Streetscape Scale Applications of Water Sensitive Urban Design

Recent Examples from Australian Cities

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Introduction

Water Sensitive Urban Design (WSUD) can help us achieve "green streets" in times of water restrictions. Stormwater runoff that usually flows down our drains and out to sea, can be harvested to irrigate street trees and other landscaping. At the same time, runoff can be filtered and cleaned of pollutants before returning it to aquatic ecosystems. The following paper describes current streetscape scale WSUD practices, and their recent application in Australian cities. This includes examples of both:

- Retrofitting of WSUD measures into existing urban streets, and
- Incorporation of integrated stormwater management systems into major urban redevelopment projects.

Streetscape Scale Applications

In recent years, WSUD treatments have evolved from large scale "end of pipe" solutions, such as constructed wetlands, to smaller scale applications which can treat runoff from local catchments "at source", and which can be integrated into the design of urban streets and public spaces (Wong 2006).

These smaller scale applications deliver a range of benefits. As well as protecting downstream waters through pollutant removal and retarding of stormwater flows, they can also harvest runoff for local landscape reuse, reducing the use of mains water for irrigation. They also help increase awareness of the connections between human activities and the water cycle, by making the processes more visible.

Streetscape scale WSUD applications can take a number of forms, however the most popular are bioretention systems, also known as "rain gardens", which can be scaled to confined spaces, and adapted to a range of urban situations. Bioretention systems filter stormwater runoff through a vegetated soil media layer. The filtered water is then collected via perforated pipes and discharged back into the stormwater system, or stored for reuse. Temporary ponding above the soil media, in an "extended detention zone", provides additional treatment by sedimentation. Bioretention systems, however, are not intended to function by infiltration. Treated water is returned to the stormwater system, rather than into the surrounding soil and groundwater. Bioretention systems also typically include a high flow by-pass, to capture the most contaminated "first flush" during rain events, while diverting excess flows to the main stormwater system (City of Melbourne 2005)

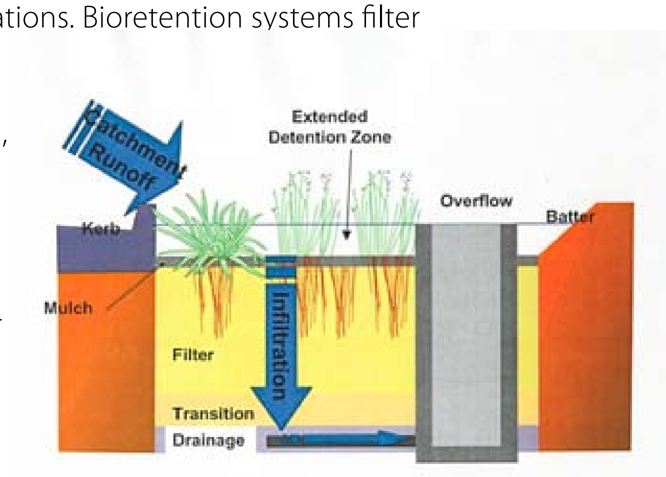

Figure 1
Typical rain garden cross section
Source: Somes &Crosby (2007)

Research

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Vegetation growing in the filter media enhances it's function in a number of ways. Plant roots help remove pollutants through a combination of physical, chemical and biological processes. They also prevent erosion of the filter media, and maintain it's porosity through continuous root growth. An appropriate filter media is therefore required, which balances the need for efficient flow through the soil profile, with the need to retain sufficient water in the soil to sustain plant growth. A wide range of plants can be used in bioretention systems, however species which tolerate periods of drought and inundation are preferred to the more aquatic species, as the former act as indicators of system failure due to clogging of the soil media (Somes and Crosby 2007).

Bioretention tree pits are a recent innovation, involving redesign of tree root-zone environments as stormwater treatment systems, allowing the incorporation of stormwater management into confined urban street spaces (Breen, Denman *et al*. 2004; Wettenhall 2006).

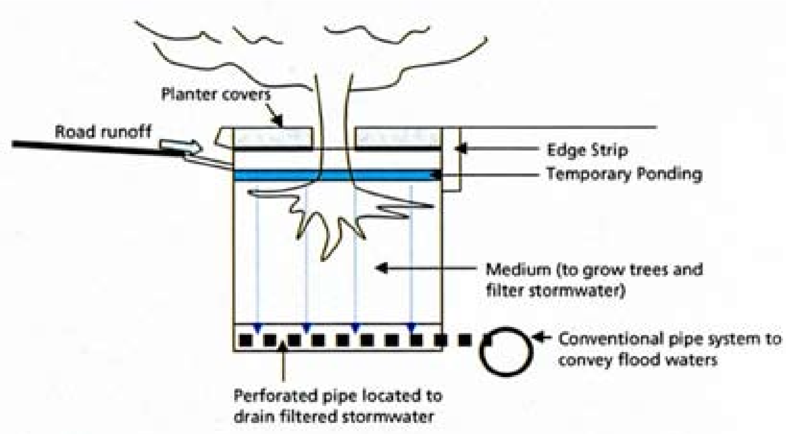

Figure 2
Typical bioretention tree pit cross section
Source: Breen, Denman *et al* (2004)

Bioretention systems can be integrated into the design of new streets, or "retrofitted" into existing streetscapes. Streetscape scale applications, however, present a number of design challenges not faced in larger scale applications. Successful design requires an innovative approach, and a close collaboration between designers, engineers and environmental specialists at all stages of the project.

Key design challenges include the following:

- The design must provide an appropriate footprint and filtration depth which meets functional water treatment criteria.
- It must then be adapted to the surrounding urban environment, including constraints of confined space, and interaction with existing services. Rain gardens can be integrated with other streetscape elements, to reduce their footprint, for example in traffic calming devices.
- Interactions with street users must also be addressed. Of particular concern is public safety and liability. Rain gardens require an extended detention zone set some distance below footpath level, creating a potential tripping hazard. The required grade change can be addressed in a number of ways.
- Aesthetics and visual appearance are significant factors in gaining community support. Installations in highly urbanised areas may require a more formal, geometrical and hard edged design than in suburban streets. Some early examples of rain gardens used standard civil engineering details and failed to enhance the streetscape or gain community acceptance

Retrofitting into Existing Streets

Metropolitan Melbourne

Melbourne is recognised as a leading city in urban stormwater management, in which WSUD best practices have become "institutionalised". The process has benefited from a number of "champions", including Melbourne Water, local Councils and the environmental engineering firm Ecological Engineering. The process began in the late 1980's with recognition of the impacts of urban runoff on the Yarra River catchment and Port Phillip Bay. An early initiative was the development of an outer suburban sub-catchment scale demonstration project at Lynbrook Estate by VicUrban in 1997, which incorporated a stormwater "treatment train" at streetscape level. Since then a number of innovative streetscape scale projects have been implemented in more highly urbanised settings, in partnership between Melbourne Water and local councils (Brown and Clarke 2007).

Kingston City Council

Kingston City Council is also recognised as a leading organisation in Victoria for advancing WSUD. Council's 1,380 hectares of road surface discharge large volumes of stormwater runoff and pollutants into Port Phillip Bay. Funding from the Victorian Stormwater Action Program was the catalyst for the construction of a trial infiltration trench in Riviera Street, Cheltenham in 2001. Council has now installed some 84 rain gardens in 11 suburban streets across 8 suburbs. These have been retrofitted into existing residential street verges or traffic calming devices as part of Council's innovative road reconstruction program (West 2006).

In Stawell Street, Mentone, bioretention basins were installed in the street's wide verges during street reconstruction in 2004. The basins were designed to fit into the available space between existing mature street trees and driveways.

In Brisbane Terrace, Mordialloc, rain gardens were incorporated into traffic calming outstands which were being installed in response to local safety issues. The project has been a success, with the heavily planted installations creating a green landscape appreciated by local residents. The project is also a good example of a multifunctional project that achieves aesthetic, water quality and traffic calming outcomes.

Figure 3
Brisbane Terrace Rain Gardens in traffic calming devices.
Source: West (2006)

Due to it's pioneering role, Kingston City Council has been able to review it's constructed projects and learn from early mistakes. Key findings have included the need for community acceptance through appropriate design and resident education, as well as the need for long term maintenance (Somes and Crosby 2007).

Lower Yarra Councils

Melbourne Water, in partnership with local councils, has implemented a number of other streetscape scale demonstration projects aimed at improving the health of the Yarra River. The 2006 Yarra River Action Plan allocated $10 million to implement WSUD projects in the four lower Yarra River councils.

City of Yarra

In the City of Yarra the reconstruction of Cremorne Street, Richmond, in 2003, incorporating rain gardens, was the first example of streetscape scale applications in a highly built up commercial area with heavy traffic volumes. The project was jointly funded by Council and a Victorian Stormwater Action Program grant. Rain gardens were installed in outstands in the parking lane. The change in level between the footpath and filter bed was addressed with post and wire fencing, however deliberate and accidental damage has detracted to the aesthetic value of the streetscape.

Figure 4
Cremorne Street rain garden

The Yarra City Council also has a program of installing WSUD treatments during the periodic renewal of city assets, such as the incorporation of rain gardens in traffic calming devices at the intersection of Napier and Kerr Streets, Fitzroy.

Figure 5
Napier Kerr Street rain garden

City of Stonnington

The City of Stonnington has adopted a Sustainable Water Management Strategy which aims to incorporate WSUD elements into all of it's facilities. Bioretention tree pits have been installed in the 2007 upgrade of Glenferrie Road, Malvern, an intensively used shopping street. The design comprises a tree pit integrated with a grated kerb inlet, grated tree pit cover and tree guard.

Figure 7
Glenferrie Road tree pit assembly.
Source: City of Stonnington

Figure 6
Glenferrie Road bioretention tree pits.

In Orchard Street, Malvern rain gardens have been incorporated into the reconstruction of a suburban street, to help reduce flooding and treat road runoff. The materials and plantings chosen complement the surrounding contemporary streetscape.

Figure 8
Orchard Street rain garden

Figure 9.
Orchard Street rain garden

City of Melbourne

A number of high profile bioretention projects have been installed in the City of Melbourne, in partnership with Melbourne Water. In 2006 bioretention tree pits were installed in Little Bourke Street in the heart of the Melbourne CBD. The project is of significance as the first example of a WSUD application in such a highly urbanised area. The project faced the challenge of integrating the design into the infrastructure and functioning of the narrow but busy street, and also of meeting the high standards of aesthetics and urban design required in the Melbourne CBD. Particular challenges included the need to relocate underground services and of achieving the required levels to connect with the existing stormwater system. The tee pits, installed in the footpath, are covered with a heavy duty bluestone cover, hinged to allow opening for the removal of accumulated litter, with the sunken tree pits also acting as litter traps.

Figure 10
Little Bourke Street bioretention tree pit

Figure 11
Little Bourke Street tree pit covers

Bioretention street tree pits were also been installed in residential Acland Street, South Yarra in 2007. The street trees are located in the parking lane, rather than the footpath, with runoff flowing directly from the road surface into the grated tree pit cover. Each tree is protected from traffic by a pair of bollards. This installation is part of Council's approach to the greening of city streets, by incorporating WSUD measures into street tree planting, to achieve water quality objectives, while at the same time reducing watering requirements.

Figure 12
Acland Street bioretention tree pits

Figure 13
Acland Street tree pit covers

In 2006 an innovative rain garden was also installed in Davidsons Place in the Melbourne CBD. Davidsons Place is a narrow, high walled CBD laneway with a hard surfaced, low amenity environment, but with a growing residential population. The opportunity was taken to install a rain garden which would improve the quality of urban runoff, while also creating urban greenery and a gathering space for residents. The rain garden comprises a raised planter bed at the end of the lane, which collects stormwater from surrounding roofs via downpipes and spreaders. It is treated by filtering through the raised garden bed, before return to the stormwater system, and at the same time irrigating the single tree and underplantings. The raised bluestone wall, built at seating height, also provides a gathering place for local residents.

Figure 14
Davidsons Place rain garden

Figure 15
Davidsons Place rain garden

Sydney

In Sydney, the Darlinghurst Road upgrade in Kings Cross included street tree bioretention pits, intended to help reduce stormwater pollution of Sydney Harbour. The design included the development of a new "suspended slab" tree grate system to allow the trees to be set down below footpath level. The project was intended as a pilot program for review prior to it's application elsewhere. Problems encountered included some difficulties connecting to the existing stormwater. The project is of significance in the development of an innovative technical system to better integrate WSUD measures into the streetscape, in both visual and functional terms, while sustaining tree growth.

Figure 16
Darlinghurst Road bioretention tree pits.
Source: Ecological Engineering

Brisbane

Brisbane City Council has incorporated stormwater harvesting system in a section of the redevelopment of Melbourne Street as a "subtropical boulevard" and gateway to the Brisbane CBD. Stormwater runoff enters through a kerb inlet that removes litter, into a filtration pit that removes sediments, then filters through the planting bed to a collection pipe and to an underground store for irrigating planting beds during dry periods.

Figure 17
Melbourne Street stormwater harvesting.
Source: Brisbane City Council

Adelaide

In Adelaide a bioretention swale was incorporated into the redesign of the South Australian Museum forecourt on North Terrace, the city's main cultural boulevard. The swale is part of a water management system that captures and treats runoff from surrounding roofs and hard surfaces, then stores it underground for irrigation reuse. A key objective of the project was to showcase the museums commitment to ecologically sustainable development, especially water conservation and reuse. The bioretention swale is designed as a concrete lined trench, to prevent stormwater infiltration impacting on the adjacent heritage buildings. The concrete edging also provides the base for integrated public seating. The project was the result of collaboration between the designers (Taylor Culitty Lethlean), civil and structural engineers, and consultants Ecological Engineering. Early integration of the water management system into the project, rather than as an "add on", assisted in it's retention in subsequent cost reviews (Allison and Taylor 2004).

Figure 18
SA Museum forecourt.
Source: Ecological Engineering

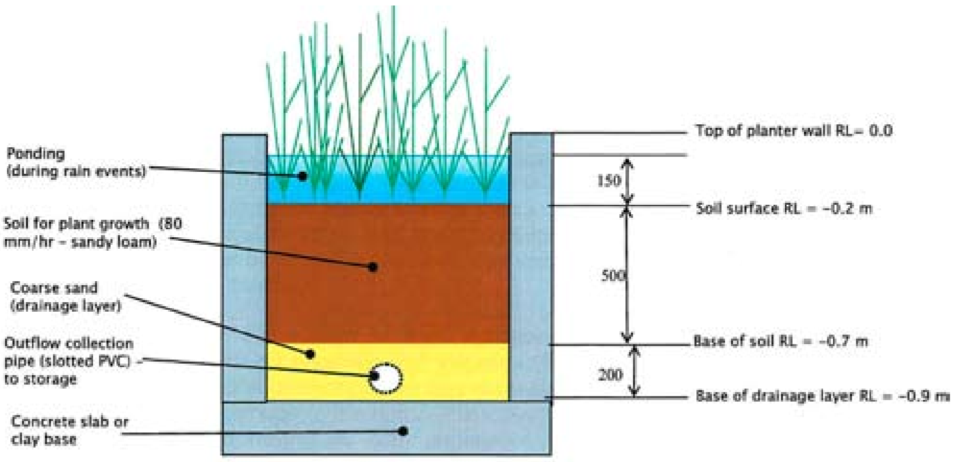

Figure 19
SA Museum forecourt bioretention trench.
Source Allison and Taylor (2004)

Urban Redevelopment Projects

A number of recent projects have seen the integration of streetscape scale WSUD measures in large scale inner urban redevelopment projects.

Docklands-Melbourne

The Docklands project comprises the redevelopment of the 200 hectare Victoria Harbour precinct adjoining the Melbourne CBD. Commenced in 2002 by the former Docklands Authority, (now Vic Urban), Docklands is a leading example of innovation in incorporating WSUD practices into a large contemporary urban development. Key stormwater management initiatives include treating runoff to reduce pollutant loads entering the Yarra River and Port Phillip Bay, and the harvesting and reuse of stormwater for irrigation of public spaces. An innovative stormwater management system is integrated into Docklands public spaces. Above ground, constructed wetlands, designed as contemporary landscape features, treat runoff and act as WSUD signature elements. Below ground, an innovative system of underground storage and "green pipes" facilitates the movement of water around the site and it's storage for local irrigation reuse. Streetscape scale bioretention systems are also part of the wider stormwater management system (Haycox 2004).

Figure 20
Docklands Park

Figure 21
NAB forecourt
constructed wetland
constructed wetland

Street tree bioretention pits have been incorporated into the design of the extension of Bourke Street into Docklands. This was possibly the first street tree stormwater treatment application in Australia.

Figure 22
Bourke Street
extension
bioretention tree pits

Bioretention systems have also been integrated into the streetscape design of Batmans Hill Drive, intended as a high profile southern gateway to Docklands, with high quality and well defined vehicular, pedestrian and cycle environments .The road is lined on one side with a linear bioretention swale and on the other with individual tree pits. The swale is at road level, protected from traffic by a row of bollards.


Figure 23
Batmans Hill Drive bioretention swale

The individual tree pits are defined by raised semi-circular elements which protect pedestrians from vehicular traffic, take up the grade change between footpath and soil level, act as seating, and provide a sculptural element in the streetscape. The project is an example of best practice in achieving multiple objectives through an integrated design.


Figure 24
Batmans Hill Drive bioretention tree pits

Another innovative feature in Docklands are the bioretention basins integrated into the design of the Docklands Point carpark, which treats carpark runoff. The bold design, which incorporates a gabion basket to take up the grade change from the surrounding surfaces, fits well into the surrounding formal environment.


Figure 25
Docklands Point carpark rain garden

Figure 26
Docklands Point carpark gabion detail

Victoria Park-Sydney

In Sydney, the Victoria Park project comprises the redevelopment of 25 hectares of former industrial land 3 kilometres south the Sydney CBD. The low-lying, flood prone land was originally a swamp and a natural wetland system. The initial masterplan was modified in 1999 to better integrate a water management system into the public domain of streets and open spaces. The scheme by Hassel, in association with the Government Architects Office and consultants Ecological Engineering, built upon the inherent physical constraints of the site. An innovative "community water management" system was developed for the whole site, which aimed to more closely mimic the original, natural water processes, by retaining, filtering, moving and recycling stormwater across the site, in a controlled fashion. These processes have been successfully integrated into a high quality public domain, in which the water cycle is made visible. Victoria Park has become a benchmark for inner urban development. The success of the project can be attributed to the strong collaboration between the developer, designers, artists, engineers and ecologists (Evans 2003).

Figure 27
Victoria Park bioretention swale with permeable kerbing

The wide east west streets of Victoria Park were reconfigured to drain to a central bioretention swale, with permeable "saw tooth" kerbing. The swales were designed to capture the most contaminated first flush stormwater, which filters to an underground storage tank for reuse.

Figure 28
Joynton Park detention basin and wetland

Excess flows are captured by a system of inlets below the pedestrian bridges over the swales, then conveyed to dished detention basins in the local parks. Runoff is further treated by a system of constructed wetlands integrated into public spaces, and recycled for irrigation use. The pumping system also draws irrigation water from the aquifer during low rainfall periods.

Figure 29
Woolwash Park constructed wetland

Conclusions

This overview identifies the scope of emerging practices applying Water Sensitive Urban Design measures at the streetscape level. This includes retrofitting into existing streets, resulting in incremental changes to the urban fabric, and incorporation in large scale urban development projects, as part of integrated water management systems. Lessons have been learnt from early projects, which were largely engineering driven. The most successful recent projects exhibit a highly collaborative and innovative approach, achieving a range of social, economic and environmental outcomes.

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