Stormwater Gardens

Bioretention Basins for Urban Streets

Dedicated to a better Brisbane

Introduction

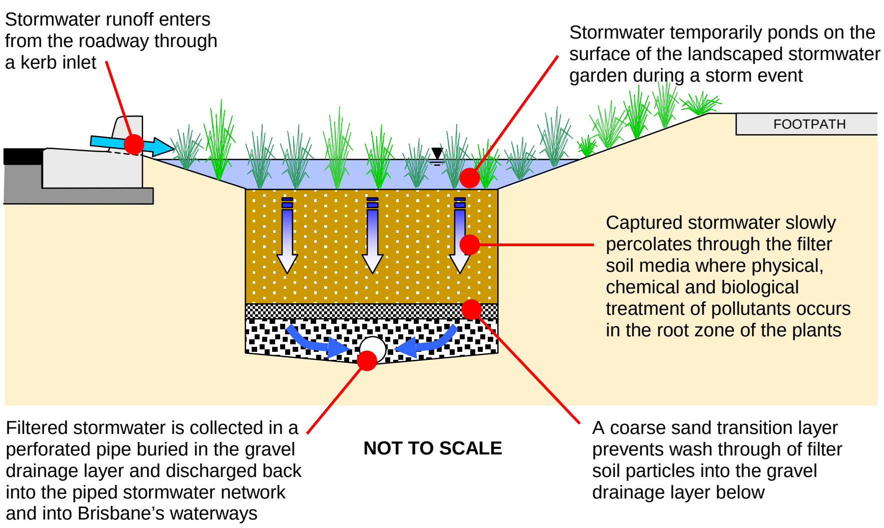
Research within South East Queensland catchments has shown urban stormwater runoff to be one of the main causes of reduced water quality in local waterways and Moreton Bay. Over the next 20 years an additional one million people are expected to move to South East Queensland. Continuation of traditional urban development practices as the population increases will result in further degradation of the region's waterways.

Water Sensitive Urban Design (WSUD) involves the integration of water cycle management with the planning and design of urban areas, from individual lots to a catchment wide scale. WSUD aims to mitigate the impacts of urbanisation on the natural water cycle by implementing techniques to manage stormwater runoff, water supply and wastewater. WSUD encompasses the management of urban stormwater as a resource and protection of receiving ecosystems.

Stormwater gardens are one of a number of techniques able to be applied at street scale to capture and treat stormwater runoff close to its source. They comprise small landscaped areas within urban streets and are designed to filter stormwater runoff prior to it being discharged to the receiving environment. Like larger bioretention basins, stormwater gardens rely on biofiltration processes to reduce stormwater pollutants. They are suitable for installation in greenfield developments as well as for retrofitting in existing urban areas.

A stormwater garden retrofitted into an established residential area of Brisbane

Stormwater Garden Function



Note: Stormwater gardens may be constructed behind existing kerbs or within kerb build-outs (traffic calming devices) where street layout and drainage permits.

Stormwater Garden Design Considerations

1. **SITE SUITABILITY**
   - Slope and space
   - Conflict with services
   - Surrounding landscape
2. **CONFIGURATION**
   - Size relative to catchment
   - Runoff capture and bypass arrangement
   - System drainage
3. **FILTER MEDIA**
   - Filter depth
   - Permeability
   - Composition
4. **LANDSCAPING**
   - Water quality function
   - Aesthetics

Key Design Considerations

Stormwater gardens are a street scale application of bioretention basins and utilise similar stormwater treatment processes. However, the components of each system must be adapted to a specific site to ensure the stormwater garden performs efficiently under design conditions.

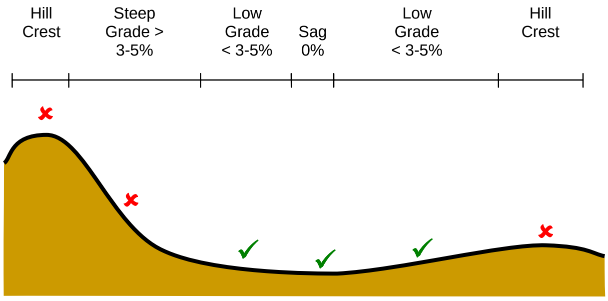
The design of stormwater gardens follows the process documented in Chapter 5 (Bioretention Basins) of the *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland* (MBWCP, 2006) herein referred to as the *SEQ WSUD Guidelines*. Important design considerations specific to stormwater gardens in streetscape applications are provided below in addition to the information provided in the *SEQ WSUD Guidelines,* and represents current best knowledge relating to stormwater gardens in Brisbane.

WSUD Guidelines Design Procedure

1. Confirm size for treatment
2. Determine design flows
3. Design inflow systems
4. Specify filter media
5. Design underdrain system
6. Check lining requirements
7. Design bypass overflow
8. Specify vegetation
9. Verify design components
10. Develop maintenance plan

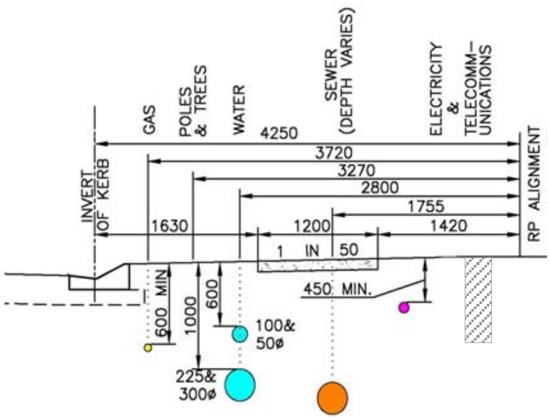
1. SITE SUITABILITY

Stormwater gardens are most suited to low grade streets (up to a maximum of around 3-5% slope) to minimise the earthworks required to create adequate detention volume for operation of the system. Stormwater gardens are also suited to sag locations (flow from two directions) provided overland flow paths are not compromised and localised flooding is not exacerbated. They are ineffective when constructed on the crest of hills or immediately downstream of stormwater gullies.



Suitable stormwater garden locations along a street

Stormwater gardens are typically constructed within the parking lane or verge of road corridors which can potentially result in conflicts with existing or future services (both above and below ground). When proposing to install a stormwater garden within the services corridor, consideration must be given to the potential construction difficulties and disturbance to the system resulting from future maintenance of underground services



Example services corridor within the road reserve

Existing site features such as landscaping, light poles, trees or driveways may limit the retrofit potential of stormwater gardens. The overall benefit of replacing or merging these features with stormwater gardens must be considered on a site-specific basis. Adjoining trees and vegetation must also be assessed to identify shading issues or the potential for leaf litter to cause premature blockage and failure of a stormwater garden.

An established tree makes site unsuitable for a retrofit stormwater garden

Stormwater gardens should not be built in streets where house construction is still occurring unless the bioretention surface can be protected from high sediment loads (e.g. inlet barriers and temporary geofabric and turf layed on stormwater garden surface).

2. CONFIGURATION

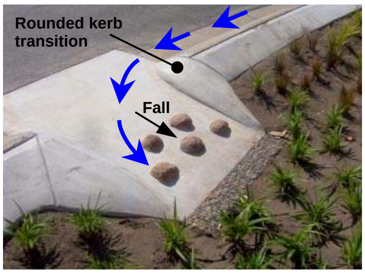
Stormwater Garden Size

Stormwater gardens can treat runoff from single lots up to entire streets. They are typically designed to treat the three month average recurrence interval (3 month ARI) rainfall event with flows in excess of this bypassed directly to the stormwater network. Appropriately configured stormwater gardens with treatment area (horizontal area only) of around 1-2% of the contributing catchment usually provide a reasonable level of treatment for urban stormwater in Brisbane, however this must be confirmed through MUSIC modelling. The overall footprint of a stormwater garden must consider both the horizontal treatment area plus the batter slopes surrounding this zone.

MUSIC (*Model for Urban Stormwater Improvement Conceptualisation*) is a numerical model developed by the CRC for Catchment Hydrology for evaluating conceptual designs of stormwater treatment systems. For more information refer to www.toolkit.net.au

Flow Entry

Stormwater garden inlets can be configured in numerous ways but typically comprise a cut-out through the kerb. The width of the opening is governed by the design flow rate entering the system (and whether it is designed as online or offline: see High Flow Bypass below). Kerb inlets aligned across the flow path (associated with kerb build-outs) should be sized based on the broad crested weir approach provided in the *SEQ WSUD Guidelines*, while inlets aligned parallel to the flow path require more detailed design approach such as that provided in the *Urban Drainage Design Manual* (FHWA, 2001).



Kerb inlets should efficiently capture design flow while managing potential scour velocities

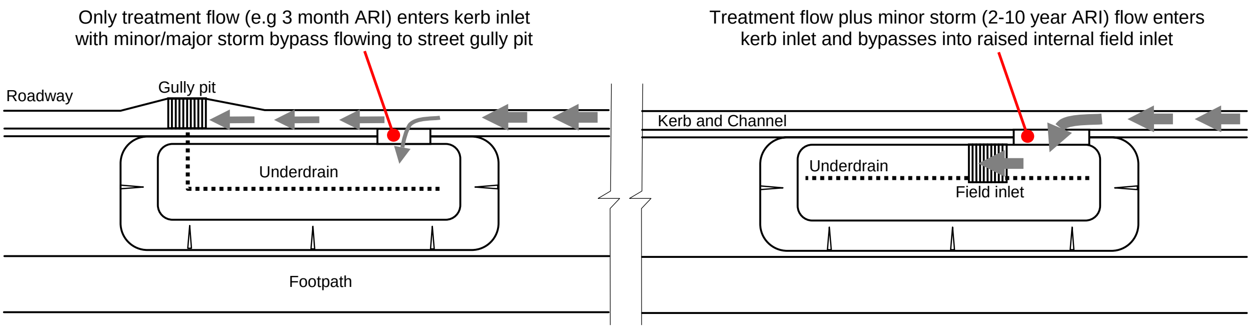
The shape of the inlet can also greatly affect the behaviour of both low and high flows. Desirable attributes of a kerb inlet are provided below.

- Rounded or tapered kerb transitions into the inlet (with sufficiently large radius)
- Depressed kerb invert (of around 50 mm) graded to match kerb invert level at either end of the inlet
- High flow bypass downstream of inlet
- Energy dissipation/ stabilisation at the interface of the inlet with the filter media

The diversion of flows from the kerb and channel using raised structures (such as small weirs across the flow path) within the kerb and channel should not be used as this poses a potential hazard to bicycles and motor vehicles.

High Flow Bypass

Flows in excess of the treatment flow (e.g. > 3 month ARI) can be conveyed directly to the piped drainage network. This bypass can be achieved via two stormwater garden configurations: Offline and online.



Offline Stormwater Garden **Online Stormwater Garden**

Offline systems typically rely on a standard street gully pit to capture above design flows. Bypass occurs when the extended detention depth within the stormwater garden reaches the kerb invert level. Online systems form a part of the minor drainage system and allow minor storm flows (2-10 year ARI) to enter the system and flow into a raised field inlet within the bioretention area. The surface of online stormwater gardens is typically lower than offline systems as additional freeboard is required over the field inlet to prevent excessive flooding in the street.

Offline systems are favoured for retrofit stormwater garden applications, as they are more straightforward to construct and have minimal impact on the hydraulics of the street drainage. Where a kerb build-out stormwater garden is to be constructed within a street, the impacts on street drainage may warrant the use of an online system to control roadway flooding. In both systems, inlets must be non-blocking types. In all cases, the addition of stormwater gardens to a street must not exacerbate local flooding or compromise the conveyance capacity of the roadway.

Pre-treatment

Where feasible, a sediment forebay should be incorporated immediately downstream of the inlet as described in Chapter 5 of the *SEQ WSUD Guidelines*. Alternatively, the surface of the stormwater garden immediately downstream of the inlet should be densely planted with vegetation to create a localised sediment and litter deposition area for ease of maintenance. Pre-treatment areas also act to dissipate energy and spread flows prior to contact with the bioretention filter surface, reducing scour potential.

Dense vegetation downstream of inlet can assist with the capture of sediment

Stormwater Detention

Capturing stormwater within the detention zone promotes settling of coarse to medium sediments. The detention depth is controlled by the kerb inlet level (for offline systems) and the bypass inlet level (for online systems).

Extended detention depths of between 100-200 mm are considered acceptable for stormwater gardens in road reserves from both a water quality and public safety perspective. Where space permits, batter slopes around the detention zone are preferable to steep or vertical sides. Where the stormwater garden is located immediately behind the kerb adjacent to on-street parking, safety issues associated with people getting into and out of parked vehicles must be addressed. A minimum 300 mm flat area behind the kerb (at top of kerb) is suggested. Fenced systems are not encouraged.

Underdrains

One or more perforated underdrains (within the gravel drainage layer) will be required to drain the base of the stormwater garden and should be connected to the internal or external bypass pit. Important aspects of stormwater garden drainage are listed below.

- 100mm minimum diameter pipes should be used.
- Rigid slotted pipes are recommended over flexible ribbed pipes.
- The drainage layer and underdrain must be graded at a minimum of 0.5% towards the outlet.
- Underdrains must lie on the base of the gravel drainage layer.
- A capped non-perforated riser should be connected to the underdrain for maintenance.
- Underdrains extending outside of the drainage layer (through in-situ soils) must be non-perforated.
- Underdrains should be connected at least 150 mm above the invert of the gully pit.

Where retrofit stormwater gardens rely on connection to existing drainage infrastructure, this will often determine the maximum overall depth of the system.

3. FILTER MEDIA

The filter media is considered one of the most critical elements of stormwater gardens as it is where physical, chemical and biological treatment of stormwater pollutants occurs. It provides the main barrier between urban runoff pollutants and the receiving environment. The installation of an unsuitable or poorly prepared filter media can potentially result in an increase in pollutant loads discharging to the receiving environment.
It is recommended that stormwater gardens constructed in Brisbane utilise the *Guideline Specifications for Soil Media in Bioretention Systems* prepared by the Facility for Advancing Water Biofiltration (FAWB, 2006). The requirements set out in this specification must be clearly communicated to suppliers when sourcing stormwater garden filter and drainage media. Laboratory testing of the soil media must confirm compliance with the specification prior to installation.

In General, a sandy loam to loamy sand soil should be used as the filter media with depths ranging from 300-1000 mm depending on the treatment required and site constraints. A 200 mm deep gravel drainage layer is required in the base of the stormwater garden. Gravels smaller than the perforations in the underdrain should not be used. A 100 mm deep transition layer of coarse sand is required between the filter media and the drainage layer to minimise migration of fine filter media particles into the drainage layer.

The walls and base of the stormwater garden trench should be lined with geofabric to prevent migration of in-situ soil particles into the filter and drainage media. Geofabric must not be used between layers. Where the stormwater garden has potential to affect road or building foundations, an impermeable barrier or full liner may be required to prevent foundation damage. This will depend greatly local soil conditions.

4. LANDSCAPING

Landscape design of stormwater gardens must address water quality functions as well as aesthetic, traffic and safety considerations of the local streetscape. Plant selection should be guided by Chapter 12 of the *SEQ WSUD Guidelines*.

Important aspects of landscaping specific to stormwater gardens are as follows.

- Planting density in the first metre of stormwater garden surface (immediately downstream of inlet) should be increased to at least 1.5 times the specified planting density of the remaining stormwater garden to provide pre-treatment and scour protection.
- The stormwater garden should be raked level following planting to ensure uniform flow distribution.
- Inorganic mulch (50-75 mm thick) layed over the filter surface provides excellent moisture retention and soil stabilisation. Use of mulch that will be mobilised (float) during rainfall must be avoided.
- Trees should only be planted in stormwater gardens where the filter media depth is 800 mm or greater.
- Turfed batters must be no steeper than 1 in 4 for mowing.
- Batters steeper than 1 in 4 must be landscaped with groundcover species (not turf) to prevent scour and deter pedestrian/cyclist access.
- Fertiliser should not be applied to stormwater gardens.

Construction Information

The detailed design of stormwater gardens must be supported by an equally rigorous construction process to ensure the system functions appropriately. It is critical that the short-term impacts of the construction process do not compromise the intended long-term benefits of the stormwater garden.

The following are important points to consider during the construction of stormwater gardens.

- Ensure construction contractors are briefed on key functional elements of the system prior to construction.
- Implement enhanced erosion and sediment controls including robust sand bagging of kerb cut-outs and provision of sediment socks attached to the underdrain outlets.

- Commence excavations at the downstream underdrain connection point to the stormwater gully and work back to ensure constant slope is achieved in the base of stormwater garden.
- Schedule work outside of rainfall periods to prevent sediment mobilisation from site.
- Allow a minimum distance of 1.0 m between excavations and footings for light/power poles to ensure stability.
- Minimise the time between excavation and placement of filter media.
- Stockpile soil off road pavements (where feasible) and ensure thorough clean-up following backfilling.
- Install filter media in two to three lifts of even thickness with light watering between lifts to aid natural compaction (no mechanical compaction).
- All concreting works should be undertaken prior to backfilling the filter media.
- Provide erosion control matting on batters (not on filter surface) during vegetation establishment.
- Consider leaving temporary erosion and sediment controls and inlet protection measures in place for a short period following construction to allow vegetation to establish prior to permitting entry of storm flows.

Maintenance

Maintenance plans for stormwater gardens should be prepared during the detailed design process. As for conventional landscaped areas, stormwater gardens require ongoing maintenance to ensure the health and functionality of the system is preserved. A two year vegetation establishment period is required for these systems to reach full functional capacity.

Key issues requiring maintenance action include:

- poor vegetation condition (foliage, density, weeds etc.)
- persistent ponding or boggy soil conditions (greater than six hours following a runoff event)
- scour/erosion or physical disturbance of filter area or batter slopes
- excessive sediment accumulation on bioretention surface
- excessive litter or debris within basin or inlet.

Reference Information

Additional information on stormwater garden design and other WSUD measures are listed below.

MBWCP 2006, *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland* – Version 1, Moreton Bay Waterways and Catchments Partnership (MBWCP). Available online at: http://www.healthywaterways.org/wsud_technical_design_guidelines.html

BCC 2005, *Draft Water Sensitive Urban Design Engineering Guidelines: Stormwater*, Brisbane City Council. Available online at:
http://www.brisbane.qld.gov.au/BCC:STANDARD:1575979104:pc=PC_1898

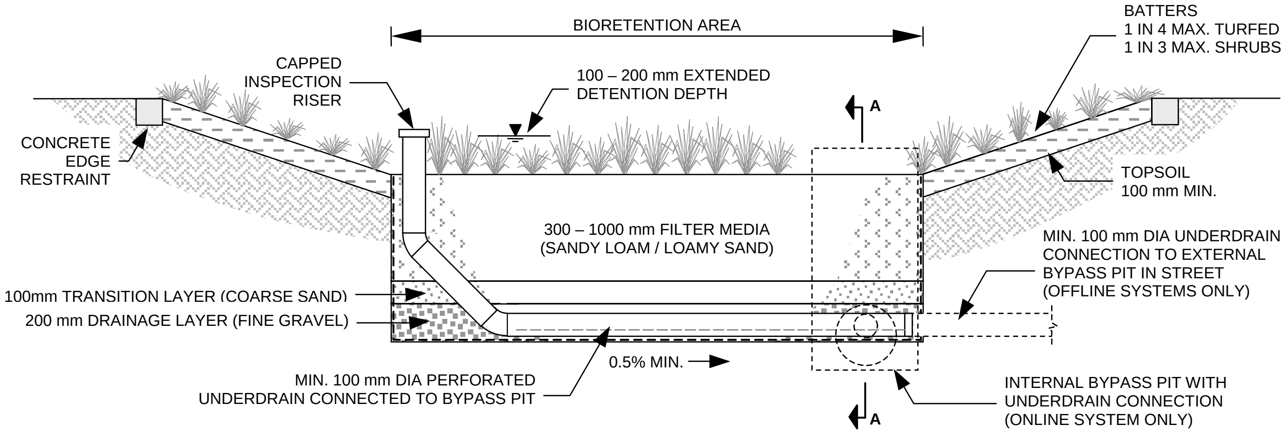
LHCCREMS 2002, *Water Sensitive Urban Design in the Sydney Region – Practice Note 2: Site Planning*, Lower Hunter and Central Coast Regional Environmental Management Strategy. Available online at: http://www.wsud.org/downloads/Planning%20Guide%20&%20PN%27s/02-Site%20Planning.pdf

FAWB 2006, *Guideline Specifications for Soil Media in Bioretention Systems*, Prepared for Facility for Advancing Water Biofiltration (FAWB) by Ecological Engineering, Sydney Environmental & Soil Laboratory Pty. Limited (SESL) and Dr Peter May (The University of Melbourne). Available online at: http://www.monash.edu.au/fawb/products/index.html

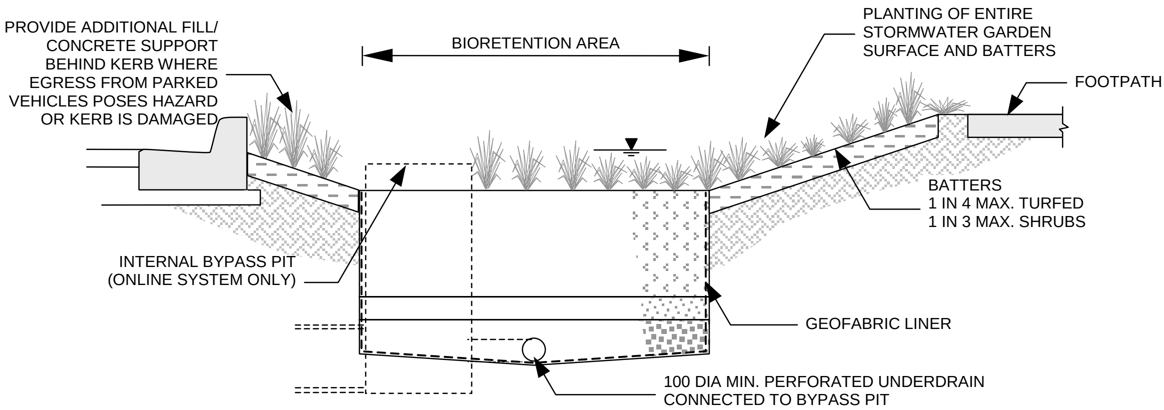
FHWA 2001, *Urban Drainage Design Manual*, Hydraulic Engineering Circular No. 22, Second Edition (Authors: Brown, S.A., Stein, S.M. and Warner, J.C.) U.S. Department of Transportation, Federal Highway Administration (FHWA), Washington D.C. Available online at: http://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=22&id=47

Typical Stormwater Garden Details

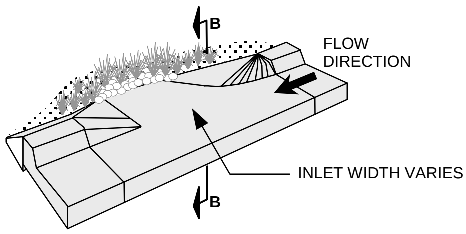
NOT FOR CONSTRUCTION



LONGITUDINAL SECTION

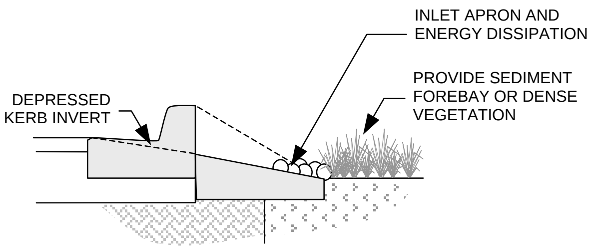


SECTION A-A

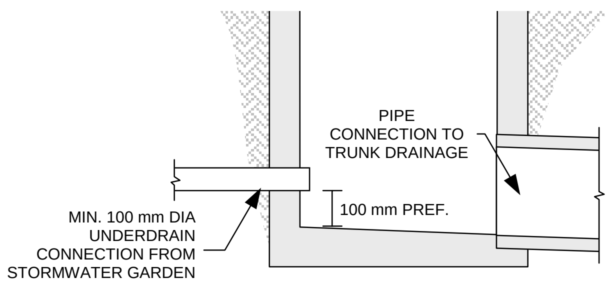


KERB INLET PERSPECTIVE VIEW

THESE DETAILS ARE PROVIDED AS GUIDANCE ONLY. DESIGNS MUST BE ADAPTED TO SPECIFIC SITE CONDITIONS AND REQUIREMENTS



SECTION B-B



UNDERDRAIN CONNECTION TO BYPASS PIT
(BOTH ONLINE AND OFFLINE SYSTEMS)