Barton and Argue (2007) found that this was due to the poor retention of capture runoff in the upper aquifer, which has meant that additional investigation would be needed prior to building reuse components such as the bore and pumping station.

The Mawson Lakes development was intended to showcase an example of sustainable development, which included WSUD. Barton and Argue (2007) found that not all elements of the WSUD approach have been realised. It was originally intended that stormwater and wastewater from the development would be treated locally, and stored for reuse as a non-potable water supply to the development. The on-site wastewater treatment plant was not constructed due to concerns of amenity, and the cost of meeting EPA requirements for noise and odour control. The ingress of groundwater to the sewer, and also wetlands, meant that water to be harvested would be too saline for reuse in gardens and public open space. Therefore, the non-potable water was supplied by taking Class A effluent from the centralised Bolivar wastewater treatment plant and blending with treated stormwater from the Parafield Wetlands harvesting scheme.

Razzaghmanesh et al. (2012) investigated the role that green roofs can have in WSUD in South Australia. The authors found that while green roofs can offer a number of environmental, economic and social benefits there are still a range of research and practical barriers that need to be addressed before widespread implementation. Many of these barriers are related to the fact that the approach is still relatively new and knowledge is still developing, and that there is a need for specific design criteria for the Australian context.

Chowdhury and Beecham (2012) investigated the rainfall patterns for Adelaide and considered the implications for the design of WSUD elements, and found that current WSUD design procedures do not explicitly consider the implications of dry spells in ensuring reliability of supply of alternative water sources, such as rainwater tanks. Gardner and Vieritz (2010) investigated the role of rainwater tanks in Australian cities, including Adelaide. They found in Adelaide, through modelling, that a 5 kL tank could yield around 42 kL per year for a household assuming a demand for rainwater of 173 kL a year per household. This represents a significant saving of mains water even if the reliability of supply is less than 50%.

There has been a range of research specific to the South Australian context that has investigated the effectiveness of WSUD elements or design approaches. Beecham et al. (2012) investigated the use of permeable pavement for stormwater treatment, which found that they do improve stormwater quality through filtration.

Managed Aquifer Recharge (MAR) has as a notable example the Parafield stormwater collection and ASR scheme, in the City of Salisbury, which was one of the first large scale schemes at the time. The intensive scientific scrutiny on this and other managed aquifer recharge schemes in SA led to the development of fundamental knowledge to inform policy on MAR and key guidelines on aquifer management for Australia (Dillon et al 2009, Ward and Dillon 2009, NRMMC, EPHC, NHMRC 2009, Page et al. 2010).

3.3 Review of impediments to the adoption of WSUD in South Australia

A preliminary literature review of impediments for WSUD adoption in South Australia has built upon previous reviews, which can be found in Tjandraatmadja et al. (2008) and Sharma et al. (2012). The review of impediments will be developed fully for subsequent reports. In particular, the review will be adapted from the broad classifications of impediments that were used in previous research to undertake a thematic analysis of impediments to the uptake of WSUD in South Australia. The impediments identified through the literature will be organised into the following categories: governance, regulations and guidelines; community acceptance and social impacts, water sector skills and knowledge; public health risks; availability of monitoring data for system evaluation and performance assessment; financial incentives for

WSUD; approaches for systems operation and maintenance; and the understanding of sustainability, and broader system impacts.

The review of WSUD schemes in the preceding section highlighted that current governance frameworks can impede the implementation of WSUD approaches, as it requires a shift from the status quo of how water supply, wastewater and stormwater services are provided and managed.

WSUD requires a change in the way urban water systems are managed and operated when compared to conventional water services. In particular, the WSUD systems are often distributed across a city rather than being a centralised infrastructure network. Also, WSUD systems, such as stormwater detention devices, are implemented at the local scale, from the development to individual households. WSUD systems also take a more coordinated approach to managing the urban water cycle, where opportunities for the cycling of water through the system are sought, such as the reuse of treated wastewater for non-drinking uses. These structural and philosophical differences between conventional urban water services and those aligned with the principles of WSUD present a challenge to mainstream uptake as there is a need to change accepted management practices. A number of authors have argued that this need to change how urban water systems are managed is the biggest impediment to achieve WSUD objectives (Brown, 2008; Brown and Farrelly, 2009; Rike et al. 2013). It is widely accepted that there is a need to change to more coordinated and participatory approaches for the management of the urban water cycle (Brown and Farrelly, 2009; Moglia et al. 2012). There are a considerable number of studies on the social and institutional aspects of successfully implementing WSUD to urban development to achieve multiple objectives and that are resilient to future uncertainties, such as climate change (Pahl-Wostl, 2002; Pahl-Wostl, 2007; Milly et al. 2008; Wong and Brown 2008; Pearson et al., 2010; Brown et al., 2011).

Brown et al (2007) noted that while policies are starting to reflect the need for a more integrated approach to managing urban water resources the implementation of more coordinated approaches to managing urban water resources is often lacking. A number of researchers have noted the need for more alignment in management and governance structures for urban water systems that can support the more widespread uptake of WSUD (MacDonald and Dyack, 2004; Brown, 2005). Brown et al. (2007) surveyed respondents from different cities to elicit the perceived effectiveness of their institutional arrangements for WSUD. In each of the case study areas (Perth, Melbourne and Brisbane) respondents predominately rated institutional arrangements as poor or neutral for WSUD. The poor coordination of policies and regulations governing water conservation and reuse is characteristic of most natural resource management issues due to the diversity of purposes for which the resource is managed. In the case of urban water, this can include household supply of water for drinking and non-drinking uses, flood protection, environmental protection, and recreational and landscape aesthetic value. This range of interests means that in South Australia, local governments, regional authorities (such as natural resource management boards), State and Federal government departments all have responsibilities and a role to play in the successful uptake of WSUD.

Brown and Farrelly (2009) suggested that there is currently a lack of strategies to overcome these entrenched institutional barriers to WSUD uptake. The authors suggested that there is a need for the systematic issues to be addressed through capacity building programs that address socio-institutional barriers through fostering social capital, inter-sectoral professional development, and inter-organisational coordination (Brown and Farrelly, 2009).

Brown and Clarke (2007) argued that in order for the principles of WSUD to enter the mainstream there is a need for an overriding socio-political driver or 'crisis' to provide the impetus required to make the required institutional changes. Complex socio-technical systems, such as urban water, typically support a largely stable area of practise that is subject to incremental adaptation and change over time, with the occasional major system-wide change often called a system-wide 'transition'. The extended period of below average rainfall in much of Australia that resulted in issues of water scarcity focused attention on the management of urban water resources and accelerated the shift to alternative water sources. However, Brown and Clarke (2007) proposed that there is a lack of an overriding socio-political driver or 'crisis' to lock in the necessary change required for WSUD to be an accepted mainstream practice.

4 Developments with WSUD features in South Australia

A list of WSUD sites in South Australia is provided in Appendix B of this report. It should be noted that this list is considered to be a work in progress; sites can and will be added in the coming months as the round of interviews and discussions with local government, state government and other practitioners continues.

In total 176 sites with WSUD features have been identified to date across South Australia, including 7 sites located outside of the greater Adelaide region, from interviews with 23 out of 26 LGAs and email referrals from across the State. This is equivalent to 88% of the LGAs and covers an area equivalent to approximately 80% of the Greater Adelaide region, and 7 from councils from the remainder of the State. The WSUD locations are shown in Figure 3. The majority of the sites (82%) were located within the 400-600 mm rainfall zone. Only seven percent of developments were in the highest or lowest rainfall zones.

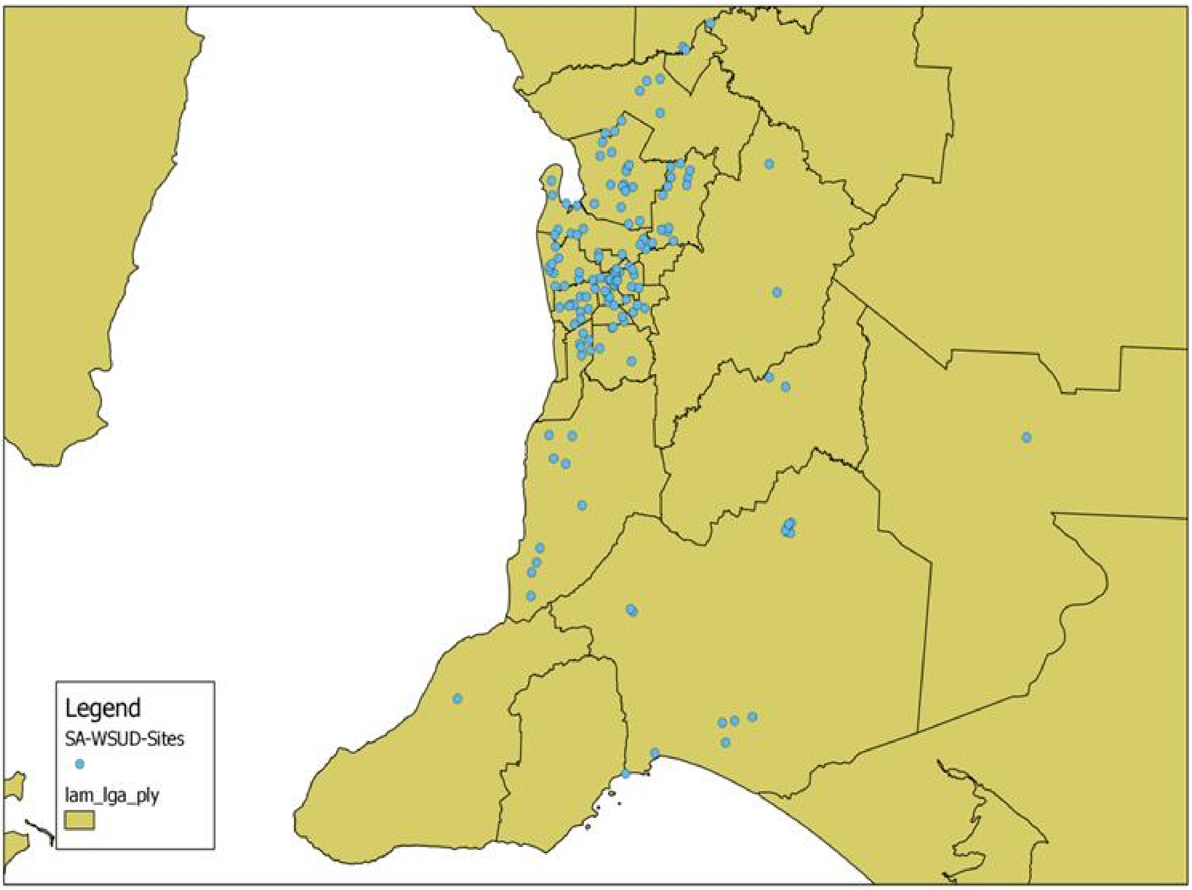

Figure 3: Geographical distribution of sites with WSUD features

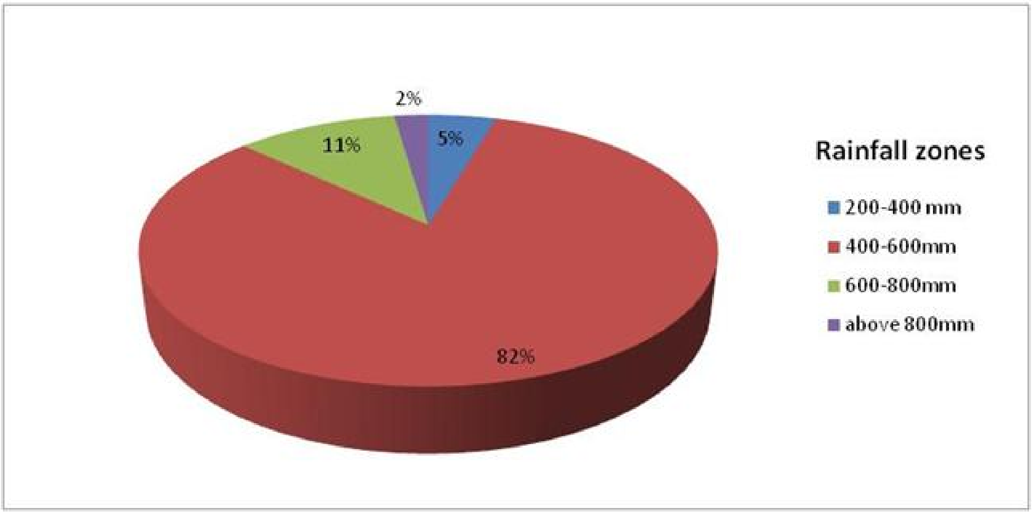

Figure 4: WSUD site distribution as per rainfall zones.

4.1 Characteristics of existing developments in South Australia

The following sections describe the characteristics of WSUD features in South Australia which have been documented, their drivers, impacts community acceptance and evaluation based on the interviews conducted with WSUD practitioners. It should be noted that this list is still being compiled and individual sites further explored.

4.1.1 WSUD features

On January 7th, 2013, the list documented 176 sites with a range of WSUD features including:

- 72 wetland sites;
- 42 bioretention system sites (including more than 178 individual installations);
- 31 infiltration only systems;
- 2 ponds;
- 2 greenroofs;
- 15 permeable pavements;
- 14 wastewater reuse schemes;
- 71 projects incorporating harvesting and reuse (onsite and distributed);
- 49 ASR sites (some sites have more multiple bores; some may not be functional)

Examples of some of the features observed are shown in Figure 5. This sample is characterised by the prevalence of stormwater management features, in particular wetlands, bioretention, managed aquifers and infiltration (swales), which comprise respectively 24.2%, 14.1%, 16.4% and 10.1% of the WSUD features as seen in Figure 6. In terms of project numbers, water reuse is dominated by stormwater reuse (19.9%), with wastewater recycling comprising only 4.7% of the project sample (disregarding volume of reuse) and rainwater harvesting 3.2%. Permeable paving, ponds and green roofs were the least commonly adopted WSUD features.

The majority of sites were located in the inner-urban areas of Adelaide, however these are dominated by smaller systems. Larger schemes, such as ASR, tend to be located several kilometres from the CBD where land was made available for development in the last few decades when WSUD began being implemented. ASR schemes have been predominantly located to the north of Adelaide due to the availability of suitable aquifers and catchment areas. However, ASR schemes are currently being implemented in the South and Western suburbs of Adelaide, with plans to proceed with further harvesting, including ASR, 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 street scale bio-retention due to a lack of available open space.

(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 5: Examples of WSUD features in the greater Adelaide region

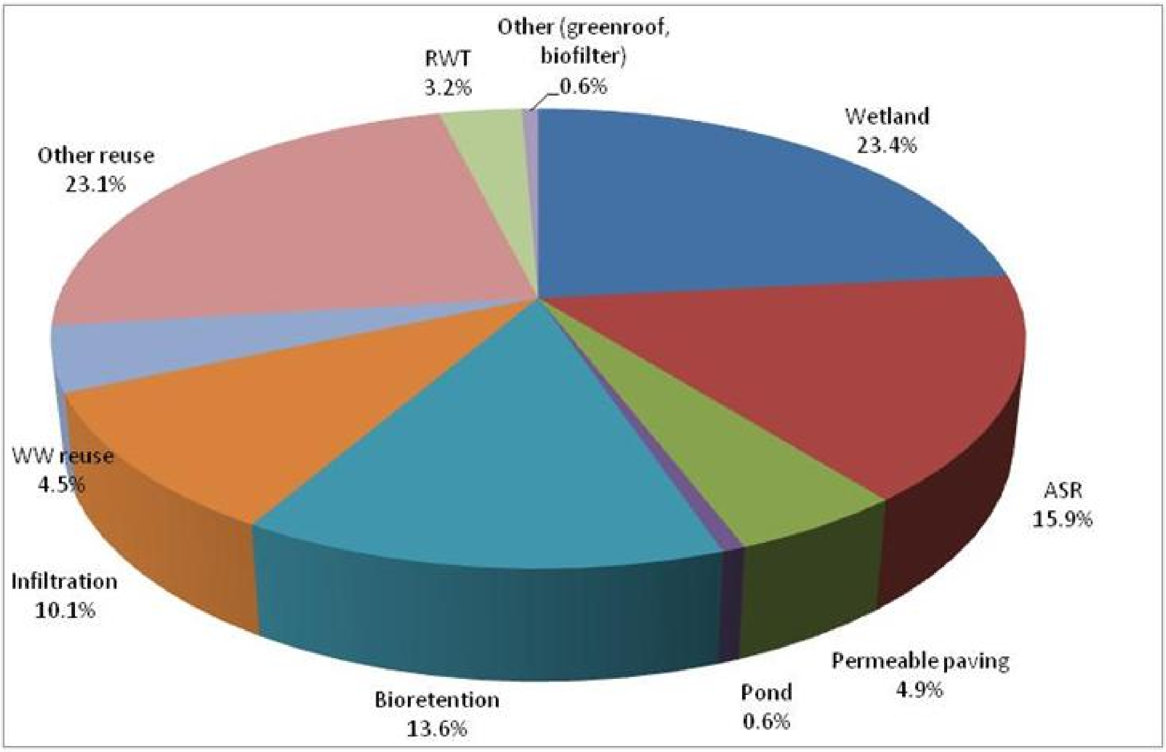

Figure 6: Typology of WSUD features in the sample of 176 sites in SA

At present, the vast majority of sites are retrofit projects which are not installed as part of greenfield or infill development, but they tend to be predominantly built on existing public land and to be installed and/or managed by local government (see Figure 7 and Figure 8). In Figure 7 'Greenfield' represents new developments in open space, typically on the urban fringe, 'Infill' is the renewal development of an existing site, or subdivision of a vacant or unused parcel within the urban landscape and retrofit is the renovation of existing development or infrastructure; for the purposes of this report, this includes the incorporation of WSUD into streetscapes, public open spaces or downstream of developments, where the WSUD is constructed independently of the greenfield or infill urban development process.

In summary, the uptake of WSUD has been largely adopted by local government in public areas and has been associated with stormwater management features.

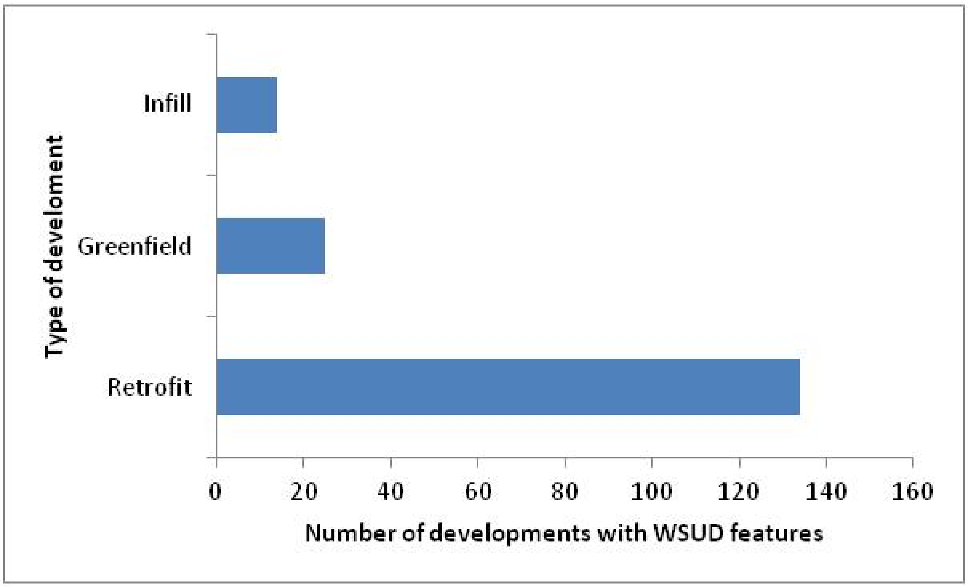

Figure 7: Type of developments with WSUD features in a sample of 176 sites in SA

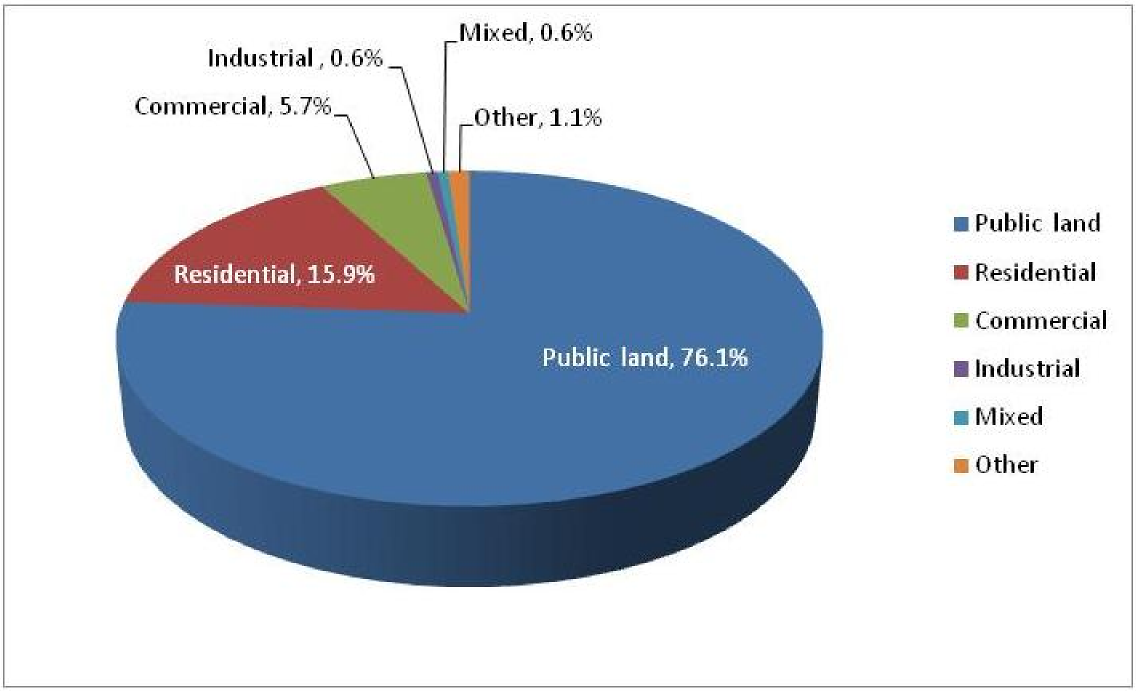

Figure 8: Distribution of WSUD sites by land use in the sample of 176 sites in SA.

An analysis of the time of completion of the schemes in Figure 9 indicates that while WSUD exemplars have been built since 1985, the growth in WSUD implementation largely occurred from 2009, with more than 13 sites constructed annually from that year onward. This is considered to be associated with funding opportunities, water scarcity and the build-up of capacity for WSUD within local government. This has been supported further by the release of locally derived guidelines such as *WSUD: Basic procedures for "source control" of stormwater* (Argue 2004) and the *WSUD Technical Manual* (Government of SA 2010).

The period prior to year 2005 was characterised by early demonstration exemplars of various WSUD technologies at the small and large scale (ASR, wetlands, permeable paving, wetlands, infiltration, recycled water). In 1999 there were two large scale projects on wastewater recycling (Bolivar treatment plant and Willunga Basin), five trials on permeable pavers and infiltration and three wetlands.

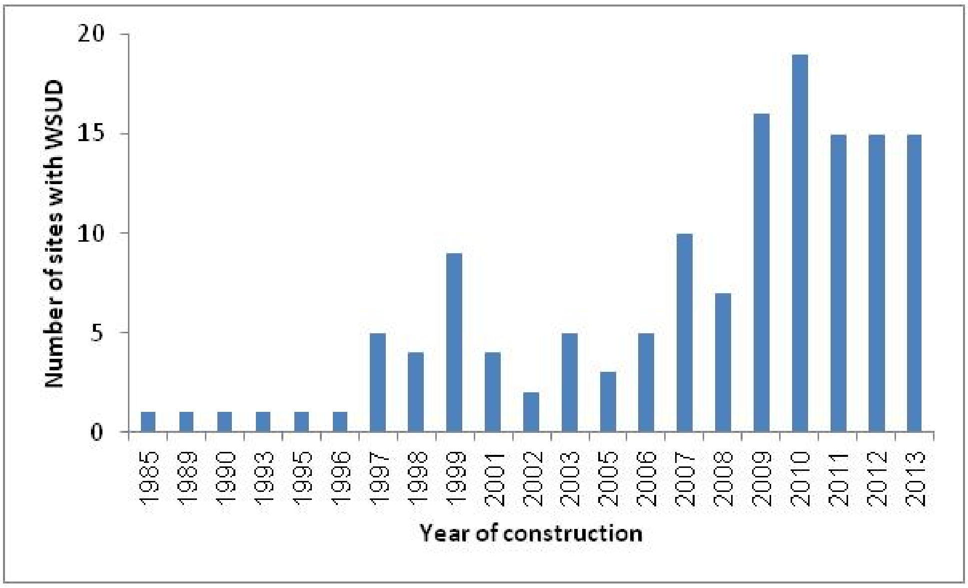

Figure 9: Time of installation of WSUD sites in SA based on a sample of 176 sites.

4.1.2 Drivers

The range of drivers reported by practitioners for the implementation of WSUD ranged from the need for management of stormwater flows and improvement in water quality, the desire for reducing mains water consumption, reduction in financial costs and the need for preservation of vegetation or amenity. Flow reduction, water conservation and quality improvement were the most common drivers identified receiving 40%, 33% and 24% mentions, respectively. Often multiple drivers govern the WSUD implementation process at a given site, as shown in Figure 10.

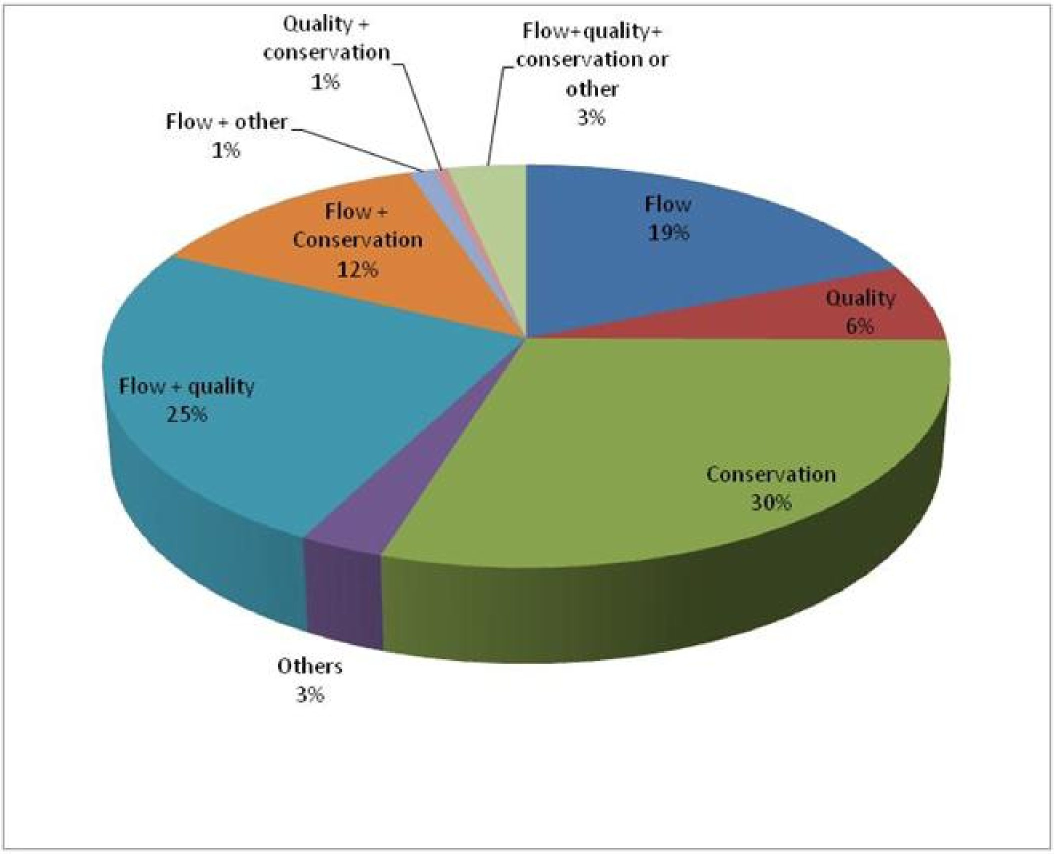

Figure 10: Major reasons for adoption of WSUD features in sample of 176 sites in SA.

For most practitioners interviewed at the local government level, a key driver for the implementation of WSUD was to 'do the right thing' when the opportunity arose. For example, several local governments 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 storm water runoff.

4.1.2.1 Flow management

Flow management was a key driver for a majority of projects. For instance, some WSUD features, such as wetlands, were constructed as an advanced form of stormwater detention. Other features, such as permeable paving, offer a solution for stormwater runoff management when underlying soils were appropriate and access to conventional drainage was difficult. However, even in projects which were ostensibly a harvesting project, flow management represented a primary or additional driver. It should be noted however that there were few instances where the benefits of flow management using WSUD have been quantified in the South Australian environment.

4.1.2.2 Availability of Funding

Availability of funding is an important driver for a majority of WSUD schemes, from streetscape to large development schemes. In the experience of council practitioners, large schemes predominantly undergo detailed design and planning, which includes an analysis of life cycle costs including maintenance costs, and tend to be able to attract grants and funding from State and Federal government. However, funding opportunities for smaller scale localised stormwater schemes are rare, and councils have had to be creative in resourcing such projects by integrating small stormwater schemes with other council upgrade and maintenance projects, such as road upgrades, or into large scale stormwater harvesting projects. For example, during the drought conditions of the mid-2000s there were funding opportunities available for stormwater harvesting schemes. Some local councils considered the lack of adequate flood management as a primary concern and used the opportunity to incorporate flow management works into harvesting projects, thus achieving both objectives.

4.1.2.3 Cost effectiveness

In some circumstances, practitioners have incorporated WSUD measures into developments based on cost effectiveness. Cost advantages have been reported to be associated with a reduction in design and installation costs for urban drainage works, reduced mains water use or to avoid the cost of upgrading infrastructure which is reaching capacity. For example, WSUD measures were reported to be adopted throughout one medium size urban development because they were more cost effective than conventional drainage works. The implementation of inner urban roadside stormwater interceptions schemes was also driven by a desire to avoid more intensive drainage upgrade works. In both circumstances, practitioners had concerns with long term maintenance; local governments do not have specific funding allocated for maintenance of WSUD features, except for larger scale wetland systems.

Extensive and (as perceived by interviewees) unpredictable cost increases for mains water was suggested as a driver for some local governments to adopt alternative water sources for non-potable usage, which was also associated with the water consumption reduction targets for some of the councils as part of the '30 year plan'. Where harvesting has been undertaken at a larger scale, practitioners prefer larger industrial customers for the recycled water scheme due to more efficient economic return on investment in distribution infrastructure. The majority of local governments undertaking investment into water harvesting schemes saw reduced reliance on mains as a primary driver. Independence was seen as important following water restrictions, particularly for open space irrigation during the recent drought which led to 'browning' of local recreational open space. Several local governments involved in water harvesting schemes considered such systems as an investment. This was however contradicted by one particular local government, who indicated that it was not profitable to run a recycling water business, even though economic return was the major interest of this proponent approximately 15 years ago when the scheme started.

There appeared to be two main approaches to large scale harvesting. Some operators are heavily focussed on building up the base of external customers. Most however, see the council itself as the biggest customer of the harvesting scheme. It is not clear whether this is merely a product of projects being in their early stages or whether this may be attributable to the initial aims of the scheme.

4.1.2.4 Amenity

Inner urban councils have specific drivers for vegetated systems. For example, several inner city councils are focussed on improving water quality in the River Torrens and improved urban amenity in the developed landscape. Other inner urban councils are strongly focussed on incorporating amenity by way of vegetation in the developed landscape and are looking at innovative ways to use WSUD techniques as a form of passive irrigation to support growth of street trees and other vegetation.

4.1.2.5 Role of 'champions'

A particularly strong driver for WSUD implementation is the role of champions in different councils who have a strong passion for innovative and sustainable stormwater management. At the City of Salisbury, early initiatives by staff in the 1970s led to significant sustainable storm water management projects being undertaken in this LGA at the present time. The installation of constructed wetlands at the Paddocks in 1975 was considered the first of its kind in Australia. Success led to the further implementation of WSUD technologies over time. Small groups of WSUD 'champions' are still driving much implementation of WSUD in South Australia at the current time by encouraging the incorporation of projects into existing works or by opportunistically applying for funds when they become available.

One observation made during the interview process was the official role of staff involved with the implementation of WSUD. These tended to be engineers whose responsibility was primarily stormwater management with a particular emphasis on flood (minor and major) management. As a result the influence of WSUD uptake tended towards projects involving larger developments or council stormwater upgrade projects. In one instance a council staff member who was responsible for traffic management was also responsible for WSUD in streetscapes, resulting in what appeared to be a well-planned schedule of implementation and maintenance.

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.

4.1.2.6 Policy

Policy plays an important role in the implementation of WSUD across Adelaide. 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. It was considered important in the early implementation of allotment detention schemes to allow for standard solutions which are available 'off the shelf' rather than leave the individual developer to propose a mechanism for each allotment. It should be noted however that in one local government area, detention tanks were found to be retrospectively sealed by residents and connected for in house reuse as if the detention tank were a rainwater tank.

4.1.2.7 Negotiation

Several local government representatives indicated that the ability to directly negotiate WSUD outcomes with developers was 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.

Interviews with representatives from the development industry had similar outcomes. There was a preference expressed for having 'looser' policy requirements for WSUD such that developers actively negotiate the WSUD outcomes for each site on a case-by-case basis rather than having a blanket 'deemed-to-comply' style requirement on development.

4.1.3 Design and Implementation

It was found that 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 however tended to require a scale and level of expertise which requires external construction services.

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, with little further detail given on what can be included to make up this 'middle ground'. This led many practitioners to consult WSUD guidelines from elsewhere, such as those provided by Melbourne Water (2005).

Design and implementation issues have benefited from engagement across council boundaries. Some local government entities have acquired a reputation based on their experience in the field of WSUD. For example, design details for significant stormwater harvesting schemes in one council area have been informally assessed by other councils with more experience in design and operations. The success of the Waterproofing the East project to the present is also evidence of the benefits of councils working together to achieve WSUD outcomes.

4.1.4 Post implementation aspects

4.1.4.1 Maintenance

Maintenance of WSUD features is a big issue of concern for WSUD practitioners. There were few practioners that reported formal maintenance procedures in place for smaller scale systems. Generally, small scale features such as tree pits and streetscape bioretention works were monitored post-construction by local government landscape staff in a semi-formal manner, with assessment based on a visual inspection of plant growth.

Many small scale systems receive almost no maintenance as they lack a fixed maintenance regime or budget after completion. For instance, some examples of system failure due to lack of maintenance and inappropriate construction timing were presented for permeable paving. While most practitioners interviewed were aware of maintenance requirements and were aware of specific equipment for cleaning permeable pavement surfaces, there did not appear to be any uptake of such services nor knowledge of whether such services were available in Adelaide. Practitioners were however aware of the problems associated with a lack of dedicated maintenance and had intentions to improve this aspect of implementation. Some practitioners were actively beginning to propose separate maintenance budgets for larger scale projects.

Larger scale WSUD schemes, such as harvesting projects, were found to be subject to more formal maintenance requirements. This is because the implementation of larger scale harvesting schemes was undertaken with an understanding that some portion of staff time was required for maintenance and reporting to state government entities. In large scale ASR harvesting schemes for example, maintenance was a continuous process with pumps and electrical equipment noted as the largest maintenance issue.

The upkeep of sub-optimal WSUD systems was considered an issue of concern where local government has inherited WSUD installations from developers. For example, some local governments have inherited the maintenance requirements of what are considered inappropriate water features which may appear to be WSUD but are in fact a net consumer of water with amenity value only. These include lake installations which have a high aesthetic value but are subject to high evaporation and require filling.

Stormwater swales have been particularly reported to have issues regarding post-implementation maintenance. This is mainly attributed to receiving runoff from too large an area or unplanned disturbance to the surface configurations due to parking of vehicles which affects their functionality and contributes to pollutant export rather than treatment.

A further notable issue regarding maintenance was the concept of ownership - who owns stormwater, and what upstream is the responsibility of an upstream catchment manager where water is harvested by an authority downstream? The quality and quantity of flows into harvesting schemes has been perceived by scheme operators to be negatively impacted by what are considered to be inappropriate water quantity and quality requirements in place by upstream authorities. However, the need to manage water quality and quantity for downstream harvesting schemes is considered to be a significant task for catchment managers who do not receive any return on investment.

4.1.4.2 Monitoring and Performance Assessment

In some cases, monitoring and maintenance of WSUD features is required as a legislated requirement. For example, ASR scheme operators are required to submit water quality monitoring results prior to injection to the aquifer store as an EPA licensing requirement. Similar requirements for monitoring exist for wastewater reuse schemes. However, in the absence of legal or licensing requirements, most systems lack monitoring of water quantity and quality and their performance has not been formally verified, although positive impacts have been anecdotally reported (such as reduced flooding, improved water quality at the catchment outlet).

Some councils have undertaken random water quality sampling from local WSUD sites in an attempt to quantify performance. These include swale systems and bio-retention systems. There have been reports of noticeable flow improvements and flood reductions in areas which have installed WSUD features for flow management, suggesting that systems are performing effectively, however their performance has not been formally quantified. Other observations from areas which drain to the coast suggest improvements in sea grass and water quality in regions including the Barker Inlet which were attributed to the upstream water conservation and quality management activities.

4.1.4.3 Capacity Building

Practioners noted that WSUD features were commonly over engineered in the learning phase due to lack of experience, however these features are being rectified in future designs. Further issues were associated with unfamiliarity of design intent during construction. For example, construction crews are generally used to designing stormwater collection systems with a definite 'low point' where water flows. This has resulted in several bio-retention basin installations with depressed overflow points, thus reducing the effective storage volume at the surface of the system which compromises overall performance.

WSUD practitioners interviewed so far have varied in their internal capacity for WSUD and technical knowledge exchange between local government representatives was characterised as being limited. However, knowledge exchange was noted to occur with large scale schemes; there were several practitioners who cited examples of large scale projects which were planned by local government in communication with consultants and reviewed on an in-kind basis by staff from other local governments who were experienced in design and operation of similar works.

4.1.5 Community involvement:

Community awareness and engagement has been recognised as an important enabler for the implementation and long-term performance of WSUD features in academic literature (Tjandraatmadja et al. 2008). This has also been reflected in the experiences of practitioners. Most local governments adopt some form of community engagement programs for local residents which may be affected by upcoming WSUD projects. In a general sense, some local governments reported that community-wide survey works have been undertaken by telephone on behalf of the council by independent consultants. They found that water management was a high priority in the community.

At the project level, community engagement varies according to project scale. For larger projects, community engagement is achieved through formal public consultation. For smaller projects, less intensive consultation was reported, such as news items in community newsletters, direct mail-outs to residents affected by construction and face-to-face consultation with the public at the project site. In most circumstances, little feedback was reported by practioners. The on-site consultation was considered effective by those who used this technique as it led to good feedback from the public. This may be due to the need to explain the concept of sustainability in a stormwater context, as well as attracting people who had a particular interest in the site in the first place.

Some councils mentioned that there is a community of residents who prefer to have everything remain at a particular standard, and those residents tend to respond negatively if something unfamiliar happened in their front yards. As a result, those councils prefer to adopt subsurface WSUD systems, which allow them to meet the water management criteria, and which are less noticeable by residents post-construction. The heritage status of specific localities also seems to be a sensitive issue and at times an impediment to WSUD.

Lack of awareness by residents has also been an issue; there is evidence of augmentation or complete removal of smaller scale bio-retention systems in some developments which has been attributed to a lack of awareness of the intended function of the system. In some circumstances, intrusive maintenance on WSUD systems such as wetlands by draining and excavating collected sediment to design levels has caused complaints. Community opposition was based on negative impact on local flora and fauna habitat. In this case, the community expectations of the system have grown to expect a natural, undisturbed system, as opposed to the original intention which was to produce a sustainable engineered treatment mechanism with benefits in terms of flora and fauna habitat.

In addition to wetland maintenance, the repair of faulty systems has also caused issues in the community. In one circumstance, the repair of a blocked detention basin, which was perceived by the community to be a permanent water feature, resulted in complaints when the blockage was removed the basin restored to its empty state. In response to concerns, the local government are exploring a rise in the outlet weir of the detention basin to produce a functional basin with a permanent storage capacity.

Significant benefits from ongoing community engagement have been experienced by councils. Several local government representatives considered community involvement as a key criterion for open space maintenance. These include community actions groups and council-led volunteer organisations who contribute to routine maintenance of WSUD feature amenity amongst other routine activities.

The incorporation of bio-retention basins in commercial sites like service stations and a fast food outlet were considered a success by practitioners, as the commercial enterprise tends to market the aesthetics aspect of WSUD to attract the public, which might also encourage other developers, or indeed other franchises of these commercial entities, to adopt similar features. Similar experiences have also been observed in Tasmania where corporate and commercial sites have adopted WSUD and adopted the promotion of such features to the public as part of their corporate and environmental credentials (Chrispijn and Weise 2012).

Several practioners raised concerns over equity issues associated with council wide implementation of WSUD. Only newer and typically more expensive developments are able to afford WSUD technologies like permeable pavements and vegetated street scapes. This was also reflected in the experience of councils which had a larger demographic of people with a low socio-economic status and as such could be limited in resources for WSUD innovation.

4.1.6 Impediments and solutions

4.1.6.1 Impediments

A significant impediment to WSUD lies in a lack of commitment at the policy level. For most local government stakeholders, 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. Most small scale developers do not have adequate open space available for WSUD features. Developers at the cluster scale in flood prone areas tend to prefer detention and sedimentation basins as a solution. This was attributed to issues of cost and known design practice by smaller engineering consultants who conduct design for smaller scale systems and may not have the capacity for planning, designing and adopting WSUD alternatives.

Unquantified externalities and difficulty in assessing the long term benefits, due to lack of monitoring, prevents councils from allocating a firm business case for WSUD projects. While local governments find it difficult to obtain extra maintenance budget for these features, developers stand back from such initiatives due to the fear of a ‘cost burden’.

Lack of capacity across the council from planning to engineering and landscape maintenance is another major impediment in the uptake of WSUD in SA. Most practitioners in local government were in the process of experimenting with the design of WSUD features with the intent of building capacity and learning from mistakes.

Major challenges in the implementation of WSUD involving biofiltration systems include selection and acquisition of adequate soil media for measures with infiltration, selection of locally appropriate vegetation, scale of structure per unit area and suitable areas for installing water management schemes. The selection and acquisition of suitable filter media was regularly mentioned to be a major issue in SA. Use of improper filter media may lead to a reduced service life for systems that require imported soil media. Currently, the most common source of filter media for street scale systems in Adelaide is from a commercial entity (or their representatives) who are trying to replicate soil filter media guidelines from FAWB (FAWB, 2009) as best they can with the resources available.

Plant selection also tends to be somewhat ad-hoc in some projects. Stakeholders have varying preferences for vegetation based on competing demands for species which:

- Are known to have water quality benefits based on literature from experience in SE Queensland, Sydney and Melbourne conditions;
- Are indigenous to their area of application;
- Are suitable for streetscapes with long, hot and dry summers and wet winters

Underground services also tend to be a significant design issue, especially for the street scale retrofit systems. Iterative designs have been undertaken by some practitioners to develop standard designs to avoid existing services. It is also important that construction crews take extra care in excavation works for bio-retention pits, to prevent damage to the existing pipes.

Terrain is a significant impediment to WSUD in some areas of SA. For example, steep slopes pose a challenge as most WSUD is not considered suitable in sloped environments. In addition to slope, there is also the issue of adequate soil conditions. Several areas of Adelaide are affected by a reactive clay substrate which discourages the use of infiltration measures, for example. In addition to this, rainfall tends to occur in the winter months throughout Adelaide, which is when these clays quickly become saturated.

4.1.7 Suggestions for WSUD Uptake

4.1.7.1 Development charges

Practitioners were asked about their general opinions on how WSUD might be further implemented in SA. Most practitioners 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. The City of Onkaparinga's experience also reflected positively on this as a means to provide financial resources that would be dedicated to WSUD adoption in priority catchments.

4.1.7.2 Develop capacity in WSUD maintenance

The need for effective maintenance guidelines appropriate for Adelaide was flagged by some local government representatives. Moreover, the need for a capacity building program for all stakeholders involved in WSUD was mentioned by most practitioners. For example, the lack of capacity was seen as a cause of incidences where the landscape maintenance workers cut down vigorously growing vegetation in a bio-retention system due to ignorance of their importance. It should be noted that the Adelaide and Mount Lofty Ranges Natural Resource Management Board has instigated a WSUD capacity building initiative for South Australia.

4.1.7.3 Legislation and policy as drivers

Meanwhile others would like to see formal recognition of WSUD as a development requirement in planning legislation. The latter would allow councils to have the power to control development more stringently than they currently can.

Some representatives suggested improving the development assessment process with a series of steps where WSUD is flagged based on the development proposal being considered. Practitioners would like to also see recognition of small scale options for WSUD in planning requirements because these are the only available solutions for infill development scenarios.

It was also found that practitioners saw a need to reduce the reliance on the use of one or a handful of 'champions' within each organisation to encourage the uptake of WSUD measures; this was perceived to be a risk because of the potential for staff to leave the organisation without a formal recognition, plan or guideline for WSUD implementation.

Hence, according to practitioners there seemed to be a strong need for WSUD to be led from the State government level and taken as a State leadership option. Practitioners generally indicated that if WSUD was made mandatory in the planning phase of the project in some way or other, 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. In the words of one practitioner, 'It would be good to follow the Melbourne model 'living rivers program' in terms of easy and effective funding opportunities for WSUD'.

4.1.7.4 Mechanisms for better coordination and integration of WSUD across catchments

The need for criteria in storm water management plans was expressed as a concern for catchments that span across council jurisdictions. Specifically, the need to maintain low flows in streams as a significant feature of creek health was also identified by some local government representatives.

Since almost all local governments are involved in the WSUD schemes at some level or another, it was indicated that some boundary rule would be beneficial where individual councils could force upstream councils to introduce infrastructure to manage their quality and quantity of flow. For example, operators of larger water harvesting schemes expressed concern that upstream catchment management was lacking in several respects, leading to the risk of harvesting water that was not sufficient for storage via ASR. The inability to control water quality beyond local government boundaries in these circumstances was seen as a frustrating issue to manage.

4.1.7.5 Measuring WSUD benefits and costs

Almost all practitioners indicated a need for quantifying the benefits of WSUD to have a realistic idea of how much a WSUD project may cost, including maintenance needs and any beneficial outcomes. Furthermore, there was general interest in determining 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.

4.2 Discussion

The inventory shows that the uptake of WSUD in South Australia has historically been characterised by the predominance of stormwater management features adopted by councils. This trend continues to the present, with flow management remaining as one of the primary drivers for WSUD uptake in councils, particularly with the objective to control flooding and peak flows. This is considered to be a trend likely to continue with the projected growth in impervious surfaces with future development in greater Adelaide.

However, WSUD is most commonly adopted to achieve multiple benefits such as flow management and the security of an additional water resource and water quality improvement. Other significant benefits include lower initial expense and amenity. WSUD has also been driven by changes in mains water supply policy, which have resulted in price increases and restrictions to use.

The type of WSUD solution 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) (ii) the technical capacity and expertise of proponents and (iii) policy support at the state or local level.

The current inventory shows that WSUD uptake has been driven by councils, with few exceptions. This partly reflects the sample composition of WSUD practioners interviewed so far, which is predominantly comprised of local government representatives. However the limited WSUD implementation by private developers (residential and commercial) also reflects the lack of incentives by this group to adopt such practices unless encouraged by policy or negotiation during the development approval process. Further investigation of the barriers for WSUD uptake from the developer's perspective and the effectiveness of push or pull strategies will be further explored in subsequent stages of the project.

The interviews with local government representatives also indicate a fragmented nature of WSUD implementation across councils, characterised by individual trial and error initiatives, self-learning and in-house development of expertise. This is often dependent on the level of expertise available from consultants engaged in the design and construction of projects. As a result, the level of expertise, whilst evolving across councils, varies markedly from one council to another and within individual departments. WSUD is still largely dependent on individual champions for ongoing implementation. This was also reflected in the processes for WSUD implementation. Councils which have had more experience with WSUD have typically learned from their systems and developed either formal or informal mechanisms for improving implementation and gathering internal support for WSUD. Yet transfer of lessons across LGAs, whilst potentially beneficial for WSUD capacity building, is not a common or formal practice.

Access to resources or funding for implementation and more importantly for on-going maintenance of WSUD features is a challenge for various councils and has required resourcefulness by councils. Examples were provided by some councils of combining WSUD implementation with road upgrades and of tailoring WSUD objectives to access State or federal funding for capital works. On the other hand there were few examples of strategies for on-going funding for operation and maintenance of WSUD features, and only one of the representatives interviewed reported the collection of a levy for WSUD projects from developers, the remainder seeking funds among other council operations, typically landscaping or vegetation management. However, all councils seemed interested in gaining better understanding on the development of better funding strategies and justification. The uncertainty in on-going costs is also seen as a deterrent for uptake in some LGAs.

The fragmented nature of WSUD uptake also 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 may require a level of overall planning coordination across shared catchments.

It is noted that this project has examined the types and number of WSUD systems across South Australia. However, it is important to acknowledge that the catchment/application area managed by the WSUD systems may influence the number of individual devices implemented. For example, the implementation of large scale "end of pipe" WSUD systems in some areas (such as constructed wetlands for treatment and harvesting or recycled water distribution schemes) may discourage the implementation of small scale systems. This may have influenced the number of WSUD devices in South Australia.

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6 Appendix A – Interview Guide

Questionnaire:

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?

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?
- 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 ?

Post-Implementation:

- Were these WSUD features been initially monitored?
- How could you rate their performance efficiency?
- Who conduct 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?

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!!

7 Appendix B – Inventory of WSUD sites in South Australia

The following table represents the list of South Australian WSUD sites identified by the project team (current to 28th February 2013). Please note that this list is preliminary - at the time of writing, the list was being reviewed by practioners to identify any sites that were not captured, or data that may need to be amended.

In addition, it should be noted that some data aggregatation has been undertaken with respect to development type due to limited space. Further information, including a brief description and co-ordinate location for each scheme will subsequently be made available in an electronic format.

Table 2: List of WSUD sites in SA

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
1	Acacia Terrace Wetland, Aldinga Beach	City of Onkaparinga	400-600	n/a	Wetland, ASR	Flow	1997	Retrofit	n/a	n/a
2	Adams Creek or Olive Grove Wetland	City of Playford	400-600	sw	Wetland, ASR	Conservation, flow	2007	Retrofit	n/a	n/a
3	Adelaide airport stormwater scheme	Other	400-600	sw	Harvest and ASR	Conservation	2013	Retrofit	n/a	n/a
4	Adelaide Botanic gardens	DEWNR	400-600	sw	Wetland, ASR (extract flow)	Conservation	2013	Retrofit	n/a	n/a
5	Adelaide Zoo	Other	400-600	n/a	Bioretention, infiltration, green roof	Flow, quality	2009	Retrofit	n/a	n/a
6	Airport Drain Wetland	City of West Torrens	400-600	n/a	Wetland	Quality	2007	Retrofit	n/a	n/a
7	Aldinga Eco village	Other	400-600	sw	Tanks	Conservation	Ongoing	Greenfield	Low	Medium

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
8	Andrews Farm South Wetlands	City of Playford	400-600	sw	Wetland, ASR	Conservation, flow	Ongoing	Retrofit	n/a	n/a
9	Barker Inlet Wetlands, Dry Creek	City of Port Adelaide Enfield	400-600	sw	Wetland, ASR	Quality	2013	Retrofit	n/a	n/a
10	Beachway Avenue, Brooklyn Park	City of West Torrens	400-600	n/a	Bioretention	Flow, quality	2010	Retrofit	n/a	n/a
11	Beadnall Terrace, Glengowrie	City of Marion	400-600	n/a	Bioretention	Water quality	2008	Retrofit	n/a	n/a
12	Bennett Road Drain, Mawson Lakes	City of Salisbury	400-600	sw	Wetland, ASR	Conservation, flow	2010	Retrofit	n/a	n/a
13	Beyond Development, Hayborough	Alexandrina Council	400-600	rw	Bioretention, wetlands	Flow, quality, conservation	Ongoing	Residential	Low	Mediu m
14	Stonehouse Drive, Camden Park	City of West Torrens	400-600	n/a	Biofiltration	Flow, quality	2011	Retrofit	n/a	n/a
15	Bolivar WWTP -	Other	400-600	ww	wastewater	Conservation	1999	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	Virginia Pipeline				reuse					
16	Break Out Creek Wetland, West Beach	City of West Torrens	400-600	sw	Wetlands	Flow, quality	1999	Retrofit	n/a	n/a
17	Brodie Road Reserve Wetland, Seaford Meadows	City of Onkaparinga	400-600	sw	Wetland, ASR	Conservation, flow	2012	Retrofit	n/a	n/a
18	Bulkana Oval, Banksia Park	City of Tea Tree Gully	600-800	sw	Bioretention, Tank	Conservation	2009	Retrofit	n/a	n/a
19	Burnside B-pods	City of Burnside	600-800	n/a	Infiltration (OSR Pods)	Flow	Ongoing	Retrofit	n/a	n/a
20	Caltex Marion Road, Marion	Other	400-600	n/a	Bioretention	Flow, quality	2012	Commercial	n/a	n/a
21	Carolyn Grove, Athelstone	Campbelltown City Council	400-600	sw	Infiltration (passive irrigation)	Flow	2010	Retrofit	n/a	n/a
22	Cheltemham/St Clair Wetlands	City of Charles Sturt	400-600	sw	Wetland, ASR	Conservation, Flow	Ongoing	Residential	Medium	Large
23	Clairville Road,	Campbelltown City	400-600	n/a	Bioretention	Quality	2005	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	Campbelltown	Council								
24	Claremont Avenue, Netherby	DPTI, UniSA and Treenet	600-800	sw	Infiltration (passive irrigation)	Flow	2003	Retrofit	n/a	n/a
25	Cooke Road/Riverside Golf Course	City of Charles Sturt	400-600	sw	Wetland, ASR	Conservation	2013	Retrofit	n/a	n/a
27	Doughty Street, Mt. Gambier	City of Mount Gambier	600-800	n/a	Infiltration (Swale), Bioretention	Flow	2008	Retrofit	n/a	n/a
28	Dunstone Grove Linde reserve, Stepney	City of Norwood, Payneham and St Peters	400-600	sw	Biofilters, reuse, ASR	Conservation	2012	Retrofit	n/a	n/a
29	Edinburgh Parks South Wetland	City of Salisbury	400-600	sw	Wetland, ASR	Conservation	2003	Retrofit	n/a	n/a
30	Evanston South	Town of Gawler	400-600	n/a	Wetland	Flow	Ongoing	Residential	Low medium	Large
31	Fletcher Lane, Woodville North	City of Port Adelaide Enfield	400-600	n/a	Permeable paving	Flow, quality	1999	Retrofit	n/a	n/a
32	Frank Smith Park Wetland,	City of Onkaparinga	600-800	n/a	Wetland	Quality	2001	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	Craigburn Farm									
33	Franklin Street, Adelaide	Adelaide City Council	400-600	n/a	Bioretention	Flow, quality	2010	Retrofit	n/a	n/a
34	Glenelg Golf Club ASR	Other	400-600	sw	Wetland, ASR	Conservation	2011	Retrofit	n/a	n/a
35	Glenelg Golf Club entrance	Other	400-600	n/a	Permeable paving, bioretention	Flow, quality	2011	Retrofit	n/a	n/a
36	Glenelg WWTP (GAP)	Other	400-600	ww	wastewater reuse	Conservation	2010	Retrofit	n/a	n/a
38	Glynde Corner biofilter	City of Norwood, Payneham and St Peters	400-600	n/a	Biofiltration	Flow, Quality	2012	Retrofit	n/a	n/a
39	Goldenfields Reserve, Golden Grove	City of Tea Tree Gully	400-600	n/a	Swale, Bioretention, Wetland	Flow, quality	2007	Retrofit	n/a	n/a
40	Goodman Crescent, Adelaide University	Other	400-600	sw	Reuse, Wetland	Conservation	2006	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
42	Goolwa Beach carpark	Alexandrina Council	400-600	n/a	Bioretention	Flow, quality	2007	Retrofit	n/a	n/a
43	Goolwa North Wetlands	Alexandrina Council	400-600	n/a	Wetland	Flow, quality	2011	Retrofit	n/a	n/a
44	Grange Golf Club Wetlands	Other	400-600	sw	Wetland, ASR	Flow, quality	2006	Retrofit	n/a	n/a
45	Greentree Walk, Paralowie	City of Salisbury	400-600	n/a	Wetland, bioretention, permeable paving, reuse	Flow, cost	Ongoing	greenfield	Medium?	Medium
46	Greenfields Wetlands	City of Salisbury	400-600	n/a	Wetlands	Quality	1995	Retrofit	n/a	n/a
47	Grote Street, Adelaide	Adelaide City Council	400-600	sw	Infiltration	Flow, conservation	2010	Retrofit	n/a	n/a
48	Harbrow Grove Reserve, Seacombe Gardens	City of Marion	400-600	sw	Flow, reuse, pond	Conservation, flow	2011	Retrofit	n/a	n/a
49	Hart Road, Aldinga Beach	City of Onkaparinga	400-600	sw	Wetland, ASR	Flow, quality	2013	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
50	Henley Annexe, Henley Beach	City of Charles Sturt	200-400	sw	Infiltration	Flow	1999	Infill	Low	Cluster
52	James Coke Park, Norwood	City of Norwood, Payneham and St Peters	400-600	sw	Reuse, Infiltration	Conservation		Retrofit	n/a	n/a
53	Jobson Road Wetland, Bolivar	City of Salisbury	400-600	sw	Wetland, ASR	Conservation	Ongoing	Retrofit	n/a	n/a
54	Kaurna Park Wetlands, Burton	City of Salisbury	400-600	sw	Wetland, ASR	Conservation	2003	Retrofit	n/a	n/a
55	King William Street, Adelaide	Adelaide City Council	400-600	n/a	Infiltration	Flow, conservation	2010	Retrofit	n/a	n/a
56	Kersbrook CWMS Reuse	Adelaide Hills Council	800+	ww	wastewater reuse	Conservation	Proposed	Retrofit	n/a	n/a
57	Kingfisher Wetland, Modbury Heights	City of Tea Tree Gully	400-600	sw	Wetland, ASR	Conservation	2007	Retrofit	n/a	n/a
58	Kingsford Regional Industrial Estate	Town of Gawler / Light RC	400-600	n/a	Detention basin	Flow	Ongoing	Industrial	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
59	Kirkcaldy Avenue, Grange	City of Charles Sturt	400-600	n/a	Permeable pavement	Flow, quality	1999	infill	n/a	n/a
60	Laratinga Wetlands, Mt Barker	DC of Mount Barker	600-800	n/a	Wetland	Quality	1999	Retrofit	n/a	n/a
61	Permeable Pavement, Largs North	City of Port Adelaide Enfield	400-600	n/a	Permeable pavement	Flow	1999	Retrofit	n/a	n/a
62	Lew Street basin, Netley	City of West Torrens	400-600	n/a	Infiltration (Swale)	Flow	2006	Retrofit	n/a	n/a
63	Linden Gardens car park, Burnside	City of Burnside	600-800	sw, rw	Permeable pavement	Conservation, quality, flow	2003	Infill	n/a	n/a
64	Lochiel Park	Campbelltown City Council	400-600	rw, sw, ww	bioretention, Wetland, reuse (ASR)	Conservation, quality, flow	2013	Infill	Low-medium	Mediu m
65	Magazine Creek Wetlands, Gillman	City of Port Adelaide Enfield	400-600	sw	Wetland	Quality	1998	Retrofit	n/a	n/a
66	Marion Cultural Centre, Oaklands	City of Marion	400-600	sw	reuse	Conservation	2001	Commercial	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	Park									
67	Mark Lane West Wetlands, Goolwa	Alexandrina Council	400-600	n/a	Wetland	Flow, quality	2001	Retrofit	n/a	n/a
68	Maude Street, Victor Harbour	City of Victor Harbour	400-600	n/a	Wetland	Flow, quality	2006	Retrofit	n/a	n/a
69	Max Amber Sports field, Athelstone	Campbelltown City Council	400-600	sw	ASR (River extraction)	Conservation	2003	Retrofit	n/a	n/a
70	Mile End retrofit	City of West Torrens	400-600	n/a	Bioretention	Flow, quality	2012	Retrofit	n/a	n/a
71	MM Building, UniSA	Other	400-600	n/a	permeable paving, reuse, green roof	Flow, quality	2012	Commercial	n/a	n/a
72	Morphettville Racecourse Wetland	Other	400-600	sw	Wetland, ASR	Conservation	2002	Retrofit	n/a	n/a
73	Morrow Road ponds, Christies Beach	City of Onkaparinga	400-600	n/a	treatment ponds	water quality, flow	2010	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
74	Mt Compass streetscape	Alexandrina Council	800+	n/a	Bioretention	Flow, quality	2013	Retrofit	n/a	n/a
75	Mt Compass Wetlands	Alexandrina Council	800+	sw	Wetlands	Flow, quality	2012	Retrofit	n/a	n/a
76	Munno Para West Wetlands	City of Playford	400-600	sw	Wetland, ASR	Conservation	2009	Retrofit	n/a	n/a
77	Murchison Street, Mansfield Park	City of Port Adelaide Enfield	400-600	sw	Bioretention	Quality	2012	Retrofit	n/a	n/a
78	New Brompton Estate, Brompton	City of Charles Sturt	400-600	sw	Infiltration, passive ASR	Conservation	1996	Infill	Medium	Medium
79	New Haven Estate, Largs North	City of Port Adelaide Enfield	400-600	sw, ww	ww reuse	Conservation	1997	Infill	Medium	Medium
80	Concerete kerbing, Henley Beach	City of Charles Sturt	200-400	n/a	Infiltration (No fines concrete)	Flow, passive irrigation	2009	Retrofit	n/a	n/a
81	Normanville CWMS Reuse	DC of Yankalilla	400-600	ww	wastewater reuse	Conservation	Ongoing	Retrofit	n/a	n/a
83	Northgate	City of Port Adelaide	400-600	sw	Wetland, ASR	Conservation	Ongoing	Greenfield	Low medium	Large

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	Wetland and ASR	Enfield								
84	Nyrstar, Port Pirie	Other	200-400	ww	wastewater reuse	Conservation	2012	Retrofit	n/a	n/a
85	Oaklands Railway Station	DPTI	400-600	n/a	Infiltration (Swale), Bioretention	Flow	2009	Retrofit	n/a	n/a
86	Old Port Road Wetlands, Hendon	City of Charles Sturt	400-600	sw	Wetland, ASR	Conservation, Flow	2013	Retrofit	n/a	n/a
87	Orleanna Waters (Evanston)	Town of Gawler	400-600	n/a	Wetland, ASR	Flow	Ongoing	Residential	Low medium	Large
88	Parafield Railway Station	City of Salisbury	400-600	sw	Bioretention, Tank	Conservation, flow	2008	Retrofit	n/a	n/a
89	Parafield Wetlands	City of Salisbury	400-600	sw	Wetland, ASR	Conservation	2002	Retrofit	n/a	n/a
90	Parfitt Square, Bowden	City of Charles Sturt	400-600	sw	Infiltration, passive ASR	Conservation	1997	Infill	Low	Cluster
91	Dorset Avenue, Colonel Light	City of Mitcham	400-600	sw	Infiltration	Flow	2008	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	Gardens									
92	East Parade Treenet, Kingswood	City of Mitcham	400-600	sw	Infiltration	Flow	2009	Retrofit	n/a	n/a
93	Letchford St Reserve, Bedford Park	City of Mitcham	400-600	sw	Infiltration	Flow	2009	Retrofit	n/a	n/a
94	Sturt Avenue, Colonel Light Gardens	City of Mitcham	400-600	sw	Infiltration	Flow	2010	Retrofit	n/a	n/a
95	Pathways, Murray Bridge	City of Murray Bridge	200-400	n/a	Wetland	Flow, quality	2013	Residential	Low	mediu m
96	Peacock Road, Adelaide	Adelaide City Council	400-600	n/a	Bioretention	Flow	2012	Retrofit	n/a	n/a
97	Permeable Pavement laneways	City of Charles Sturt	200-400	n/a	Permeable pavement	Flow	2010	Retrofit	n/a	n/a
98	Permeable pavement, Morphett Vale	City of Onkaparinga	600-800	sw	Permeable pavement, reuse	Flow, conservation	2010	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
99	Pine Lakes Estate, Parafield Gardens	City of Salisbury	400-600	sw	Wetland, ASR	Conservation	2001	Infill	Low	Medium
100	Plympton Church Waterless Garden	Other	400-600	sw	Infiltration (passive irrigation)	Conservation	1997	Retrofit	n/a	n/a
101	Point Boston Peninsula	Other	400-600	rw, ww	Rainwater tanks, wastewater reuse	Conservation	Ongoing	Greenfield	Low	Large
102	Railway Terrace, Mile End	City of West Torrens	400-600	n/a	Infiltration (Swale)	Flow	1999	Retrofit	n/a	n/a
103	Range Wetlands, Gillman	City of Port Adelaide Enfield	400-600	sw	Wetland	Quality	1998	Retrofit	n/a	n/a
104	Richards Park, Maylands	City of Norwood, Payneham and St Peters	400-600	sw	Rainwater harvest	Conservation		Retrofit	n/a	n/a
105	River Road Wetlands, Noarlunga Downs	City of Onkaparinga	400-600	n/a	Wetland	Quality	1985	Retrofit	n/a	n/a
106	Roy Amer Wetlands,	City of Port Adelaide	400-600	sw	Wetland, ASR	Conservation,	1993	Greenfield	Low	Large

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	Oakden	Enfield				flow				
108	Royal Adelaide Golf Club	Other	400-600	sw	Wetland, ASR	Conservation	2008	Retrofit	n/a	n/a
109	SA museum forecourt, Adelaide	Other	400-600	sw	Bioretention, reuse	Conservation	2005	Retrofit	n/a	n/a
110	SA Police Building, Adelaide	Other	400-600	n/a	Infiltration (swale)	Flow, quality	2011	Commercial	n/a	n/a
111	Satsuma Wetland, Golden Grove	City of Tea Tree Gully	600-800	sw	Wetland, ASR	Conservation	2007	Retrofit	n/a	n/a
112	Scotch College, Torrens Park	Other	400-600	creek	Extraction, ASR	Conservation	1989	Retrofit	n/a	n/a
113	Sellicks Beach Wetland	City of Onkaparinga	400-600	n/a	Wetland	Quality	2007	Retrofit	n/a	n/a
114	Solandra Wetland, Modbury North	City of Tea Tree Gully	400-600	sw	Wetland, ASR	Conservation	2007	Retrofit	n/a	n/a
116	Springbank	City of Salisbury	400-600	sw	Wetland, ASR	Flow, quality,	2005	Greenfield	Low	Mediu

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	Waters, Burton					conservation				m
117	Spingwood (Gawler East)	Town of Gawler	400-600	n/a	Wetland	Flow	Ongoing	Residential	Low medium	Large
118	St Elizabeth of Hungary Church, Oaklands Park	City of Marion	400-600	sw	permeable paving, reuse, passive asr	Conservation	1998	Retrofit	n/a	n/a
119	Stebonheath Park - Andrews Farm wetlands	City of Playford	400-600	sw	Wetland, ASR	Conservation	2009	Residential	n/a	n/a
120	Tea Tree Gully Golf Course	City of Tea Tree Gully	600-800	sw	ASR	Conservation	2007	Retrofit	n/a	n/a
121	The Paddocks Wetlands, Pooraka	City of Salisbury	400-600	sw	Wetland, ASR	Conservation, flow	1990	Retrofit	n/a	n/a
122	Tree Pits e.g. Bus station, Adelaide	Adelaide City Council	400-600	sw	Infiltration	Flow, conservation	2010	Retrofit	n/a	n/a
123	TREENet Pits (Various)	City of Mitcham	600-800	n/a	Infiltration (kerbside)	Flow	2011	Retrofit	n/a	n/a
124	Underdale Torrens	City of Charles Sturt	400-600	sw	ASR, flow	Conservation	2013	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	harvesting				extraction					
126	Unity Park, Pooraka	City of Salisbury	400-600	sw	Wetlands, ASR, biofilters	Conservation	Ongoing	Retrofit	n/a	n/a
127	Urrbrae Wetland	City of Mitcham	800+	sw	Wetland	Flow	1997	Retrofit	n/a	n/a
128	Valiant Road, Aldinga Beach	City of Onkaparinga	400-600	n/a	Bioretention	Flow, water quality	2010	Retrofit	n/a	n/a
129	Wadmore Park, Athelstone	Campbelltown City Council	600-800	n/a	Infiltration (Swales)	Vegetation	2008	Retrofit	n/a	n/a
130	Warraparinga Wetlands	City of Marion	400-600	n/a	Wetland	Quality	1998	Retrofit	n/a	n/a
131	Wattle Street, Fullarton	City of Unley	400-600	sw	Harvest, reuse	Flow, conservation	2012	Retrofit	n/a	n/a
133	Goyder Pavillion, Wayville Showgrounds	Other	400-600	sw	Tanks	Conservation	2008	Retrofit	n/a	n/a
134	West Street, Brompton	City of Charles Sturt	400-600	n/a	Bioretention	Flow, water quality	2011	Retrofit	n/a	n/a
135	Willunga basin co.	Other	400-600	ww	wastewater	Conservation	1999	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
					reuse					
136	Station road Wetlands, Woodside	Adelaide Hills Council	600-800	n/a	Wetland	Flow, quality		Retrofit	n/a	n/a
137	Aberdeen Park, Strathalbyn	Alexandrina Council	400-600	n/a	Wetland	Flow, quality	2009	Residential	Low	Medium
138	Frencham Lane, Strathalbyn	Alexandrina Council	400-600	n/a	Bioretention	Flow, quality	2010	Residential	Low	Cluster
139	Kessel Road Lagoon, Goolwa	Alexandrina Council	400-600	sw	Wetland	Flow, quality		Retrofit	n/a	n/a
140	Mawson Lakes	City of Salisbury	400-600	sw, ww	reuse (ASR+WW)	Conservation, flow	Ongoing	Greenfield	Low medium	Large
141	Colman Terrace carpark, Strathalbyn	Alexandrina Council	400-600	n/a	Bioretention	Flow, quality	2012	Retrofit	n/a	n/a
142	Felixtow Reserve, Klemzig	City of Norwood, Payneham and St Peters	400-600	sw	Wetland, ASR	Conservation	PROPOSED	Retrofit	n/a	n/a
143	Walkerville Terrace,	Corporation of the	400-600	sw	Infiltration	Flow,	2009	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
	Walkerville	Town of Walkerville			trench	conservation				
144	Pipers Crest, Strathalbyn	Alexandrina Council	400-600	n/a	Bioretention	Flow, quality	Ongoing	Residential	Low	Large
145	Archer Court, Strathalbyn	Alexandrina Council	400-600	n/a	Bioretention	Flow, quality	2011	Residential	Low	Cluster
146	Strathalbyn Hub, Strathalbyn	Alexandrina Council	400-600	n/a	Wetland	Flow, quality	2010	Retrofit	n/a	n/a
147	Ridge Park, Glen Osmond	City of Unley	400-600	sw	ASR	Conservation	2013	Retrofit	n/a	n/a
148	Heywood Park, Malvern	City of Unley	400-600	sw	ASR	Conservation	2013	Retrofit	n/a	n/a
149	Hamilton Boulevard, Wayville	City of Unley	400-600	sw	Bioretention	Flow, conservation	2011	Retrofit	n/a	n/a
150	Cornerstone College Wetland, Mt Barker	Other	600-800	n/a	Wetland	Flow	2010	Other	n/a	n/a
151	Old Treasury Lane, Adelaide	Other	400-600	n/a	Permeable paving	Irrigation, soil aeration	2012	Retrofit	n/a	n/a

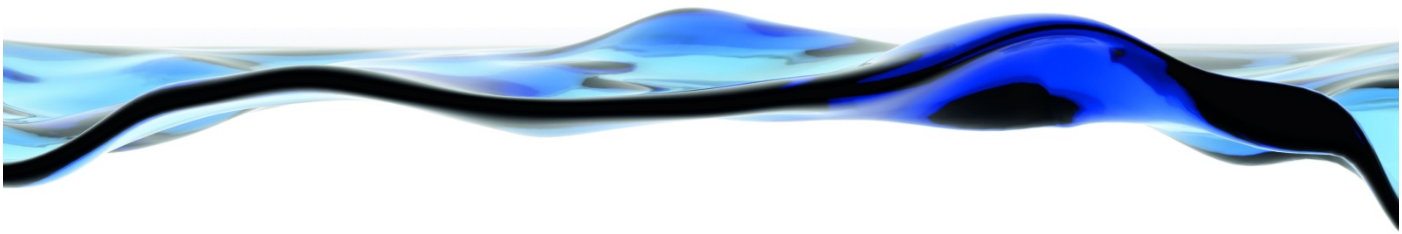
Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
152	Oaklands Wetland	City of Marion	400-600	sw	Wetland, ASR	Conservation	2013	Retrofit	n/a	n/a
153	Edinburgh Wetland, Modbury	City of Tea Tree Gully	600-800	sw	Wetland, ASR	Conservation	2007	Retrofit	n/a	n/a
154	Torrens 1 & 3 Wetlands, Dernancourt	City of Tea Tree Gully	400-600	sw	Wetland, ASR	Conservation	2009	Retrofit	n/a	n/a
155	Wastewater harvesting, Greenwith	City of Tea Tree Gully	600-800	ww	Wastewater reuse	Conservation	2010	Retrofit	n/a	n/a
156	Wynn Vale Wetland	City of Tea Tree Gully	600-800	sw	Wetland, ASR	Conservaton	2009	Retrofit	n/a	n/a
157	James Melrose Road, Novar Gardens	City of West Torrens	400-600	n/a	Bioretention	Flow, quality	2011	Retrofit	n/a	n/a
158	Galway Ave, North Plympton	City of West Torrens	400-600	n/a	Bioretention	Flow, quality	2011	Retrofit	n/a	n/a
159	Deacon Ave., Richmond	City of West Torrens	400-600	n/a	Bioretention	Flow, quality	2011	Retrofit	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
160	ANZ House	Other	400-600	n/a	Green roof	Flow	2011	Commercial	n/a	n/a
161	Tower 8	Other	400-600	n/a	Green roof	Flow	2011	Commercial	n/a	n/a
162	Royal Adelaide Hospital	Other	400-600	n/a	Green roof	Flow	2016	Commercial	n/a	n/a
163	Beadall Street wetland, Burton	City of Salisbury	400-600	n/a	Wetland	Flow			n/a	n/a
164	Churchill Road Bioretention	City of Prospect	400-600	n/a	Bioretention	Flow, quality	2010	Retrofit	n/a	n/a
164	TREENet Pits (City of Unley)	City of Unley	400-600	n/a	Infiltration	Flow		Retrofit	n/a	n/a
165	Witton Centre carpark	City of Onkaparinga	200-400	sw	Bioretention	Flow, quality	2009	Retrofit	n/a	n/a
166	Murraylands Life	Other	200-400	sw, ww, gw	Reuse	Quantity, flow, quality	Ongoing	Residential	Low	Medium
167	Kapunda CWMS	Light Regional Council	400-600	ww	Reuse	Quantity		Retrofit	n/a	n/a
168	Freeling CWMS	Light Regional	400-600	ww	Reuse	Quantity	2009	Infrastructure	n/a	n/a

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
		Council								
169	Esplanade Infiltration	City of Holdfast Bay	200-400	n/a	Infiltration	Flow		Retrofit	n/a	n/a
170	Glenelg WWTP - CHB Pipeline	City of Holdfast Bay	400-600	ww	Reuse	Quantity		Retrofit	n/a	n/a
171	The Parkway, Barossa	The Barossa Council	400-600	n/a	Bioretention, swale	Flow, Quality	Ongoing	Residential	Low	Small
172	The Barossa Council Building	The Barossa Council	400-600	rw	Swale	Flow, conservation		Commercial	n/a	n/a
173	Nuriootpa CWMS	The Barossa Council	400-600	ww	Reuse	Conservation	2010	Retrofit	n/a	n/a
174	Adelaide Workmans Homes Retrofit 1	Other	400-600	rw	Permeable paving, tank (communal)	Flow, conservation	Ongoing	Infill	Medium	Small
175	Tennyson Centre	Other	400-600	rw	Bioretention, tank	Flow, quality, concervation	2009	Commercial	n/a	n/a
176	Playford Alive - Brownfield	City of Playford	400-600	n/a	Permeable pavement, swale, infiltration	Flow, quality	Ongoing	Residential	Low	Large

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
177	Playford Alive - Greenfield	City of Playford	400-600	sw	Reuse, Wetland	Flow, conservation	Ongoing	Residential	Low	Large
178	Craigmore Creek/Blakeview	City of Playford	400-600	n/a	Permeable pavement, Infiltration	Flow	2012	Residential	Low	
179	Curtis Stebonheath wetlands	City of Playford	400-600	sw	Wetland/ASR	Conservation	2013	Retrofit	n/a	n/a
180	Northern Expressway basin	City of Playford	400-600	sw	Wetland/ASR	Conservation	2013	Retrofit	n/a	n/a
181	Mt Gambier Library carpark	City of Mount Gambier	600-800	n/a	Wetland, swales, permeable pavement	Flow, quality	2009	Retrofit	n/a	n/a
182	Lady Nelson Vistor Centre	City of Mt Gambier	600-800	n/a	Bioretention	Flow, quality	2012	Commercial	n/a	n/a
183	Cluster Communal Rainwater Tank	Housing SA	400-600	rw	Communal tank	Conservation		Retrofit	Low	Cluster
184	Christies Walk	Other	400-600	rw	tank	Flow,	2006	Residential	Medium	Cluster

Id	Site name	Organisation	Rain zone	Source Water	WSUD Types	Function/Driver	Date Complete	Development type	Development density	Scale /size
					(communal)	conservation				



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