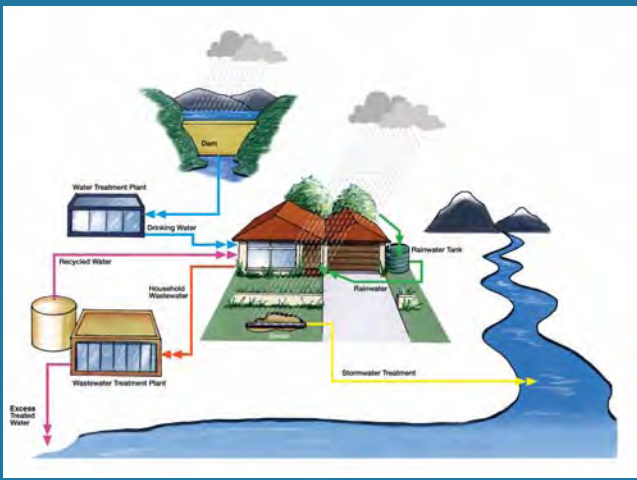
Evaluating Options for Water Sensitive Urban Design – A National Guide

Appendices

APPENDIX A: WSUD CASE STUDIES

Pimpama Coomera Water Futures Project



Coomera Pimpama Water Cycle Illustration

Wetland at Coomera

The Pimpama Coomera region will grow from its current population of approximately 15,000 people to almost 120,000 people over the next 50 years. Gold Coast City Council initiated the Coomera Pimpama Water Futures Project in late 2002 to deliver a Master Plan for the region that provides water and wastewater services in a more sustainable way.

Key elements of the Pimpama Coomera Waterfuture Master Plan include:

• Houses will have water supplied from the following three water sources:
- Drinking water for kitchen use and to top up the rainwater tank
- Class A+ recycled water for all toilet flushing and external uses
- Rainwater for approved uses throughout the home.

Stormwater management will be improved with:
- Water Sensitive Urban Design (WSUD)
- Rainwater tanks to capture clean water for use in the home.

• The use of Smart Sewers:
- To reduce stormwater and groundwater entering the wastewater system.

• Education and communication:
- To ensure the entire community is informed and involved in the Master Plan implementation.

Further information
www.goldcoast.qld.gov.au/attachment/edmp/is2_pimpama_coomera.pdf

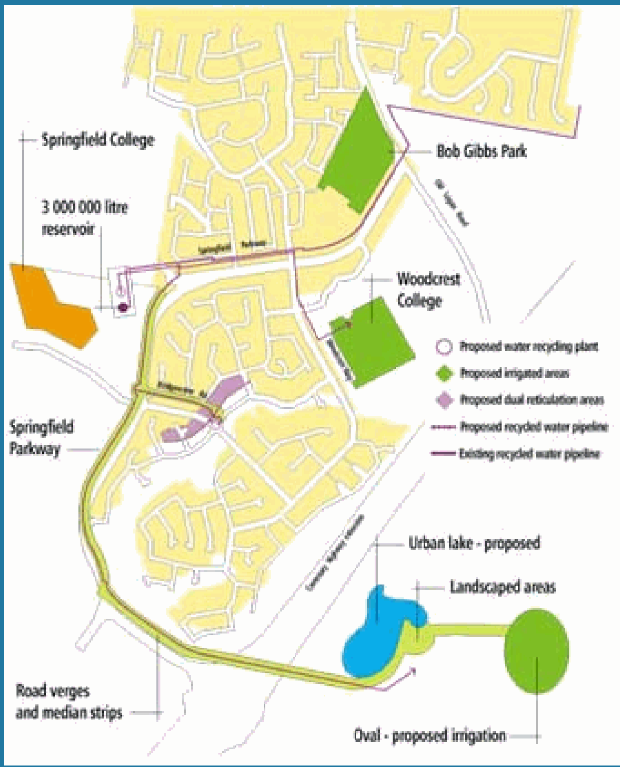
WSUD Features

- Alternate water sources (eg. treated wastewater, rainwater)
- Stormwater treatment devices (e.g. swales, wetlands, bioretention, rainwater tanks).
- Smart sewers
- Education and communication

Results/Observations

- Significant reduction in mains water usage
- Reduced quantity of treated wastewater discharged to waterways
- Reduced greenhouse gas emissions from water infrastructure
- Reduced stormwater entering the wastewater system and waterways
- Improved quality of stormwater runoff to waterways

Springfield Development – Ipswich, Qld



The Healthy Home

The Springfield Total Urban Development is a new residential development, located between Brisbane and Ipswich. It covers 2,850 hectares, with a projected 18,000 home sites, and is estimated to house 60,000 people by 2012. The site has been chosen to demonstrate a water recycling management program. Springfield will be supplied with treated recycled water from the Carole Park Sewage Treatment Plant, which is managed by Ipswich City Council. The scheme will feature:

• Dual reticulation to 30 houses for non-potable uses such as toilet flushing, garden watering and carwashing
• Surface and sub-surface irrigation of road verges, median strips, public parks, pathways, bike paths, drainage and wildlife corridors, sports grounds and school grounds with stormwater and recycled water
• Topping up of an urban lake that will be used for non-contact recreation such as canoeing.

The project also includes a consultation process with a full-time community liaison/education officer attached to the project. Recycled water quality, water usage and environmental response are being monitored to ensure the scheme's performance.

WSUD Features

- Advanced wastewater treatment and reuse via dual reticulation
- Urban lakes
- Urban wetlands
- Overland flow across buffer strips

Results/ Observations

- Successful application of WSUD principles in a 'conventional' urban setting

Carindale Pines – Brisbane, Queensland

A water tank concealed under the exterior deck

The road drainage layout at Carindale Pines

Carindale Pines is a greenfield development site, 20 minutes drive from the Brisbane CBD. The development site is about 14 hectares, with 31 blocks of an average size of 720m^2.

All homes constructed on the site include a 25 kL rainwater tank, collecting rainwater after filtering through a first-flush system. Tank water is used for all household uses, including drinking water. Additionally, homes are fitted with AAA-rated water-saving appliances.

On a larger scale, roads in the development were designed to conform with natural landforms where possible, and catchment runoff is directed through a series of vegetated swales.

WSUD Features

- 25 kL rainwater tanks on each house
- Collected rainwater supplied for all household uses
- Use of AAA-rated water saving devices
- Road runoff treated and conveyed in vegetated swales

Results/ Observations

- Rainwater provides 70-80% of household requirements

The Healthy Home – Gold Coast, Qld

The Healthy Home

The Healthy Home is the creation of Queensland University, the Queensland Department of Natural Resources and industry partners. It was designed by the Queensland University Architectural Department and incorporates leading edge technology, passive solar design and resource efficiency strategies, and won the 2000 Master Builders of Australia National Resource Efficiency Award/Housing Under A$0.5 million category.

The water features of the home include:·

• A water flow control system that reduces water use by up to 50 per cent and controls the amount of hot water used, saving heating energy.

• A triple-filtered rainwater storage system sourced from a 22,500-litre concrete rainwater tank. Water is utilised in the laundry, kitchen, bathrooms and garden sub-surface watering system. This system includes a first-flush device and water filter to ensure adequate drinking water quality and has a manually controlled mains refill capacity for when the stored rainwater runs low.

• Ultraviolet water disinfection ensures pure, healthy drinking water. Polypropylene piping ensures a high quality uncontaminated water supply for life.

• High-density polyethylene plumbing and ducting used is highly durable, non-PVC, with minimum environmental impact in manufacture or assembly.

• A greywater treatment system allows for greywater reuse and will reduce the load on the council treatment plant when fully operational.

WSUD Features

- Collection and treatment of roofwater
- Reuse of collected roofwater for all internal and external uses
- Use of AAA-rated water saving appliances
- Greywater treatment

Results/ Observations

- Significant reductions in potable water use
- Significant reductions in wastewater produced
- High quality water supplied to the premises from the rainwater tank collection and treatment system
- Treated greywater quality suitable for use in the yard

Fig Tree Place – Newcastle, NSW

Figtree Place detention basin under dry and wet conditions

Figtree Place is a 27-unit community housing development on 0.6 hectares in the inner city Newcastle suburb of Hamilton. In terms of WSUD, the objectives of the development were to retain stormwater onsite and reduce the demand on potable water supply.

Roof runoff from the townhouse-style units on the site is directed to underground rainwater tanks for storage, while other impervious surfaces drain to an infiltration basin where the stormwater permeates through the base and into an underground aquifer.

Stormwater stored in the rainwater tanks and underlying aquifer and is put to use in a number of ways including garden irrigation, hot water and toilet flushing and washing of buses at the adjacent depot.

Since construction of the site in 1998, monitoring results have shown a 60 per cent reduction in the total demand for mains water. After passing through a hot water system, the quality of the reused stormwater complies with Australian Drinking Water Standards.

Further information
http://www.eng.newcastle.edu.au/~cegak/Coombes/

WSUD Features

- On-site stormwater harvesting and storage
- Infiltration of runoff from impervious surfaces
- Reuse of stormwater for irrigation, hot water supply and bus washing

Results/ Observations

- Quality of stormwater- supplied hot water complies with Australian Drinking Water Standards
- Demand on mains water supply reduced by 60%

Kogarah Town Square – Sydney, NSW

Kogarah Town Square

The Kogarah Town Square redevelopment site covers about one hectare and includes about 4500 square metres of commercial and retail space, along with 193 residential apartments, a public library and town square. The philosophy behind the Kogarah Town Square redevelopment was to provide a place where people can meet, live and interact.

The site concept involves the collection and treatment of all rainwater (with the exception of first-flush runoff) into underground storage tanks or cisterns. The water receives physical and biological treatment such as sand filters and biologically engineered 'ecosoil'. The harvested water is used for toilet flushing, carwashing, in the Town Square water feature and for landscape irrigation. At least 70 per cent of toilet flushing water is supplied by harvested stormwater In addition, the complex includes AAA-rated water-efficient fittings and appliances.

The Kogarah Town Square Site also includes innovative eco-friendly urban design features such as passive solar design and solar energy use.

Further information
http://www.kogarah.nsw.gov.au/www/html/334-achieving-sustainability-kogarah-town-square-development.asp?intSiteID=1

WSUD Features

- Collection and treatment of stormwater
- Reuse of collected stormwater in toilet flushing, car washing and water features
- Use of AAA-rated water saving facilities

Results/ Observations

- 85% of stormwater captured
- 60% of captured stormwater reused

Lynbrook Estate – Melbourne, Victoria

Lynbrook Estate bioretention system

Overflow pit at the base of a bioretention system

Comprising 271 lots on about 55 hectares, this project was constructed in Melbourne's outer south-eastern suburbs between 1999 and 2000.

Roof and road runoff from the site is conveyed through a system of roadside swales and median strip bioretention systems. Following treatment, stormwater is discharged to a constructed wetland system, which in turn discharges to an ornamental lake.

Preliminary monitoring results indicate that compared with a conventional design, nitrogen loads have been reduced by 60 per cent, phosphorus 80 per cent and suspended solids 90 per cent.

Economic analysis has shown the cost of installing WSUD elements to be only marginally higher than conventional systems, increasing overall development costs by as little as 0.5 per cent.

WSUD Features

- 'Treatment train' approach
- Runoff directed to vegetated swales, bioretention systems and constructed wetland

Results/ Observations

- Significant pollutant reductions
- Only a small extra expense for WSUD

Further information

http://thesource.melbournewater.com.au/content/archive/june2000/coverstory.asp

Lloyd, Fletcher, Wong and Wootton (2001), Assessment of Pollutant Removal in a Newly Constructed Bio-retention System, proceedings of the 2nd South Pacific Stormwater Conference, Auckland, New Zealand

Doncaster Park and Ride – Melbourne

Interrupted kerbs direct stormwater to treatment facilities

The Doncaster Park and Ride project was initiated to promote public transport, primarily for peak-hour commuters who use Melbourne's Eastern Freeway. The 1.9-hectare site includes parking spaces for more than 400 vehicles.

Due to concerns about the impact of the site on the adjacent Koonung Creek, WSUD principles were incorporated into the design. These included directing most stormwater via overland flow and intermittent kerbs to bioretention and infiltration systems. Litter traps were incorporated into side entry and grated pits to capture gross pollutants from the high use areas of the facility.

Monitoring of the performance of the stormwater facilities onsite indicate that as much as 93 per cent of runoff from the site is directed to the treatment facilities.

Further information

Smolenska, Somes and Papadopoulos (2002). Environmental Sustainability Through Water Sensitive Design – Converting Theory To Innovative Reality

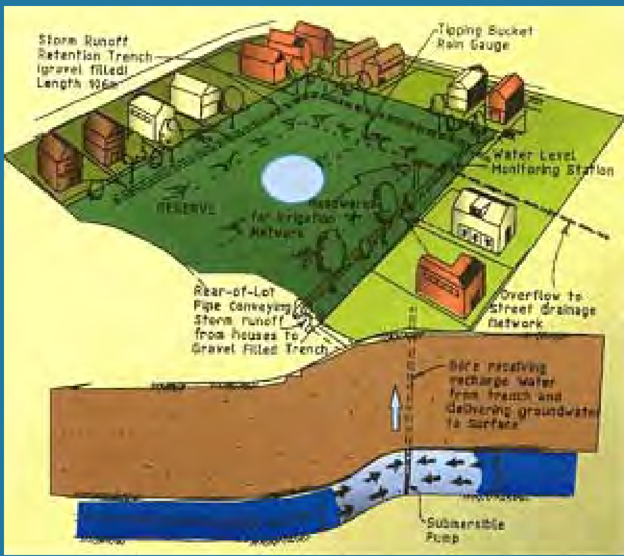
WSUD Features

- Use of overland flow paths
- Bioretention
- Litter baskets in inlet pits
- Infiltration

Results/ Observations

- 93% of site runoff is directed to the stormwater facilities

New Brompton Estate – Adelaide, SA



Conceptual layout of the New Brompton Estate

The New Brompton Estate Recreation Reserve

The scheme to collect, treat and use runoff generated on the roofs of 15 residences surrounding the three sides of the 50 m x 45 m central recreation reserve in New Brompton Estate was commissioned in 1991. Since then the scheme has been improved and expanded to include aquifer storage and recovery and the potential for providing irrigation for the estate's central reserve.Roof runoff from the 15 houses is collected and passed into an underground gravel-filled trench situated around the three sides of the reserve.

Flow passes along the underground trench, with some of the water taken up from the soil by the roots of trees that have penetrated the trench since commissioning of the project. The remaining, now clean, runoff congregates at a central location, where it is conveyed to an aquifer 30 metres below present ground level. During the summer months, water stored in the aquifer is reused to irrigate the reserve.

The system reduces downstream flooding and uses stormwater runoff to provide catchment 'greening'. It also leads to reduced use of mains water.

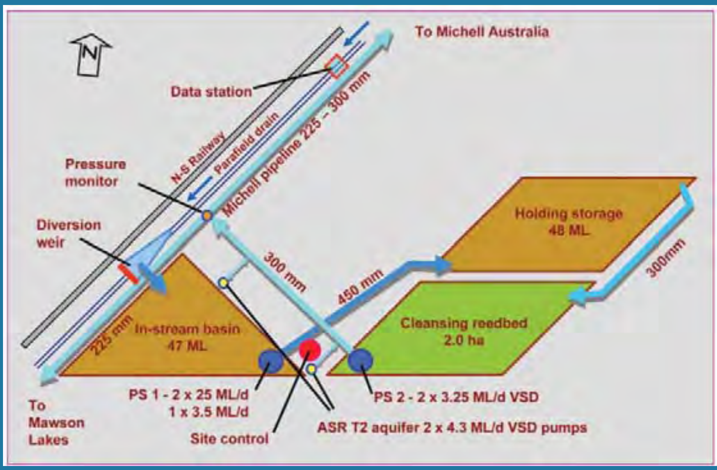
WSUD Features

- Collection and treatment of stormwater
- Storage of collected water in an aquifer
- Reuse of collected stormwater for irrigation during the summer months
- Reduced demand

Results/ Observations

- Reduced downstream flooding
- Reduced demand on mains water for irrigation of public space

Parafield Stormwater Harvesting Scheme



Harvesting Scheme

Aerial View at Parafield Airport

The Parafield Stormwater Harvesting Facility is an innovative and unique project based on principles established through years of implementation of water sensitive urban designs by the City of Salisbury throughout its 161 sq. km municipality in the northern suburbs of the Adelaide metropolitan area, South Australia.

The facility is located on Parafield Airport land adjacent to the main southwest-northeast runway and is the first stage of a three stage stormwater harvesting development supplying water for non-potable use. The three stages with harvesting works on the airport land are as follows:

- Parafield Drain Scheme capturing water from 1,580 ha of residential and industrial catchment to the north and north–east of the airport to provide some 500 ML/a of non potable water to Michell Australia wool processing works 3 km to the north–east, and some 600 ML/a of non potable water to Mawson Lakes residential development 3 km to the south.
- Bennett Drain Scheme (future) capturing water from 2,023 ha of residential catchment to the north–east and east of the airport to provide some 1,300 ML/a of non potable supply for future consumers.
- Cobblers Creek Scheme (future) capturing water from 1,044 ha of residential catchment to the more distant north–east of the airport to provide some 600 ML/a of non potable supply for future consumers.

The total supply from these schemes will be 3,000 ML/a generated from an average catchment yield of about 5,000 ML/a.

Further information
http://cweb.salisbury.sa.gov.au/manifest/servlet/page?pg=16064&stypen=html

WSUD Features

➢ Wetlands for stormwater harvesting and treatment
➢ Storage of treated stormwater in an underground aquifer for subsequent extraction and reuse.

Results/ Observations

➢ Significant reduction in mains water usage
➢ Reduced stormwater flows and pollutant loads entering waterways

Ascot Waters – Perth, Western Australia

Ascot Waters stormwater detention basin

A vegetated swale drain at Ascot Waters

Ascot Waters is set on 97 hectares in the City of Belmont in Perth. The challenge of this development was to convert a disused, degraded area of land into an attractive, cosmopolitan estate.

Redevelopment plans for the site divided the estate into three zones, each with different roles in the management of water quality on the site. Zone A includes two lakes, designed to deal with water quality issues in the Belmont Main Drain, along with a wet detention basin and gross pollutant traps.

Zone B includes a linear park, and WSUD features such as vegetated swales, overland flow across buffer strips, bioretention and detention basis.

Zone C included high conservation wetland areas, so maintaining water supply while also ensuring the quality of runoff was important. This was achieved through installation of grass swales and buffer strips, delivering varying volume of water to the wetlands depending on runoff volume.

WSUD Features

- 'Treatment Train' approach
- Vegetated swales
- Bioretention
- Sand filters
- Overland flow across buffer strips
- Wet and dry detention basins

Results/ Observations

- Successful conversion of a degraded, disused inner city site to an attractive cosmopolitan development incorporating WSUD principles

Further information

http://ascotwaters.com.au/

Evangelisti (2002). "*Sharing the Experience – We are all in the ring*": The Ascot Waters Experience. Proceedings of the 2nd National Conference on Water Sensitive Urban Design.

APPENDIX B: WSUD BMP DESCRIPTIONS

Swales & Buffer Strips

Description

Swales are shallow channels lined with vegetation (usually grass) and are often used in combination with alternative kerb design to provide flow conveyance, minimising the use of piped stormwater drainage systems. Swales are commonly combined with buffer strips, which are vegetated strips adjacent to drainage lines where stormwater runoff sheet-flows across.

Application/ Function

Vegetated swales are used to convey stormwater in lieu of, or with, underground pipe drainage systems to slow stormwater flow-rates and provide for the removal of coarse and medium sediment. They are usually not suitable on very flat (<1%) or steep (>4%) land.

Buffer strips are suitable where even inflow and throughflow distribution can be maintained. They are typically used as a pre-treatment device for small, local catchments (e.g. sheet flow from immediately surrounding car-park or road). They are commonly used in lieu of conventional (curb-and-gutter) road-side drainage to provide pre-treatment to runoff before discharging to swales and bioretention swales.

Operational Risks

• *Erosion/ Scour*: If flow velocities are too high (e.g. due to steep gradients), there is potential for erosion and scour of collected pollutants and vegetation.

• *Water-logging*: If flow velocities are too low (e.g. due to flat gradients), there is potential for waterlogging and stagnant ponding.

• *Sediment accumulation*: Sediment can accumulate, particularly at the edge of a buffer strip/ swale, resulting in flows not sheet-flowing across the buffer strip or swale batter.

• *Vehicle damage*: Vehicles driving on buffer strips and swales can result in vegetation damage and cause ruts that can create preferential flow paths and subsequently diminish the treatment performance of the buffer strip and/ or swale, as well as creating depressions that can retain water and potentially mosquito breeding sites.

• *Public Safety*: Swales could pose a fall hazard to persons accessing the swale during times of high flow.

Swales & Buffer Strips

Maintenance Requirements

The maintenance requirements of swales and buffer strips typically involve the following:

• Visual inspection, which typically involves identifying items such as indications of any obvious sediment deposition, scouring from storm flows, rill erosion from lateral inflows or vehicle damage, and inspection of inlet points, surcharge pits and overflow pits to identify any scour, litter build-up and blockages. It is recommended that this be undertaken after the first three significant storm events after construction and then at least every three months.

• Removal of sediment (and, if necessary, re-profiling and re-vegetating) if it is impeding conveyance capacities and/ or smothering vegetation .

• Repairing any damage due to scour, rill erosion or vehicle damage.

• Clearing blockages of inlets and/ or outlets.

• Regular watering/ irrigation of vegetation until plants are established and actively growing.

• Mowing of turf or slashing of vegetation (if required) to preserve the optimal height for the vegetation.

• Removal and management of invasive weeds.

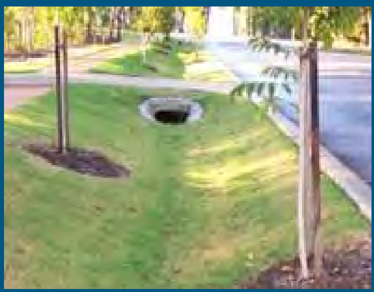
• Removal and suitable replacement of plants that have died.

• Removal of litter/ debris.

Design Considerations

• *Capacity*: For water quality improvement, swales and buffer strips need only focus on treating/ conveying frequent storm flows (typically up to the 3-month ARI). However, swales may be required to provide a flow conveyance function as part of a minor and/ or major drainage system, and it may be necessary to augment the capacity of the swale with overflow pits along the invert of the swale that discharge to underground pipe drainage.

• *Driveway Crossings*: Driveway crossings for swales along roadways can be ‘at-grade’ or ‘elevated’ and their applicability will be dependent on a number of factors (e.g. aesthetics, cost, requirement for ponding, public safety and traffic movement).

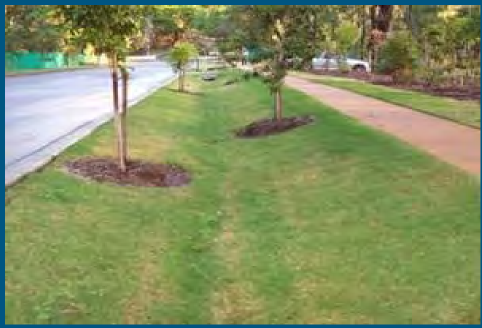


Driveway Crossings: At-grade (left) under construction with trees yet to be established, pre-constructed ‘at-grade’ (centre) and elevated driveway crossings to allow vehicle access across swales

Swales & Buffer Strips

Design Considerations (Cont'd)

• *Gradient*: Swales typically operate best between longitudinal slopes of 1% and 4%, given that slopes milder than this can become waterlogged and have stagnant ponding (which can be remedied with subsoil drains) and steeper slopes can result in scour (which can be potentially prevented through check dams, or equivalent measures).



• *Flow Velocity*: Velocities within swales should be kept low (preferably less than 0.5m/s for minor flood flows and not more than 2.0m/s for major flood flows) to avoid scouring of collected pollutants and vegetation.

• *Landscape Design*: Swales and buffer strips can be successfully integrated into a landscape such that both functional stormwater objectives, landscape aesthetics and amenity are achieved.

• *Services*: Swales located within road verges or within footpaths must consider the standard location for services within the verges and ensure access for maintenance of services without regular disruption or damage to the swale.

• *Public Safety*: Swales located within road reserves must allow for the safe use of adjoining roadway, footpaths and bike paths by providing sufficient conveyance capacity to satisfy local infrastructure design requirements. Consideration must also be given to both the velocity and depth of water in the swale to ensure it does not exceed design safety factors.

Kerb without Set-Down, showing sediment accumulation on road.

• *Vegetation Selection*: Swales and buffer strips can use a variety of vegetation types including turf, sedges and tufted grasses. Vegetation is required to cover the whole width of the swale and/ or buffer strip, be capable of withstanding design flows and be of sufficient density to prevent preferred flow paths and scour of deposited sediments.

• *Edge Treatment*: For buffer strips adjacent to impervious areas (e.g. roads), to avoid sediment accumulation on the edge of the impervious area, a flush kerb arris (or 'drop-down') should be used that sets the top of the vegetation 60mm below the pavement edge. This requires the finished topsoil surface of the buffer strip (i.e. before turf is placed) to be approximately 100mm below the pavement edge level.

• *Roof Water Drainage*: Roof water (directly from roof areas or overflow from rainwater tanks, etc) should be discharged to swales (if possible), which may require the use of a small surcharge pit (with perforations allowing drainage to the surrounding sub-soil) in the invert of the swale to allow roof water to surcharge to the swale.

• *Traffic Control*: To prevent vehicles driving on buffer strips and swales (and reducing treatment performance, etc.) appropriate traffic control measures should be considered (e.g. dense vegetation, physical barriers).

Swales & Buffer Strips

Relevant Guidelines

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Wong, T. H. F., Lloyd, S. D., & Breen, P. F. (2000). *Water sensitive road design - design options for improving stormwater quality of road runoff* (Technical Report No. 00/1). Melbourne: Cooperative Research Centre for Catchment Hydrology.

Wong, T. H. F., Duncan, H. P., Fletcher, T. D., Jenkins, G. A., & Coleman, J. R. (2001). *A unified approach to modelling urban stormwater treatment.* proceedings of the Second South Pacific Stormwater Conference, Auckland, 27-29 June 2001, pp. 319-327.

Gross Pollutant Traps

Description

Gross Pollutant Traps (GPTs) are devices for the removal of solids conveyed by stormwater that are typically greater than 5mm. There are a variety of gross pollutant traps currently suitable for use in urban catchments including gully baskets, in-ground gross pollutant traps, trash racks and pipe nets.

Example of a Gully Basket

Application / Function

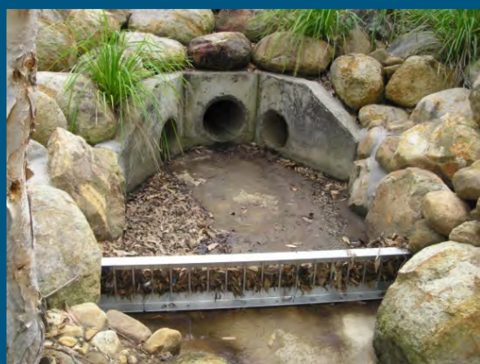
Gully baskets are installed as a component of the gully pit design (not within the pipeline) and screen pollutants out of the runoff as it enters the pit. In-ground gross pollutant traps typically create centripetal forces to draw pollutants into the centre of the unit, which then gravitate to an offline sump. Trash racks consist of a series of metal bars located across a channel or pipe, which act to trap large litter and debris such as plastic bottles, cans, leaves and branches. Pipe nets are simply netting attached over the outlet of a pipe and, if the design flow is exceeded or the netting is full, the net can detach from the drain, with the net being choked by a short tether.

In-Ground GPT Basket Being Removed for Cleaning

When installed in isolation, GPTs are primarily used for aesthetic reasons, to protect downstream waters from litter. As part of a stormwater 'treatment train', they are an upstream stormwater treatment device and are installed to protect the integrity of downstream treatment devices by removing gross pollutants.

Operational Risks

The main operational risks associated with GPTs are as follows:



Example of a Trash Rack

- *Bio-Transformation*: A poorly maintained GPT can hold gross pollutants for extended periods of time, during which some types of GPTs (particularly those that retain pollutants in wet sumps) can transform collected contaminants into more bio-available forms. Small flows through the device can then transport transformed pollutants downstream.

- *Afflux*: If not designed appropriately, on-line GPTs can cause an increase in upstream flood levels.

Example of a Pipe Net

Gross Pollutant Traps

Maintenance Requirements

The key maintenance requirement for GPTs is the removal and transportation/ deposition of gross pollutants retained by the GPT. The removal method will be dependent on the type of GPT installed with methods ranging from manual cleaning, vacuuming, using a crane to retrieve a basket or net or using large excavators with 'clam shell retrievers' for large GPTs.

It is typically recommended that site visits and monitoring of GPT capture performance and contaminant volumes should be undertaken on a three-monthly basis and also following any significant rainfall event (i.e. greater than approximately two month ARI and following approximately five days of consecutive rainfall).

Design Considerations

Key considerations in the design of a GPT are as follows:

• *Design Objectives*: The target design flow and (gross pollutant and sediment) capture efficiency should be established.

• *Type of GPT*: A wide range of GPTs are available and the reader should review available comparitive performance literature before selecting a device.

• *Sizing*: The size of a GPT will be dependent on design flow rates

Relevant Guidelines

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Sedimentation Basins

Description

Sedimentation basins can take various forms and can be used as permanent systems integrated into an urban design, or temporary structures to reduce sediment discharge during upstream construction activities. The text below focuses largely on permanent systems integrated into urban design.

Application/ Function

Within a stormwater 'treatment train', sedimentation basins are typically installed upstream of vegetated SQBMPs such as the macrophyte zone of a constructed wetland or a bioretention basin. They are typically installed to provide two key roles:

- *Coarse sediment removal*: removing coarse to medium sized sediment prior to stormwater flows discharging into downstream treatment devices (e.g. macrophyte zone of a constructed wetland or a bioretention basin). This ensures the vegetation in the downstream treatment system is not smothered by coarse sediment and allows downstream treatment systems to target finer particulates, nutrients and other pollutants.

- *Flow Regulation*: controlling or regulating flows entering downstream treatment systems, allowing low flows (from small/frequent rainfall events) to enter the downstream treatment systems and bypassing high flows (from large/ infrequent rainfall events) around any downstream treatment systems (e.g. macrophyte zone of constructed wetlands or a bioretention basin) and subsequently protecting them from scour.

Operational Risks

The main operational risks associated with sedimentation basins are as follows:

- *Public Safety*: Like any permanent or temporary water body, there is the potential for drowning to occur.

- *Exotic Species*: Sedimentation basins can attract some potentially undesirable species (e.g. cane toads, exotic fish, mosquitoes).

- *Erosion*: High stormwater flow rates can discharge into a sedimentation basin, which can result in erosion (or similar damage) within the basin.

- *Sediment Re-Suspension*: High stormwater flow rates can cause sediment that has been retained/ captured within the sedimentation basin to scour/ re-suspend and be discharged into downstream waters or treatment devices.

Sedimentation Basins

Maintenance Requirements

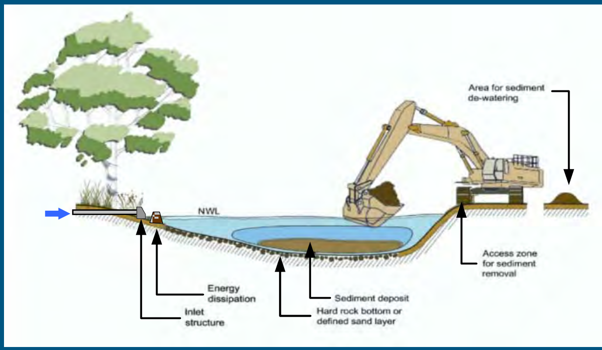
The maintenance requirements of sedimentation basins typically involve the following:

• Visual inspection, which typically involves checking items such as the depth of sediment accumulation, damage to vegetation, scouring and litter/ debris build-up. It is recommended that this be undertaken after the first three significant storm events following construction and then at least every three months).

• Removal of litter/ debris.

• Removal and management of invasive weeds (both terrestrial and aquatic).

• Periodic (usually every 5 years) desilting, which typically requires excavation and dewatering/ drying of removed sediment (and disposal to an approved location).



• Replacement of any plants that have died.

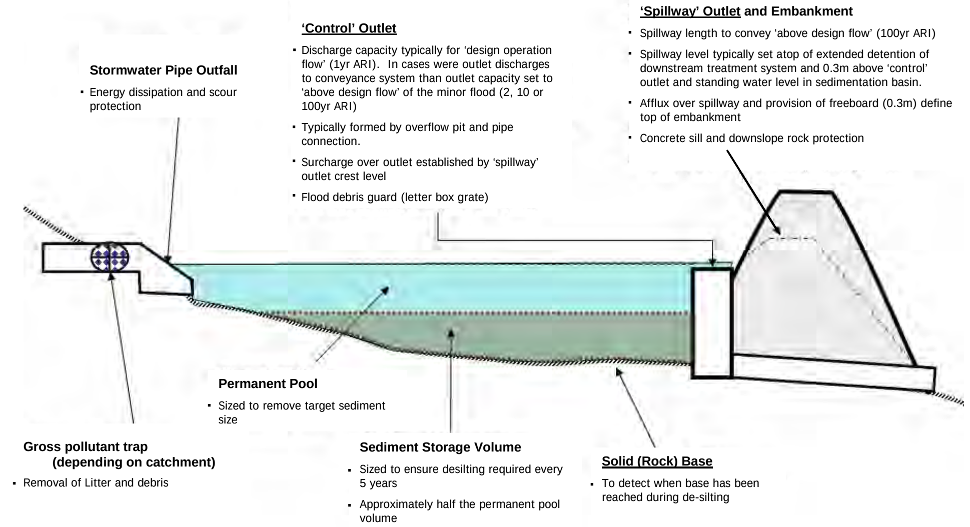
Design Considerations

The key considerations for the design of sedimentation basins are as follows:

• *Size*: Sedimentation basins are typically sized to achieve approximately 80% reduction of coarse sediment (particle sizes of 125 μm and larger) loads for a given design flow (typically 1 year ARI).

• *Sediment Storage*: Adequate storage volume needs to be provided within sedimentation basins for accumulated sediment. A desirable frequency of basin desilting is once every five years (generally triggered when sediment accumulates to half the basin depth).

• *Outlet Design*: In most cases, the outlet design of a sedimentation basin consists of a 'control' outlet structure (to discharge low lows to any downstream treatment systems) and a 'spillway' outlet structure to discharge high flows to a bypass channel (that bypasses high flows from any downstream treatment systems).



Sedimentation Basins

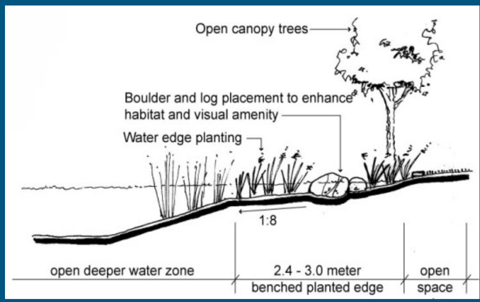
Design Considerations (Cont'd)

• *Water Retention*: Sedimentation basins are required to retain water and therefore the base must be of a suitable material to retain water (e.g. clay), typically overlaid with a hard (e.g. rock) bottom.

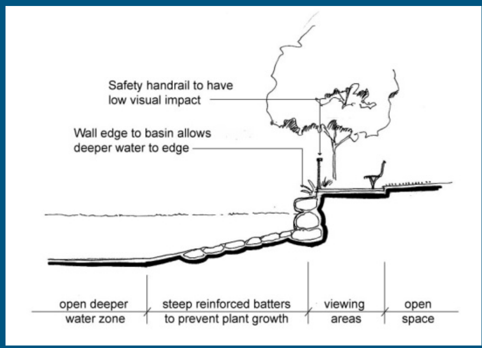
• *Landscape Design & Public Safety*: Sedimentation basins should be designed to be integrated with or enhance the surrounding landscape, and providing/ enhancing local habitat. Dense littoral vegetation planting of basins is typically undertaken to restrict public access to open water zones (and subsequently increase public safety). A variety of internal batter configurations are available, but fencing may be required if batter slopes are too steep (e.g. greater than 1V:5H).

• *Vegetation Specification*: Planting within sedimentation basins is typically restricted to the waters edge and batters (typically to a depth of around 0.2m) to provide scour and erosion protection, and the littoral zone to restrict public access. The basins should primarily consist of open water to allow for settling of only the target coarse sediment (e.g. 125µm or larger) and to permit periodic sediment removal.

• *Maintenance*: Accessibility for maintenance is an important design consideration. Sediment removal by excavator is periodically required, which will require all parts of the basin below the top of the batter (e.g. by access track around the perimeter) and hard (i.e. rock) bottom.



Examples of a Soft Edge Treatment (above) and Hard Edge Treatment (below) for Open Waterbodies



Example of Fencing to Waters Edge

Relevant Guidelines

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Constructed Wetlands

Description

Constructed wetland systems are shallow, extensively vegetated water bodies and typically consist of an inlet zone (sedimentation basin), macrophyte zone, and high flow bypass channel.

Application / Function

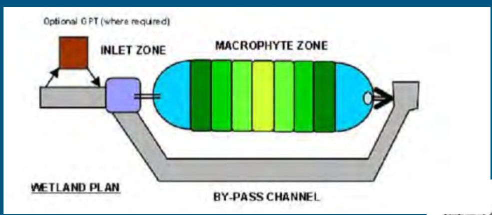
Constructed wetlands use enhanced sedimentation, fine filtration and pollutant uptake processes to remove pollutants from stormwater. Wetlands also provide a flow control function by rising during rainfall events and slowly releasing flows. To increase the flow control benefits, wetlands can be constructed within retention or detention basins.

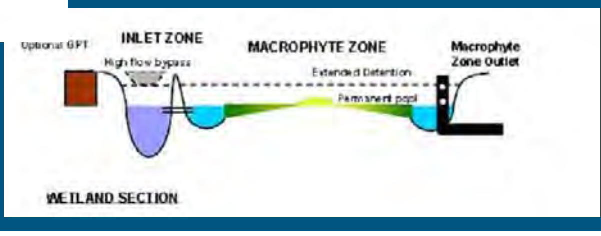
When flows exceed the ‘design operation flow’ excess water is directed around the wetland (macrophyte zone) via the bypass channel.

Operational Risks

The main operational risks associated with wetlands include the following:

- *Public Safety*: Like any permanent or temporary water body, there is the potential for drowning to occur.
- *Exotic Species*: Wetlands can attract some potentially undesirable species (e.g. cane toads, exotic fish, mosquitoes).
- *Erosion*: High stormwater flow rates can result in erosion (or similar damage) within the wetland.
- *Re-Suspension*: High stormwater flow rates can cause sediment that has been retained/ captured within the sedimentation basin to scour/ re-suspend and be discharged into the downstream macrophyte zone. Similarly in the macrophyte zone, high flow rates can wash out ‘biofilms’ attached to the surface of macrophyte vegetation and re-suspend and remobilise accumulated pollutants (e.g. sediment and attached pollutants).





Constructed Wetlands

Maintenance Requirements

The maintenance requirements of wetlands typically involve the following:

• Visual inspection, which involves checking items such as the depth of sediment accumulation, damage to vegetation, scouring and litter/ debris build-up. It is recommended that this be undertaken after the first three significant storm events following construction and then at least every three months).

• Removal of litter/ debris.

• Removal and management of invasive weeds (both terrestrial and aquatic).

• Mowing of turf or slashing of vegetation (if required) in bypass channel to preserve the optimal height for the vegetation.

• Replacement of any plants that have died.

• Periodic (usually every 5 years) desilting of inlet zone, which typically requires excavation and dewatering/ drying of removed sediment (and disposal to an approved location).

Design Considerations

The key considerations for the design of the inlet zone (sedimentation basin) are given in the 'Sedimentation Basins' chapter of this Appendix.

The key considerations of the design of the macrophyte zone are as follows:

• *Size & Extended Detention*: The macrophyte zone should be designed to detain and provide treatment to the majority of runoff volume generated from the surrounding catchment (greater than 80% of mean annual volume for well designed wetlands). The recommended extended detention depth for macrophyte zones is approximately 0.5m. The macrophyte zone outlet structure should be designed to provide a notional detention time (usually 48 to 72 hours) for a wide range of flow depths, and be designed to exclude debris to prevent clogging. Typically, this is designed as a riser outlet within a submerged structure so as to prevent floating vegetation from interfering with the riser holes.

• *Bathymetry/ Zonation*: The bathymetry of the macrophyte zone should be designed to promote a sequence of ephemeral, shallow marsh, marsh and deep marsh zones in addition to open water zones, with macrophyte zone bed levels ranging from approximately 1.5m below to 0.2m above the permanent/ typical water depth. The bathymetry should also be designed so that all marsh zones are connected to a deeper open water zone to allow mosquito predators to seek refuge in deeper open water zones during periods of dry weather.

Constructed Wetlands

Design Considerations (Cont'd)

•*Hydraulic Efficiency*: To further improve the distribution of flows across a macrophyte zone, attention should be given to the placement of inlet and outlet structures, the length to width ratio and other flow control features.

• *Scour Protection*: Inlet and outlet structures should be designed and batters appropriately protected to prevent erosion during periods of high inflow rates.

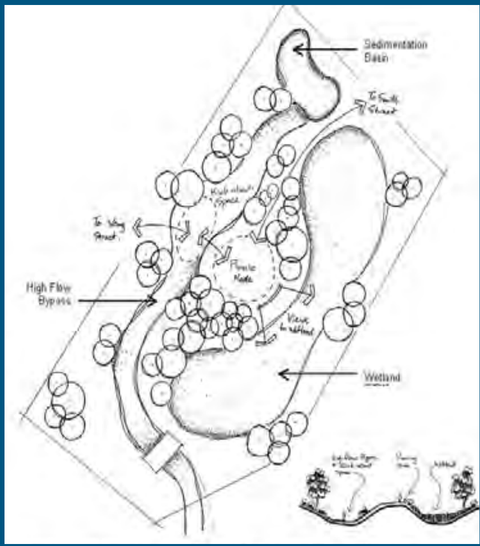
• *Water Retention*: The macrophyte zone is required to retain water and therefore the base must be of a suitable material to retain water (e.g. clay).

• *Landscape Design & Public Safety*: Wetlands should be designed to be integrated with or enhance the surrounding landscape, and providing/ enhancing local habitat. Dense littoral vegetation planting of basins is typically undertaken to restrict public access (and subsequently increase public safety). A variety of internal batter configurations are available, but fencing may be required if batter slopes are too steep (e.g. greater than 1V:5H).

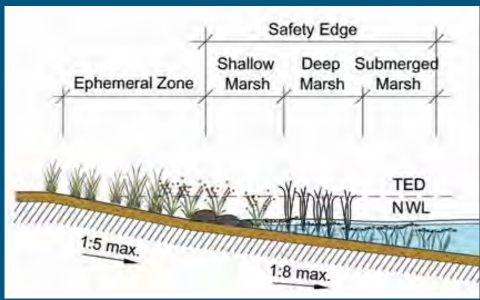
•*Vegetation Specification*: Vegetation plays a critical role in the performance and function of the macrophyte zone and an extensive cover (at least 70% of the total macrophyte zone area) of a wide variety of native plants is recommended for the various plant zones. Plant species for the macrophyte zone should be selected based on the hydrologic regime, microclimate and soil types of the region, and the life histories, physiological and structural characteristics, natural distribution and community groups of the wetland plants.

•*Maintenance*: Access to all areas of the macrophyte zone is recommended for maintenance, with maintenance access typically incorporated with walking paths around the wetland system. Provision to drain the macrophyte zone for water level management during the plant establishment phase should be considered.

The key design considerations for the bypass channel are as follows:



Example Relationship Between High Flow Bypass, Wetland and Basins & the Creation of Open Space



Example of Edge Design to a Constructed Wetland Systems


Constructed Wetland Bypass Weir & Channel Configuration

•*Capacity*: The bypass channel will need to be designed to convey the 'above design flow' (e.g. 100 year ARI) and to avoid bed and bank erosion. Typically, a turf finish will provide appropriate protection for most bypass channel configurations (but velocities will need to be checked).

•*Flow Velocity*: Velocities within the bypass channel should not exceed approximately 2.0m/s for major flood flows to avoid scouring. Flow 'velocity x depth' should also satisfy local design requirements for public safety.

Constructed Wetlands

Design Considerations (Cont'd)

•*Landscape Design & Public Safety*: Bypass channels can be successfully integrated into a landscape such that both functional stormwater objectives and landscape aesthetics and amenity are achieved. The bypass channel of a wetland must have provide sufficient conveyance capacity to satisfy local infrastructure design requirements (e.g. low 'depth x velocity' factor).

Relevant Guidelines

Gold Coast City Council (2007) Water Sensitive Urban Design Guidelines www.goldcoast.qld.gov.au/t_standard2.aspx?pid=6866

Healthy Waterways (2006), *WSUD Technical Design Guidelines for South East Queensland*. http://www.healthywaterways.org/wsud_technical_design_guidelines.html

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Bioretention Swale

Description

A bioretention swale is a soil and plant-based stormwater treatment device, combining a swale and a bioretention system (at the base of the swale). The swale component is a shallow channel lined with vegetation providing both stormwater treatment and conveyance functions, whilst the bioretention system consists of a porous filter media (at the base of the swale) such as gravel, sand and/ or sandy loam with perforated under-drainage to collect infiltrated stormwater.

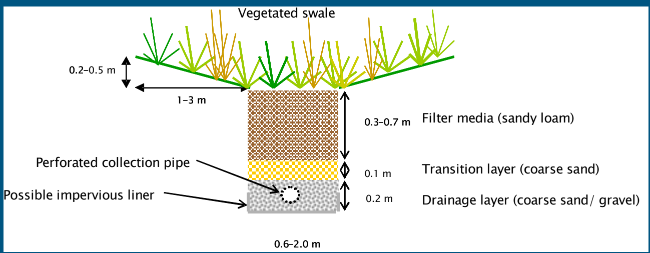
The bioretention component is typically located at the downstream end of the overlying swale 'cell' (i.e. immediately upstream of the swale overflow pit(s) or along the full length of a swale as a continuous trench).

Application/ Function

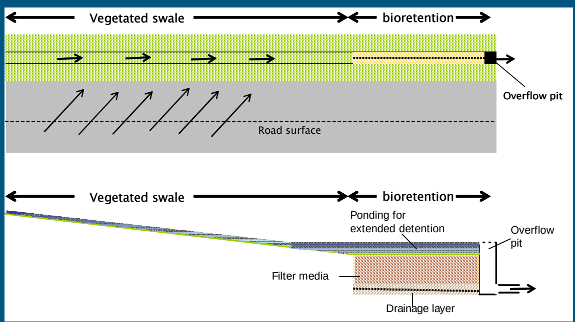
The bioretention swale treatment process operates by filtering stormwater runoff through surface vegetation associated with the swale and then percolating the runoff through the prescribed filter media forming the bioretention component, which provides treatment through fine filtration, extended detention treatment and some biological uptake. Bioretention swales also act to disconnect impervious areas from downstream waterways and provide protection to natural receiving waterways from frequent storm events by reducing flow velocities compared with pipe systems.

The swale component provides pre-treatment of stormwater to remove coarse to medium sediments, whilst the bioretention system removes finer particulates and associated contaminants. The vegetation within the bioretention swale performs several functions such as promoting evapotranspiration, maintaining soil porosity, encouraging biological activity, and promoting uptake of some pollutants.

Bioretention swales are used to convey and treat stormwater in lieu of, and with, underground pipe drainage systems to slow stormwater flow-rates and provide for the removal of sediment, finer particulates and associated pollutants. The swale component is usually not suitable on very flat (<1%) or steep (>4%) land, whilst the bioretention component is best suited to predominantly flat areas



Typical Section of a Bioretention Swale



Example of Bioretention Swale Conceptual Layout

Bioretention Swale

Operational Risks

The main operational risks associated with bioretention swales are as follows:

• *Erosion/ Scour*: If flow velocities are too high (e.g. due to steep gradients), there is potential for erosion and scour of collected pollutants and vegetation.

• *Vehicle damage*: Vehicles driving on to bioretention swales can result in vegetation damage and cause ruts that can create preferential flow paths and subsequently diminish the treatment performance of the bioretention swale, as well as creating depressions that can retain water and potentially mosquito breeding sites.

• *Public Safety*: Bioretention swales could pose a fall hazard to any persons accessing the swale component during times of high flow. Although the temporary maximum depth of bioretention swales is typically limited to approximately 100mm, there is the potential for drowning to occur.

• *Slow Draining*: If the surface of the filter media becomes blocked (e.g. due to surface compaction, accumulated sediment), the rate at which stormwater detained within the bioretention component is drained can be significantly reduced.

Maintenance Requirements

The maintenance requirements of bioretention swales typically involve the following:

• Visual inspection, which typically involves identifying items such as indications of any obvious sediment deposition, scouring from storm flows, rill erosion from lateral inflows or vehicle damage, and inspection of inlet points, surcharge pits and overflow pits to identify any scour, litter build-up and blockages. It is recommended that this be undertaken for the first three significant storm events following construction and then at least every three months.

• Removal of sediment if it is impeding conveyance capacities of the swale and/ or smothering vegetation (and, if necessary, re-profiling of swale and re-vegetating).

• Tilling of the bioretention surface if there is evidence of clogging.

• Repairing any damage due to scour, rill erosion or vehicle damage.

• Clearing blockages of inlets or outlets.

• Regular watering/ irrigation of vegetation until plants are established and actively growing.

• Mowing of turf or slashing of vegetation (if required) to preserve the optimal height for the vegetation.

• Removal and management of invasive weeds.

• Removal and suitable replacement of plants that have died.

• Removal of litter/ debris.

Bioretention Swale

Design Considerations

The key considerations of the design of bioretention swales are as follows:

• *Capacity*: For water quality improvement, bioretention swales need only focus on treating/ conveying frequent storm flows (typically up to the 3-month ARI). However, bioretention swales may be required to provide a flow conveyance function as part of minor and/ or major drainage system, and it may be necessary to augment the capacity of the bioretention swale with overflow pits along the invert of the bioretention swale that discharge to underground pipe drainage.

• *Gradient*: The swale component of a bioretention swale typically operates best between longitudinal slopes of 1% and 4%, given that slopes milder than this can become waterlogged and have stagnant ponding and steeper slopes can result in scour (which can be potentially prevented through check dams, or equivalent measures). The bioretention component of a bioretention swale is best suited to predominantly flat gradients due to the requirement to pond water over the filter media.

• *Flow Velocity*: Velocities within bioretention swales should be kept low (preferably less than 0.5m/s for minor flood flows and not more than 2.0m/s for major flood flows) to avoid scouring of collected pollutants and vegetation.

• *Landscape Design*: Bioretention swales can be successfully integrated into a landscape so that functional stormwater objectives, landscape aesthetic and amenity goals are achieved.

• *Driveway Crossings*: Driveway crossings for bioretention swales along roadways can be 'at-grade' or 'elevated' and their applicability will be dependent on a number of factors (e.g. aesthetics, cost, requirement for ponding, public safety and traffic movement).

• *Services*: Bioretention swales located within road verges or within footpaths must consider the standard location for services within the verges and ensure access for maintenance of services without regular disruption or damage to the bioretention swale.

• *Public Safety*: Bioretention swales located within road reserves must allow for safe use of adjoining roadway, footpaths and bike paths by providing sufficient conveyance capacity to satisfy local infrastructure design requirements.

• *Vegetation Selection*: Bioretention swales can use a variety of vegetation types including turf (swale component only), sedges and tufted grasses. Vegetation is required to cover the whole width of the bioretention swale, be capable of withstanding design flows and be of sufficient density to prevent preferred flow paths and scour of deposited sediments.

Bioretention Swale

Design Considerations (Cont'd)

• *Bioretention Filter Media*: Selection of an appropriate bioretention filter media is dependent on (1) saturated hydraulic conductivity for optimised treatment performance; (2) depth of extended detention above the filter media; and (3) suitability of filter media to support vegetation. The bioretention filter media typically consists of a sandy loam filter media (approximately 0.4 to 1m deep), transition layer (approximately 0.1m of coarse sand) and drainage layer (approximately 300mm gravel surround, encompassing perforated pipe under-drainage).

• *Under-Drainage*: The perforated under-drainage should be free-draining and be designed with a capacity that exceeds the saturated hydraulic conductivity of the filter media. Rodding points should also be incorporated into the under-drainage to allow any blockages to be removed.

• *Ex-Filtration*: If ex-filtration of treated stormwater runoff to surrounding soils (from bioretention filter media) is to be avoided, it may be necessary to install an impermeable liner around the sides of the filter and the transition layer and base of the drainage layer.

• *Traffic Control*: To prevent vehicles driving on bioretention swales (and reducing treatment performance, etc.) appropriate traffic control measures should be considered (e.g. dense vegetation, physical barriers).

• *Roof Water Drainage*: Roof water (directly from roof areas or overflow from rainwater tanks, etc) should be discharged to bioretention swales (if possible), which may require the use of a small surcharge pit (with perforations allowing drainage to the surrounding sub-soil) in the invert of the swale to allow roof water to surcharge to the swale.

Relevant Guidelines

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www.wsud.org/downloads/WSUD%20Tech%20Guide/WSUD%20Technical%20Guidelines%20low%20res%20Part%201.pdf

Bioretention Basin

Description

A bioretention basin is a soil and plant-based stormwater treatment device, consisting of a porous filter media (e.g. sandy loam) with perforated under-drainage to collect infiltrated stormwater.

Application / Function

Bioretention basins treat stormwater by filtering runoff through the plant/mulch/soil environment as it percolates downwards into the under-drainage. As the stormwater percolates, pollutants are retained through fine filtration, adsorption and some biological uptake. Bioretention basins often use temporary ponding above the filter media surface to increase the volume of runoff infiltrating through the filter media.

Bioretention basins can be installed at various scales, for example, as landscape planter boxes, in streetscapes integrated with traffic calming measures, in suburban parks and in retarding basins. In larger applications, it is considered good practice to have pre-treatment measures (e.g. swales) upstream of the basin to reduce the maintenance frequency of the bioretention basin.

Operational Risks

The main operational risks associated with bioretention basins are as follows:

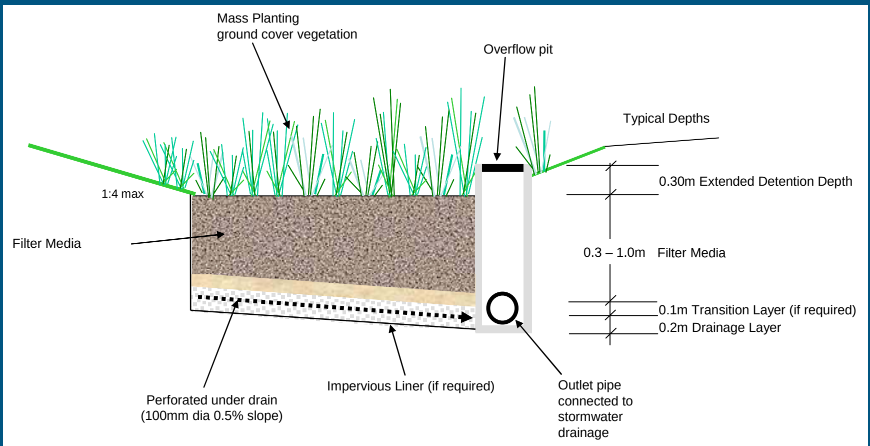
• *Erosion/ Scour*: If flow velocities are too high, there is potential for erosion and scour of collected pollutants and vegetation.

• *Vehicle damage*: Vehicles driving on bioretention basins can result in vegetation damage and cause ruts that can create preferential flow paths and subsequently diminish the treatment performance of the basin, as well as creating depressions that can retain water and potentially mosquito breeding sites.

• *Public Safety*: Like any permanent or temporary water body, there is the potential for drowning to occur.

• *Clogging*: If the surface of the filter media becomes blocked (e.g. due to surface compaction, accumulated sediment), the rate at which stormwater detained within the bioretention component is drained can be significantly reduced, potentially creating mosquito breeding sites and posing a public safety risk (e.g. due to increased risk of drowning).

Bioretention Basin



Typical Cross Section of a Bioretention Basin

Maintenance Requirements

The maintenance requirements of bioretention basins typically involve the following:

• Visual inspection, which involves identifying items such as indications of any obvious sediment deposition, scouring from storm flows, rill erosion of the batters from lateral inflows, vehicle damage, and clogging of the bioretention basin (evident by a 'boggy' filter media surface), inspection of inlet points, surcharge pits and overflow pits to identify any scour, litter build-up and blockages. It is recommended that this be undertaken for the first three significant storm events and then at least every three months.

• Tilling of the bioretention surface if there is evidence of clogging.

• Removal of sediment where it is smothering the bioretention basin vegetation.

• Repairing any damage due to scour, rill erosion or vehicle damage.

• Clearing blockages of inlets or outlets.

• Regular watering/ irrigation of vegetation until plants are established and actively growing.

• Mowing of turf or slashing of vegetation (if required) to preserve the optimal height for the vegetation.

• Removal and management of invasive weeds.

• Removal and suitable replacement of plants that have died.

• Removal of litter/ debris.

Bioretention Basin

Design Considerations

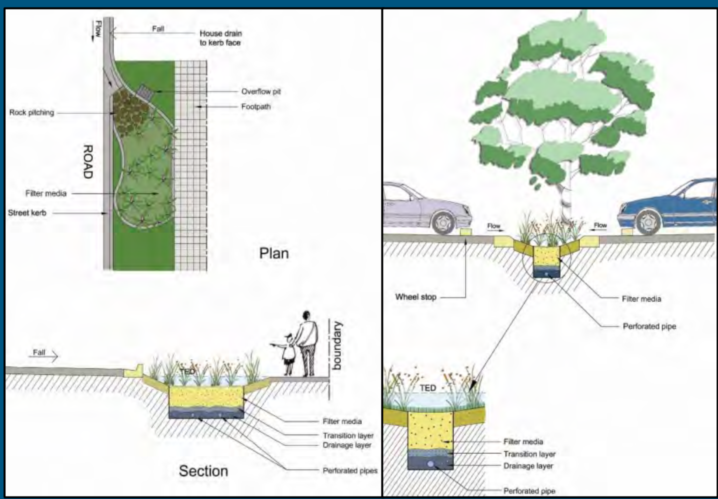
The key considerations of the design of bioretention basins are as follows:

• *Extended Detention*: Temporary ponding (i.e. extended detention) of up to approximately 0.5m (depending on local council requirements) can assist in managing flow velocities and increasing the volume of stormwater runoff treated.

• *Gradient*: The finished surface of the bioretention filter media should be horizontal (i.e. flat) to ensure full engagement of the filter media by stormwater flows and to prevent concentration of stormwater flows.

• *Flow Velocity*: Velocities within bioretention basin should be kept low (preferably less than 0.5m/s for minor flood flows and not more than 2.0m/s for major flood flows) to avoid scouring of collected pollutants and vegetation. Where possible the overflow pit or bypass channel should be located near the inflow zone to prevent high flows from passing over the surface of the filter media.

• *Landscape Design & Public Safety*: Bioretention basins can be successfully integrated into a landscape such that both functional stormwater objectives and landscape aesthetics and amenity are achieved.



Bioretention Basin Integrated into a Local
Streetscape (left) and a Car Park (right)

• *Services*: Bioretention basins located within road verges or within footpaths must consider the standard location for services within the verges ane ensure access for maintenance of services without regular disruption or damage to the bioretention system.

• *Public Safety*: Bioretention basins located within road reserves must allow for safe use of adjoining roadways, footpaths and bike paths by providing sufficient conveyance capacity to satisfy local infrastructure design requirements. In larger applications, measures may be necessary (e.g. batters with gradients not greater than 1V:5H, dense littoral planting) to increase public safety.

• *Vegetation Selection*: Bioretention basins can use a variety of vegetation types including sedges and tufted grasses. Vegetation is required to cover the whole width of the bioretention basin, be capable of withstanding design flows and be of sufficient density to prevent preferred flow paths and scour of deposited sediments.

Bioretention Basin

Design Considerations (Cont'd)

• *Bioretention Filter Media*: Selection of an appropriate bioretention filter media is dependent on (1) saturated hydraulic conductivity for optimised treatment performance; (2) depth of extended detention above the filter media; and (3) suitability of filter media to support vegetation. The bioretention filter media typically consists of a sandy loam filter media (approximately 0.4 to 1m deep), transition layer (approximately 0.1m of coarse sand) and drainage layer (approximately 300mm gravel surround, encompassing perforated pipe under-drainage).

• *Under-Drainage*: The perforated under-drainage should be free-draining and be designed with a capacity that exceeds the saturated hydraulic conductivity of the filter media. Rodding points should also be incorporated into the under-drainage to allow any blockages to be removed.

• *Ex-Filtration*: If ex-filtration of treated stormwater runoff to surrounding soils (from bioretention filter media) is to be avoided, it may be necessary to install an impermeable liner around the sides of filter and transition layer and base of the drainage layer.

• *Traffic Control*: To prevent vehicles driving on bioretention basin (and reducing treatment performance, etc.) appropriate traffic control measures should be considered (e.g. dense vegetation, physical barriers).

• *Roof Water Drainage*: Roof water (directly from roof areas or overflow from rainwater tanks, etc) should be discharged to bioretention swales (if possible), which may require the use of a small surcharge pit (with perforations allowing drainage to the surrounding sub-soil) in the invert of the swale to allow roof water to surcharge to the swale.

Relevant Guidelines

Department of Environment (2004) *Stormwater Management Manual for Western Australia*. Government of Western Australia. http://portal.water.wa.gov.au/portal/page/portal/WaterManagement/Stormwater/StormwaterMgtManual

Gold Coast City Council (2007) Water Sensitive Urban Design Guidelines

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Porous Paving

Description

Porous pavement is a load bearing pavement structure that is permeable to water. There are a wide variety of porous pavement types, but common features of all porous pavements include a permeable surface layer overlying an aggregate storage layer. The surface layer of porous pavement may be either monolithic (such as porous asphalt or porous concrete) or modular (clay or concrete blocks). The reservoir storage layer consists of crushed stone or gravel which is used to store water before it is infiltrated to the underlying soil or discharged towards a piped drainage system.

Application / Function

Porous paving can be used as an alternative to conventional paving and hardstand surfaces within urban developments to reduce stormwater runoff velocity and volume by:

• limiting the amount of impervious surface area on a site.

• encouraging infiltration of surface runoff.

• detaining and slowly releasing water from a site.

Water quality improvement is achieved through:

• filtering through the pavement media and underlying material.

• potential biological activity within the base and sub-media.

• reduction of pollutants through reduced runoff volumes.

Permeable pavement systems can function in two ways:

• as an infiltration system, holding water to allow percolation in underlying soils.

• as a detention system, holding surface water temporarily to reduce peak flows by later release of stormwater to the drainage system.

Porous Paving

Operational Risks

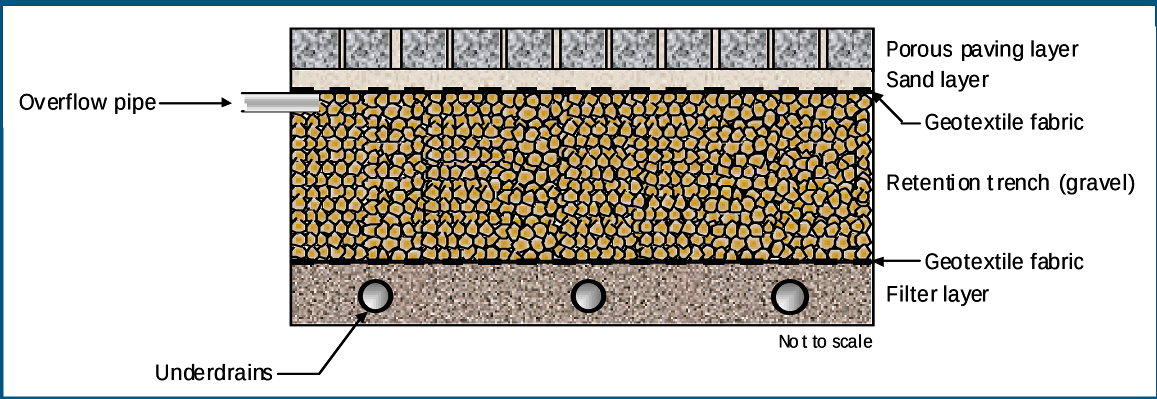
The main operational risks associated with porous paving are as follows:

• *Property Damage*: Water infiltration adjacent to road pavements can cause damage such as asphalt stripping and loss of strength in sub-grades. Similarly, porous paving can be broken or cracked if subjected to loads in excess of the design capacity of the pavement.

• *Clogging*: Without adequate pre-treatment (e.g. by vegetated buffers, swales), there is potential for clogging of the paving media, which will cause reduced permeability rates and extended periods of ponding across the pavement (and potential for property damage, water-logging, etc).

• *Public Safety*: Porous paving could present an increased risk of slips, trips and falls associated with a slippery pavement surface.

• *Slow Draining*: The infiltration rate of collected stormwater could be reduced by clogging or high water tables, which could result in extended periods of ponding across the pavement.



Typical Porous Paving Section

Maintenance Requirements

The maintenance requirements of porous pavement typically involve the following:

• Visual inspection, which typically involves identifying items such as indications of any obvious accumulated sediment, surface clogging/ blockage of the underlying aggregate/ filter layers, and holes/ cracks in pavement, and inspection of inlet points, pre-treatment and contributing catchment. It is recommended that be undertaken every 1 to 6 months (or after each major rainfall event).

• Removal of accumulated sediment and clearing of blockages to inlets.

• Regular vacuum sweeping and/ or high pressure hosing to free pores in the top layer from clogging.

• Periodic replacement of aggregate layer (about every 20 years) and replacement of geotextile fabric.

• Maintaining surface vegetation (if present).

Porous Paving

Design Considerations

The key considerations of the design of porous paving systems are as follows:

• *Pavement Type*: A wide range of porous pavement types are available, and the preferred type of paving for any particular application will be dependent on site conditions and desired amenity or built environment/ local character requirements.

• *Sizing*: The sizing of a porous paving system requires consideration of the volume and frequency of runoff, the available 'detention volume' and the infiltration rate.

• *Siting*: Permeable paving systems should be avoided in areas with high water tables, saline soils, acid sulphate soils, wind blown areas, high traffic volumes and runoff from areas expected to have a high sediment load.

• *Pre-Treatment*: Stormwater runoff should be treated (e.g. by vegetated buffers, swales) to remove coarse and medium sized sediments and litter prior to entering the porous paving system to prevent blockage.

• *Vegetation*: In modular or grid paving systems, grass may be grown in the voids. However, factors may result in this being unsuccessful, such as (1) lack of sufficient soil depth and nutrients for grass to grow; (2) heat retained in the pavers; and (3) wear from vehicle movement.

Relevant Guidelines

Stormwater Trust and Upper Parramatta River Catchment Trust (2004) Water Sensitive Urban Design – Technical Guidelines for Western Sydney
www.wsud.org/downloads/WSUD%20Tech%20Guide/WSUD%20Technical%20Guidelines%20low%20res%20Part%201.pdf

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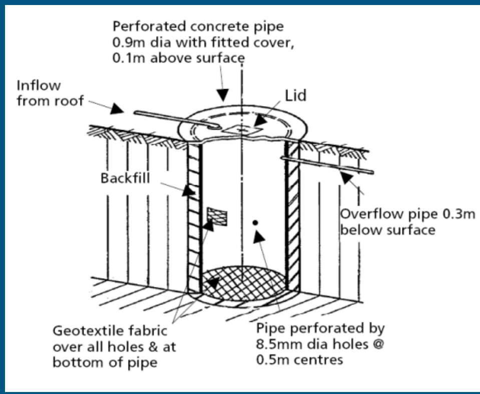
http://portal.water.wa.gov.au/portal/page/portal/WaterManagement/Stormwater/StormwaterMgtManual

Infiltration Measures

Description

Infiltration measures typically consist of a 'detention volume' (above or below ground, designed to detain a certain volume of runoff for subsequent infiltration) and an 'infiltration area/ surface'. There are four basic types of infiltration systems: (1) leaky well; (2) infiltration trench; (3) infiltration 'soak-away'; and (4) infiltration basin.



'Leaky Well' Infiltration System
(Engineers Australia 2006, LHCCREMS 2002)

Application/ Function

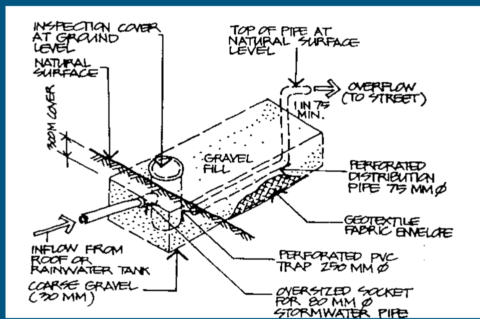
Stormwater infiltration measures capture stormwater runoff and encourage infiltration into the surrounding in-situ soils and underlying groundwater. The purpose of infiltration systems in a stormwater management strategy is as a conveyance measure (to capture and infiltrate flows), NOT as a treatment system.

Infiltration systems can operate at a variety of scales from:

• Small (lot scale) systems receiving overflows from rainwater tanks to

• Larger (regional scale) systems receiving (treated) runoff from whole urban catchments.

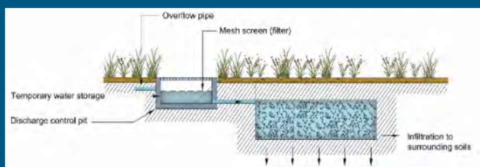
They are best suited to moderately to highly permeable in-situ soils (i.e. sandy loam to sandy soils), but can still be applied in locations with less permeable soils by providing larger detention volumes and infiltration areas.



Infiltration Trench
(Engineers Australia 2006)

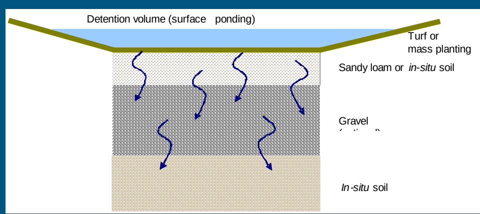
Operational Risks

The main operational risks associated with infiltration measures are as follows:



Infiltration 'Soakaway'

• *Slow Draining*: If the infiltration system becomes blocked (e.g. due to surface compaction, accumulated sediment), the rate at which stormwater detained within the infiltration system can be significantly reduced, potentially creating mosquito breeding sites and posing a public safety risk.



Infiltration Basin Typical Section

• *Erosion/ Scour*: If flow velocities into an infiltration system are too high, there is potential for erosion and scour of infiltration media, collected pollutants and vegetation (if present).

• *Vehicle damage*: Vehicles driving into exposed infiltration systems can result in vegetation damage (if vegetation is present) and cause ruts that can create preferential flow paths and subsequently diminish the infiltration rate of the infiltration system, as well as creating depressions that can retain water and potentially create mosquito breeding sites.

Infiltration Measures

Operational Risks (Cont'd)

• *Public Safety*: Like any permanent or temporary water body, there is the potential for drowning to occur in exposed infiltration systems.

• *Stormwater Re-Emerging*: Infiltration into steep terrain can result in stormwater re-emerging on to the surface at some point downslope, which can result in hazardous/ nuisance flooding, salt leaching and increase the risk of slope instability.

• *Building Damage*: A continually wet sub-surface or greatly varying soil content can damage the structural integrity of buildings situated at less than the recommended clearance distances.

Maintenance Requirements

Maintenance for infiltration systems is aimed at ensuring the system does not clog with sediments, that an appropriate infiltration rate is maintained and pre-treatment measures are operating properly (to prevent clogging and groundwater contamination). Typical maintenance of infiltration systems involves:

Infiltration Basin

• Routine inspection to identify any surface ponding after the design infiltration period (indicating clogging/ blockage of the underlying aggregate or the base of the trench). This should be done every 1 to 6 months (or after each major rainfall event), depending on the size and complexity of the system.

•Routine inspection of inlet points to identify any areas of scour, litter build up, sediment accumulation or blockage.

• Removal of accumulated sediment and clearing of blockages to inlets.

• Tilling of the infiltration surface, or removing the surface layer, if there is evidence of clogging.

• Maintaining the surface vegetation if present.

South Australian Stormwater Infiltration/ASR System, stormwater enters from grated channel

Design Considerations

The key considerations of the design of infiltration systems are as follows:

• *Design Objectives*: Infiltration systems can be designed to achieve a range of objectives, including: (1) minimising stormwater runoff volume; (2) preserving pre-development hydrology; (3) enhancing groundwater recharge.

• *Type*: As outlined above, a range of infiltration systems are available. In general, selection of the type of infiltration system is determined by size of the contributing catchment.

• *Pretreatment*: Pretreatment of stormwater entering an infiltration system is primarily required to minimise the potential for clogging of the infiltration media to protect groundwater quality.

• *Size*: The size of an infiltration system requires consideration of the volume and frequency of runoff discharged to the system, the available 'detention volume' and the infiltration rate.

Design Considerations (Cont'd)

• *Site Terrain*: As outlined above, there is an increased risk of stormwater re-emerging on steep gradients and resulting in flooding etc. Therefore, infiltration systems are typically suited to sites with a gradient of less than 5%.

• *In-Situ Soils*: The hydraulic conductivity of in-situ soils will influence both the suitability of infiltration systems and size of infiltration area required. Infiltration systems are not suitable in areas with poor soil conditions, in particular sodic/ saline and dispersive soils, and shallow saline groundwater. They are also not suitable in locations where soils are underlain by rock or a soil layer with little or no permeability.

• *Groundwater Level*: The base of an infiltration system should always be above the groundwater table and it is generally recommended that the base be a minimum of 1m above the seasonal high water table.

• *Building Setbacks*: Infiltration systems should not be placed near building footings to avoid the influence of continually wet sub-surface or greatly varying soil moisture content on the structural integrity.

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Aquifer Storage & Recovery

Description

Aquifer Storage and Recovery (ASR) is a means of introducing recycled water into underground aquifers, either via direct injection (i.e. pumping) or gravity for subsequent extraction and reuse.

Application / Function

Most ASR systems provide seasonal water storage, storing water during high rainfall periods and recovering it during dry periods. ASR systems operate by storing water (e.g. treated stormwater in wet periods) in water-bearing geological formations (or 'aquifers'). The stored water displaces the water naturally present in the aquifer. The water can then be recovered (e.g. during dry periods) to supplement water demands.

There is a range of aquifer types that can accommodate an ASR scheme, including fractured unconfined rock and confined sand, and gravel aquifers. In addition, it may be possible to construct an aquifer if the economics allow. Detailed geological investigations are required to establish the feasibility of any ASR scheme.

Operational Risks

The main operational risks associated with ASR systems are as follows:

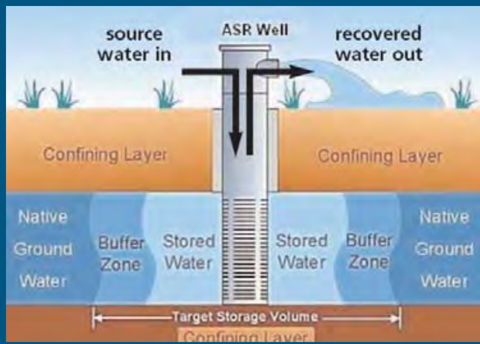
• *Groundwater Contamination*: Water (e.g. stormwater, wastewater) introduced into an aquifer has the potential to deteriorate groundwater quality and its beneficial uses.

• *Poor Quality Extracted Water*: Recycled water extracted from an aquifer can be a risk to public and environmental health (e.g. due to poor quality of extracted water).

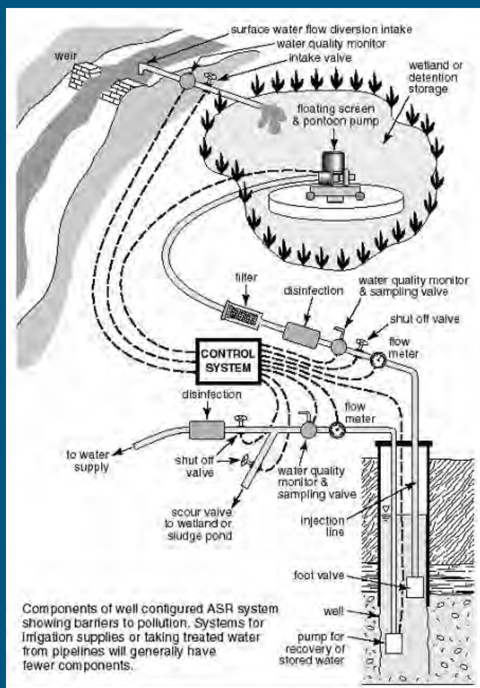
• *Clogging*: Suspended solids, air entrapment or nutrients in the water introduced into the aquifer can clog the aquifer.

• *Altered Hydrogeology*: Recharged water may discharge directly to watercourses or the ground surface. Alternately, excessive extraction can decrease groundwater levels.

• *Environmental Flow Requirements*: For stormwater ASR systems, reduced volumes of surface water can be delivered downstream of the harvesting point. This may conflict with environmental flow requirements.



Example ASR Operation
(from www.amlrnrm.sa.gov.au)



Components of a Well Configured ASR System
(from Dillon et all 2000 in DWLBC 2002)

Aquifer Storage & Recovery

Design Considerations

The key considerations of the design of ASR systems are as follows:

• *Aquifer Suitability*: A number of factors need to be considered when assessing an aquifer for an ASR scheme, including existing environmental values and beneficial uses of the aquifer, permeability, salinity, and potential adverse effects of groundwater pressure increases and decreases due to operation of an ASR scheme.

• *Pre-Treatment*: The level of pre-treatment required for an ASR system will be highly dependent on the predicted quality of the introduced water and existing groundwater (and associated environmental values).

• *Recovered Water Post-Treatment*: The extent of post-treatment will depend on the intended end use (e.g. irrigation).

• *Contingency Plans*: Controls and plans to prevent or reduce the injection of contaminated water into an aquifer will be likely required.

Relevant Guides

Healthy Waterways (2006), *WSUD Technical Design Guidelines for South East Queensland*. http://www.healthywaterways.org/wsud_technical_design_guidelines.html

Gold Coast City Council (2007) Water Sensitive Urban Design Guidelines www.goldcoast.qld.gov.au/t_standard2.aspx?pid=6866

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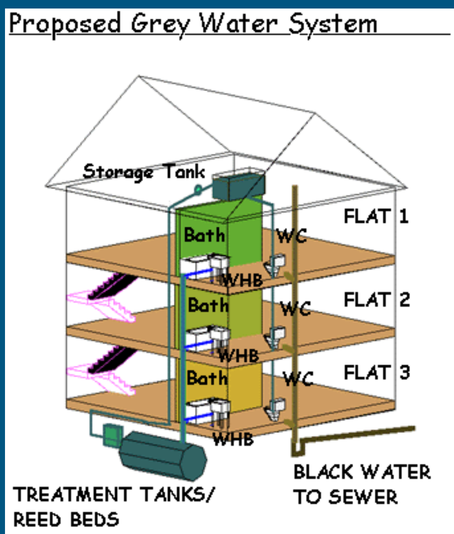
Greywater Reuse

Description

Greywater is wastewater from non-toilet plumbing fixtures such as showers, basins and taps. Depending on its use, greywater can require less treatment than blackwater and generally contains fewer pathogens. Treated greywater can be re-used indoors for toilet flushing and clothes washing, both of which are significant consumers of water. Greywater can also be used for garden watering.



Application / Function

There are several potential combinations of treatment and reuse of greywater ranging from no treatment/manual bucketing to advanced treatment and reuse for applications such as toilet flushing and garden irrigation. In all cases the key function of this measure is to simultaneously reduce wastewater flows and potable water use.

Operational Risks

Greywater must be treated and disinfected before storage and general re-use because:

• It can contain significant numbers of pathogens which spread disease.

• It cannot be stored for longer than a few hours untreated as it begins to turn septic and smell.

When reusing greywater for clothes washing, discoloration of clothing from dissolved organic material may be an issue. This can be avoided by installing an activated carbon filter.

Design Considerations

• Site characteristics (slope, soil types, proximity to neighbour etc)

• What the greywater will be used for (e.g. irrigation of a community area)

• How the greywater will be stored, treated and applied (e.g. sub-surface irrigation, toilet flushing)

• The maintenance and monitoring regime required.

Greywater Reuse

Relevant Guides

Create an Oasis with Greywater: your complete guide to managing greywater in the landscape. Art Ludwig

NSW Health, Greywater reuse in sewered single domestic premises 2000 can be found at:

http://www.health.nsw.gov.au/public-health/ehb/general/wastewater/greywater_policy.pdf

Environment & Health Protection Guidelines On-site Sewage Management for Single Households can be found at:

http://www.dlg.nsw.gov.au/dlg/dlghome/PublicTopicsIndex.asp?mi=0&ml=10&id=10

"Model Guidelines for Domestic Greywater Reuse for Australia" by the Urban Water Research Association of Australia Research Report 107, 1996

Draft Guidelines for the Reuse of Greywater in Western Australia –

www.health.wa.gov.au/publications/documents/HP8122%20Greywater%20Reuse%20Draft%20Guidelines.pdf

Effluent Reuse/Dual Reticulation/Sewer Mining

Description

Water recycling is becoming a critical element for managing our water resources. By safely irrigating recycled water, sustainable development can be achieved while conserving our high quality water supplies. Being able to access alternative safe water sources is particularly critical in times of drought.

By providing an additional source of water, recycling can help to decrease the diversion of water from sensitive river and wetland ecosystems. Another major benefit of effluent reuse by irrigation is the decrease in wastewater discharges to natural waterways. When pollutant discharges to waterways are removed or reduced, the pollutant loadings to these waters are decreased.

Substances that can be pollutants when discharged to waterways can be beneficially reused for irrigation. For example, plant nutrients such as nitrogen and phosphorus can stimulate harmful algal blooms in waterways but are a valuable fertiliser for crops.

Sewer mining is the process of tapping directly into a sewer (either before or after a sewage treatment plant) and extracting wastewater for treatment and reuse as recycled water. Some sewer mining by-products may be returned into the sewerage system.

Application / Function

• Demand for high quality drinking water can be significantly reduced by replacing it with recycled water supplied through effluent reuse, water recycling and sewer mining for non-drinking purposes.

• Effluent reuse, water recycling and sewer mining also reduces stresses on urban streams and rivers by capturing some of the water and nutrients that would otherwise be discharged from sewage treatment plants.

Operational Risks

• Cross connections and inadequate water quality

•Design Considerations

Social

• Consultation requirements for all relevant government agencies, local communities and other stakeholders

• Current and proposed changes in land zonings, land use, or tenure that may affect the future viability of the project (e.g. if urban development is planned for the future this may influence viability of irrigation with lower quality recycled water)

Effluent Reuse/Dual Reticulation/Sewer Mining

- Compatibility of surrounding land uses and possible impacts on public amenity (e.g. visual impacts, access, odours, noise) or neighbouring properties (e.g. impact on property values or future development potential)
- Possible health or other impacts on local communities, particularly subgroups of concern like children, the elderly and people with weakened immune systems
- Possible health impacts on employees, site visitors or customers who buy products produced with recycled water, including inadvertent or unauthorised use
- Location of utilities and infrastructure (e.g. supply of electricity, road access, requirement for easements)
- Impacts on cultural heritage from construction or operation
- Economic costs and benefits

Environmental

- Topography (e.g. slope and runoff potential)
- Local climate (e.g. rainfall patterns and intensity, evaporation, prevailing winds)
- Soils (e.g. permeability and drainage, salinity and sodicity, pH, cation exchange capacity, soil structure, acid sulphate soil status, cadmium and boron levels) and potential impacts from nutrients, salts and heavy metals in recycled water
- Ground water depth and quality and impacts from hydraulic loadings and recycled water quality
- Interaction between recycled water and crops (e.g. evapotranspiration rates, salinity tolerance, nutrient requirements, hydraulic requirements)
- Site hydrology and flooding potential
- Quality of surface water draining from the site and possible impacts on water quality and aquatic flora and fauna from recycled water runoff
- Terrestrial and aquatic flora and fauna that could be affected by the development
- Construction impacts (e.g. for pipelines and storage)
- Baseline monitoring requirements to satisfy regulators

Relevant Guides

http://www.landcom.com.au/Wastewaterreuse.aspx#WHAT

Queensland Water Recycling Guidelines - http://www.nrw.qld.gov.au/compliance/wic/guidelines_recycle.html

Rainwater Tanks

Description

Rainwater tanks conserve water through substituting potable water supply, protect urban streams by reduce stormwater runoff volumes (particularly for small, frequent storms) and reduce the loads of stormwater pollutants entering waterways. Maximum benefits are gained from rainwater tanks when the collected water is regularly used, that is if tanks are plumbed into the house and used for applications such as toilet flushing and washing machine supply.

Application/ Function

Widespread applications of rainwater tanks are possible, and in fact are mandatory in many areas of Australia.

Operational Risks

- Microbial contamination
- Chemical hazards
- Accumulated sediments
- Mosquitoes
- Tastes and odours

Design Considerations

The collection and storage of rainwater involves relatively simple systems. A reasonably low level of management including roof surface management, first flush diverters, the screening of all flows entering the tank and appropriate pumping can ensure the provision of good quality water which can be used for a wide range of purposes including bathing, laundry and hot water system supply, toilet flushing and garden watering. Potable use of water collected by a rainwater system should only be considered after reviewing State and Local Government specific management recommendations.

Relevant Guides

Enhealth Guidance on use of Rainwater Tanks - http://enhealth.nphp.gov.au/council/pubs/ecpub.htm

Sydney Water Guidelines for rainwater tanks on residential properties http://www.sydneywater.com.au/Publications

Stormwater Harvesting

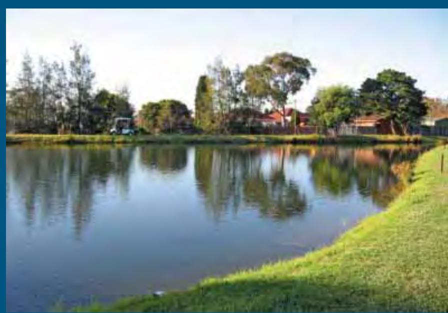
Description

The capturing or harvesting of urban stormwater for reuse can contribute to water conservation, water quality and streamflow objectives. It complements other approaches to sustainable urban water management such as demand management, rainwater tanks, and the reuse of effluent and greywater.

Application / Function

Stormwater harvesting and reuse can be defined as the collection, treatment, storage and use of stormwater run-off from urban areas. It differs from rainwater harvesting as the runoff is collected from drains or creeks, rather than roofs. The characteristics of stormwater harvesting and reuse schemes vary considerably between projects, but most schemes would have the following elements in common:

- collection – stormwater is collected from a drain, creek or pond
- storage – stormwater is temporarily held in dams or tanks to balance supply and demand. Storages can be on-line (constructed on the creek or drain) or off-line (constructed some distance from the creek or drain)
- treatment – captured water is treated to reduce pathogen and pollution levels, and hence the risks to public health and the environment, or to meet any additional requirements of end-users
- distribution – the treated stormwater is distributed to the area of use.



Some components of a scheme may serve multiple purposes, such as a grass swale that collects and treats stormwater while forming a feature in the urban landscape. Stormwater harvesting and reuse is a relatively new form of water reuse compared to rainwater tanks and the reuse of STP effluent. It is, however, increasingly recognised as a potential option for meeting the water demands and other objectives of many projects and sites. Harvested stormwater has commonly been used for irrigating public parks and golf courses, and other non-potable uses are possible.

Stormwater Harvesting

Operational Risks

There are a range of potential public health, public safety and environmental hazards from stormwater harvesting and reuse, as follows:

• Public health, specifically microorganisms (pathogens) and chemical toxicants in harvested water.

• Public safety, primarily related to potential drowning in a stormwater storage, or embankment failure/overtopping of such a storage

• Environmental

- Over-extraction of stormwater flows
- Storage constructed on natural watercourses
- Flooding above any diversion weir
- Surface water pollution by run-off (irrigation schemes)
- Groundwater pollution (irrigation schemes)
- Soil contamination (irrigation schemes)

Design Considerations

• Stormwater collection

• Stormwater storage

• Stormwater treatment

• Stormwater distribution

• Stormwater irrigation systems

• Construction

Relevant Guides

•Qld DNR (1999) Stormwater Recycling Background Study (Report 4)

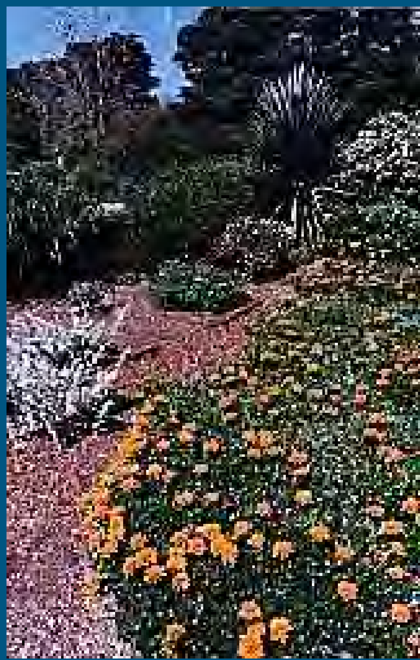
•Water & Rivers Commission (1998) A Manual for managing Stormwater Quality in Western Australia

•NSW EPA Managing Urban Stormwater - Harvesting and Reuse - www.epa.nsw.gov.au/resources/managestormwatera06137.pdf

Xeriscaping/Landscape Form

Description

Xeriscape, is a term derived from the Greek word 'xeros' meaning dry and from the word landscape, to form a new term for water conserving gardens. A Xeriscape garden can feature both native and exotic species and is landscaped to minimise water use and to channel water to plants which have a higher requirement.



xeriscape garden

Canberra's water-wise garden

Application / Function

- To reduce water consumption (as irrigation) by the selection of plant species which are adapted to the local environment and which are adapted to the local environment and therefore require minimal or no irrigation

- To reduce water use (as irrigation) by the replacement of planting with non-vegetative garden elements

Operational Risks

- Minimal

Design Considerations

- Feasible in all areas

- Need to consider the following issues carefully

    - Planning and design
    - Soil analysis
    - Appropriate plant selection
    - Practical turf areas
    - Efficient irrigation
    - Use of mulch
    - Appropriate maintenance

Relevant Guides

Elizabeth Caldwell. "With xeriscaping, grass needn't always be greener", USA Today, 2007-07-15.

Demand Management

Description

Demand management measures aim to minimise either the overall or peak demand for water. Measures can be categorised as shown below.

· *Increase system efficiency*: No change in resource usage by consumers but less system losses. e.g. leakage detection and repair; change in system operations such as pressure reduction and changes to mains flushing and reservoir cleaning; installing peak balancing capacity.

· *Increase end use efficiency*: Less resource used by the consumer to provide the same service. e.g.regulate AAA rated shower heads and dual flush toilets in new developments; waterless urinals and sensor flush systems; enforce minimum performance standards on new appliances (dishwashing machines, clothes washing machines); offering financial incentives for water efficient purchase and installation; programs to retrofit efficient equipment into existing buildings.

· *Promoting distributed sources of supply*: Provide services via a locally sourced resource not currently being used. e.g. encouraging household rainwater tanks and greywater reuse systems; provide recycled effluent for non-potable uses via dual reticulation.

· *Substitute resource use*: Provide same service without use of the resource in question. e.g. planting indigenous plants adapted to local rainfall; use of waterless sanitation.

· *Improve the market in resource usage*: Inform the consumer about the full costs of their resource use. e.g. full cost recovery charges for water use; volume-based pricing set at or above the long run marginal cost; providing better feedback on the level and cost of ongoing water usage by universal metering with at least quarterly billing or smart metering with instant feedback; remove perverse incentive for increased resource use such as declining block tariffs; provide comprehensive information on the environmental impacts of water use, run education campaigns; conduct detailed water use analysis (audits) for water customers in key sectors.

Application/ Function

•Water use efficient devices are generally feasible and applicable to all situations.

•Up to 30% water use savings are not difficult to achieve by the retrofitting of small-scale devices such as low flow taps and showerheads. The replacement of household equipment with more water efficient types is generally seen as practical on an ‘as needed’ basis.

Demand Management

•The retrofitting of low flush toilets systems is similarly practical, however retrofitting of other lower water using system types such as chemical composting etc is likely to be less practical.

Operational Risks

•Minimal

Relevant Guides

NSW Treasure Demand Management Guidelines - www.treasury.nsw.gov.au/__data/assets/pdf_file/0003/5097/demand_management.pdf

http://www.greenhouse.gov.au/yourhome/technical/fs21.htm

White, S. ed (1998). Wise water management: A demand management manual for water utilities, Chapter 8. Water Services Association of Australia and NSW Department of Land and Water Conservation.

Windust, A (2003) Waterwise House & Garden, Collingwood, Landlinks Press

Mobbs, M. (1998). Sustainable house: living for our future. Sydney, Choice Magazine.

Australia water conservation tips - www.savewater.com.au

APPENDIX C: PHOTOCOPYING TEMPLATES FOR CHECKLISTS

On subsequent pages, the checklists presented in Section 4 are given on separate pages to allow easy copying.

Broad Scale Assessment Checklist

Outcome	Intent Achieved	
	Y	*N*
Integration of the whole water cycle		
- Single WSUD measures deliver multiple water related benefits		
Management and minimisation of hydrologic impacts		
- Hydrologic Objectives have been identified (design events, conveyance requirements, peak flows, environmental flows etc)		
- High flows have been catered for (bypass structures etc)		
- Impacts upon the receiving environment have been determined and minimised where appropriate (erosion protection, minimisation of velocities etc)		
Protection and enhancement of the ecological function of receiving environments		
- Water Quality Management Objectives are identified		
- A treatment train approach has been developed		
- Source controls are used where practicable		
Provision of alternative sources of water		
- Use of rainwater harvesting considered		
- Alternative water sources identified and used appropriately		
Maintenance and/or enhancement of visual and social amenity		
- WSUD measures have been integrated into landscape form		
- Multiple use assets and/or corridors are proposed		
- Public Health and Safety issues considered and addressed		
Minimisation of whole of life asset costs		
- Maintenance requirements are considered (plans, access etc)		
- Asset life cycle costs determined		
- Asset ownership and responsibility defined		
- Cost-effectiveness of strategy evaluated and maximised		
Potable water/wastewater generation		
- Potable water use reduction targets achieved		
- Wastewater generation reduction targets achieved		

Site Suitability Review

Characteristic	Potential Implementation Constraint			Score
	Low	Moderate	High	
% Imperviousness (post implementation)	1 = 0-10%	2 = 10-50%	3 = 50-100%	
Average Slope	2 = 0-1%	1 = 2-5%	3 = >5%	
Developed Area	1 = <1ha	2 = 1-10ha	3 = >10ha	
Mean Annual Rainfall	1 = <600mm/yr	2 = 600-1200mm/yr	3 = >1200mm/yr	
			Total Score	

Information Requirements

Total Score	Implementation Risk	Local Scale Assessment Level	Information requirements
4 - 5	Low	Demonstrate implementation of best practice techniques	(i) Site Plan showing location, size and dimensions of measures (ii) Detailed design calculations (compliant with relevant guidelines) (iii) Public Health and Safety Issues considered and addressed
6 - 8	Medium	Demonstrate how relevant WSUD objectives are achieved (e.g. load based reduction targets achieved, peak flows compliant with hydraulic objectives)	Overall Water Management Plan provided, including: (i) Site Plan showing location, size and dimensions of measures (ii) Detailed design calculations (compliant with relevant guidelines) (iii) Estimates provided to show how WSUD targets are achieved (e.g. MUSIC modelling, Hydraulic assessments, compliance with planning codes for landscape elements etc, % of potable water demand satisfied by alternative sources) (iv) Public Health and Safety Issues considered and addressed
9 -12	High	Demonstrate how relevant WSUD objectives are achieved (e.g. load based reduction targets achieved, peak flows compliant with hydraulic objectives) Demonstrate how high risk factors addressed	Overall Water Management Plan provided, including: (i) Site Plan showing location, size and dimensions of measures (ii) Detailed design calculations (compliant with relevant guidelines) (iii) Estimates provided to show how WSUD targets are achieved (e.g. MUSIC modelling, Hydraulic assessments, compliance with planning codes for landscape elements etc, % of potable water demand satisfied by alternative sources) (iv) Detailed assessment of risk factors and proposed mitigation (v) Public Health and Safety Issues considered and addressed

WSUD Design Suitability Assessment

Objective	Suitability			Score	Essential Component (y/n)
Water Quality					
Treatment Train elements					
- Primary Treatment (Screening / Sedimentation)	1 = None (no specific measure)	2 = Incidental (measure may treat though not designed to)	3 = Dedicated (e.g. GPT, Sediment Basin)		Y
- Secondary Treatment (Enhanced sedimentation / Vegetative filtering)	1 = None (no specific measure)	2 = <50% Vegetation coverage (e.g. pond)	3 = >50% Vegetation coverage (e.g. wetland, swale)		
- Tertiary Treatment (Biological uptake)	1 = None (no specific measure)	2 = Filtration Only (e.g. sand filter, porous pavement)	3 = Filtration + Vegetation (e.g. bioretention system, raingarden)		
Load Based Reductions Achieved	1 = No compliance for any parameter	2 = Partial Compliance	3 = Full Compliance / Not Applicable		Y*
Water Quantity					
Disconnection of Impervious areas	1 = no disconnection	2 = Conveyance provides disconnection, but >10% directly connected impervious area	3 = Disconnection achieves <10% directly connected impervious area		
Maintenance of hydrologic regimes	1 = significant increases in flow volumes, frequencies and runoff peaks	2 = minor increases in volumes, frequencies and/or runoff peaks	3 = maintenance or improvement of pre-development regime		
Detention	1 = no detention capacity	2 = detention component provided for minor flows	3 = detention for major flows integrated into measure		
Water Supply					
Measure can provide alternative water source	1 = None possible	2 = One potable water source can be substituted	3 = Two or more water sources can be substituted		
Reduces Potable Water Demand	1 = No demand reduction possible	2 = 0-20% reduction expected	3 = >20% reduction expected		Y*
Wastewater					
Reduce Wastewater discharge	1 = No reduction possible	2 = 0-20% reduction expected	3 = >20% reduction expected		Y*
Amenity					
Multiple uses provided by the measure	1 = only has one function	2 = has an amenity function in addition to primary function	3 = has multiple functions		
Form is integrated into landscape	1 = discontinuous from other landscape elements	2 = has one or more consistent features with overall landscape character	3 = completely integrated within landscape		
Existing natural features retained	1 = <25% natural features retained	2 = 25-75% features retained or enhanced	3 = >75% of natural features retained		
Public safety elements addressed	1 = likely to pose public safety hazard	2 = public safety elements incorporated into design	3 = No public safety issue		
Linkages (pedestrian, bicycle, vehicular) maintained or enhanced	1 = links severed by measure	2 = existing links retained through measure	3 = existing links maintained and additional linkages provided		
Functionality					
Maintenance elements incorporated within measure	1 = no dedicated maintenance elements incorporated	2 = maintenance access provided	3 = maintenance access provided, working areas highlighted and provision for waste handling included		
Maintenance plans provided	1 = no maintenance plans given	2 = generic maintenance plan provided	3 = maintenance plan specific to measure provided, including costings		Y
Service corridors allowed for	1 = no services allowed for	2 = services can be included, but constrained	3 = service corridors dedicated and sufficient		

* indicates this may not be required in all applications

Total Score:
19 – 29 – Strategy, measure or treatment train may need considerable refinement
30 – 42 – Strategy, measure or treatment train may achieve WSUD objectives, however further refinement would be beneficial
43 – 57 – Strategy, measure or treatment train has a high likelihood of successful implementation

APPENDIX D: GLOSSARY OF TERMS

Aquifer - A layer of porous rock and soil that stores water and allows it to flow at rates that enable pumping from wells. Aquifers provide natural underground storage and treatment of water.

ARI – Average Recurrence Interval, a term used to describe the probalistic return period of a given rainfall event. It is therefore given with an appropriate return period e.g. 10 year ARI, which is the rainfall event which has a probability of return every 10 years.

ASR – Aquifer Storage and Recovery, a method where stormwater is treated and stored in a local aquifer for later recovery and reuse

Bathymetry – The shape of the surface of a treatment system that lies below standing water level.

Bioretention/Biofiltration - Biological removal of contaminants or nutrients as fluid passes through a media or a biological system.

Brownfield - Brownfields are abandoned, idle, or under-used already developed urban, industrial and commercial areas.

Detention Basin - An artificial flow control structure used to contain flood water for a limited period of a time, thereby providing flood protection for areas downstream. This is opposed to a retention basin that holds water for an extended period of time. These basins are generally a part of a larger engineered flood water management system.

Drinking water - Water that is treated to meet the *Australian Drinking Water Quality Guideline 2004*, and is safe for supply directly to households, commercial premises and industry for drinking and other purposes. These guidelines address contaminants that may be present in source waters, typically rivers or groundwaters.

Ecology - The scientific study of the distribution and abundance of living organisms and the interactions among organisms and between organisms and their environment. The environment of an organism includes physical properties, which can be described as the sum of local abiotic factors such as insolation (sunlight), climate, and geology, and biotic factors, which are other organisms that share its habitat.

Effluent - The outflow from a sewage treatment facility or the wastewater discharge from industrial facilities

Evaporation - The process by which molecules in a liquid state (e.g. water) spontaneously become gaseous (e.g. water vapor). Generally, evaporation can be seen by the gradual disappearance of a liquid, when exposed to a significant volume of gas.

Greenfield - Greenfield land is a term used to describe a piece of undeveloped land, either currently used for agriculture or in a natural state.

Greenhouse gas emissions - Generally relates to the enhanced greenhouse effect where anthropogenic emissions of gases such as carbon dioxide and methane collect in the lower atmosphere and reflect solar radiation back to earth.

Greywater - Wastewater from household laundries, bathrooms and kitchens that varies in quality from relatively clean to containing significant contamination including harmful microorganisms.

Groundwater - Water collecting below ground level in an aquifer.

Hydrology - The study of the movement, distribution, and quality of water throughout the Earth, and thus addresses both the hydrologic cycle and water resources. A practitioner of hydrology is a hydrologist, working within the fields of either earth or environmental science, physical geography or civil and environmental engineering.

Infiltration - The process by which water on the ground surface enters the soil.

Nutrients - Substances such as nitrogen and phosphorus which promote the growth of plants and algae. Excessive nutrients in waterways contribute to algal blooms and degrade our waterways.

Potable - Fit or suitable for drinking

Rainwater - Rain is a type of precipitation, a product of the condensation of atmospheric water vapour that is deposited on the Earth's surface. It forms when separate drops of water fall to the Earth from clouds.

Receiving waters - Water (such as rivers, lakes, estuaries or oceans) into which treated wastewater and stormwater is discharged.

Retention Basin - A type of basin that is used to contain stormwater or rain runoff. A retention basin provides an area to hold water from a small surrounding drainage area that would otherwise flow into other areas. The water remains in the local area that it was deposited in. This is opposed to a detention basin that holds water for a limited period of time from a larger basin area to prevent flooding and releases all the water contained in a short period of time.

Retrofit - The addition of new technology or features to older, established, urban systems.

Riparian - The interface between land and a flowing surface water body. Plant communities along the river margins are called riparian vegetation, characterized by hydrophilic plants. Riparian zones are significant in ecology, environmental management, and civil engineering due to their role in soil conservation, their biodiversity, and the influence they have on aquatic ecosystems. Riparian zones occur in many forms including grassland, woodland, wetland or even non-vegetative. In some regions the terms riparian woodland, riparian forest, riparian buffer zone or riparian strip are used to characterize a riparian zone.

Sewage - see Wastewater

Stormwater - Rainfall that runs off roofs and roads and other surfaces and flows into gutters, rivers, creeks, bays and oceans. This water can carry a wide range of contaminants. Some are obvious such as plastic bags or oil from roads. Others are not so obvious, such as nutrients, pathogens and heavy metals.

Wastewater - Any water which has been used at least once and cannot be used again without being treated. Treated wastewater can often be used for recycling purposes depending on the level of treatment undertaken.

Water conservation - An approach to reducing the overall demand for water. It is also called demand management. Water conservation measures include educating people about how to save water, promoting the use of household and industrial appliances that use water more economically, such as dual-flush toilets, and pricing water to a level that provides people with a signal of its true value.

Water quality - The physical, chemical and biological characteristics of water in relationship to a set of standards. Water quality standards are created for different types of water bodies and water body locations per desired uses. The primary uses considered for such characterization are parameters which relate to drinking water, safety of human contact, and for health of ecosystems.

Water recycling - The multiple use of water, usually sourced from sewerage or stormwater systems, that is treated to a standard appropriate for its intended use.