Introduction

This Practice Note has been prepared by Water Resources to assist Development Assessment staff and applicants in assessing and applying Water Sensitive Urban Design (WSUD). It is one in a series on WSUD. It should be used in conjunction with the WSUD Engineering Guidelines: Stormwater and other relevant Practice Notes within the series. The reader is particularly encouraged to use the introductory Practice Notes (Practice Notes 1a – 1e) which refer to the ‘Treatment Train’.

Overview of Bioretention Swales

Bioretention swales are particularly efficient at removing nutrients and provide flow retardation for frequent storm events. They consist of a vegetated trench located either along the invert of a vegetated swale (Plate 1) or at the most downstream part of a swale (Figure 1). The swale component filters stormwater runoff through the surface vegetation, which promotes the settling of coarse and medium sized sediments and helps to prevent the clogging of the bioretention component. Stormwater is then percolated through the trench, which contains a prescribed soil, such as sand or gravel. The soil media supports vegetation growth and filters fine sediment out of stormwater. Some biological uptake of nutrients occurs through biofilms growing on the plant roots in the upper layer of the soil media. After percolating through the bioretention component, the water is collected within perforated under-drains for discharge or storage for reuse.

Bioretention swales are best used as a source control at the head of a ‘Treatment Train’ and may be located within private property, parkland areas, easements, carparks and along roadway corridors (i.e within footpaths and centre medians).
Design Considerations

Design considerations that relate to the interactions between the swales and bioretention components only are presented below. Refer to Practice Note 3: Swales (incorporating Buffer Strips) for design considerations relating to the swale component and information on traffic control, public safety and services.

Hydraulic design

- Flow needs to be uniformly distributed over the full surface area of the filter media to achieve maximum pollutant removal performance.
- When the bioretention trench is located along the full length of the swale base, the desirable maximum longitudinal grade is 4%.
- When the bioretention trench is located at the most downstream part, the desirable grade of the bioretention zone is horizontal, to encourage uniform distribution of stormwater flows over the full surface area of the bioretention filter media and to allow for temporary storage of flows for treatment before bypass occurs.
- Velocities are to be less than 0.5 m/s for minor flood flows (2 year Average Recurrence Interval (ARI)) and not more than 2.0 m/s for major flood flows (50 year ARI) to avoid scouring of the swale and the bioretention surface.
- Shallow temporary (i.e. extended detention) ponding can be created over the surface of the filter media via check dams or raised field inlet pits to ensure the minimum volume of stormwater is treated and to assist in managing velocities. Note that check dams may not be approved where pedestrian access is required.
- Parallel perforated pipes can be used to increase the capacity of the under drains to ensure there is sufficient capacity to collect the maximum infiltration rate. The maximum spacing of parallel perforated pipes is to be no greater than 1.5 m.

The bioretention component can consist of four layers (Figure 2).

![Example section of bioretention system](image)

Figure 2: Typical Cross Section of the Bioretention Component
Filter media
- The top layer is the filter media, which provides stormwater treatment.
- Depth is to be between 300 mm and 1000 mm.
- The saturated hydraulic conductivity is to be no greater than 500 mm/hr and preferably less than 200 mm/hr in order to sustain vegetation growth and ensure sufficient time for pollutant removal.
- The perforated pipe capacity is to be greater than the infiltration capacity of the filter media to ensure the filter media drains freely and does not become the hydraulic control.

Drainage layer
- The bottom layer is a minimum 150 mm, preferably 200 mm, deep drainage layer of coarse sand (1 mm) or fine gravel (2-5 mm) that conveys treated water from the base of the filter media to the perforated under-drains.
- Coarse material is preferred as it generally avoids the need to provide a transition layer between the filter media and the drainage layer, however the slot sizes in the perforated pipes will determine the minimum drainage layer particle size.

Impermeable liner
- Bioretention basins are generally not designed to be infiltration systems.
- If the surrounding soil is more effective at transmitting water (i.e. where the saturated hydraulic conductivity of filter media is less than 10 times greater than that of the surrounding soils), an impermeable liner on the base and sides of the drainage layer should be provided, particularly in sensitive areas (e.g. areas of shallow groundwater or in close proximity to structures such as roads and pavements). In addition, the base of the bioretention trench should be shaped to direct water flow paths towards the perforated under-drains.

Transition layer
- A minimum 100 mm thick transition layer of sand or a geotextile fabric is to be used when the filter media particle size is more than 10 times the drainage layer particle size. This is to prevent the filter media being washed through the voids of the drainage layer and into the perforated under-drains.

Roof water
- A small surcharge pit located within the invert of the swale and/or within the bioretention filter media will be required where roof water cannot freely drain because of the depth of the roof water drainage system and finished levels of the bioretention swale.
Landscape design and plant selection

- The overall landscape design for the bioretention swale is to integrate with the natural and/ or built environment.
- To meet stormwater quality objectives, vegetation needs to cover the whole width of the swale and bioretention top surface area, be capable of withstanding design flows and be of sufficient density to prevent preferred flow paths and scour of deposited sediments.
- The preferred vegetation for the bioretention component is sedges and tufted grasses, which require minimal maintenance and are higher and denser, thus providing enhanced sedimentation. Sedges are not desired in footpaths.
- Grassed (turf) bioretention swales are suited to residential areas where a continuous bioretention trench approach is used but the filter media will be compacted over the long term and will require replacement.
- Occasional tree planting may occur as long as it complies with acceptable sight line and safety requirements, and is located at the top of the bioretention swale to avoid the roots damaging the bioretention component.
- Hard and soft landscaping is not to impede other functions, such as pedestrian movements, access to/ from properties, post delivery and garage collection.
- Refer to Chapter 12 of the WSUD Engineering Guidelines: Stormwater and Practice Note 12: Plant Selection for WSUD Systems for guidance on selecting suitable plant species.

Plate 3 and 4: Bioretention Swale in a Residential Setting at Watarrka St, Parkinson

Plate 5: Bioretention swale in a median strip in a commercial setting at Kelvin Grove Urban Village, Kelvin Grove
Operational Works Assessment Checklist

This checklist notes the key design features to be reviewed when assessing the design of a bioretention swale.

**Treatment**
- Treatment performance verified

**Swale component**
- Longitudinal slope of invert > 1% and < 4%
- Manning’s ‘n’ selected appropriate for the proposed vegetation type
- Overall flow conveyance system sufficient for design flood event
- Maximum flood conveyance width does not impact on traffic requirements
- Overflow pits provided where flow capacity exceeded
- Energy dissipation provided at concentrated inlet points to the swale
- Velocities within bioretention cells will not cause scour
- Top of swale/ buffer vegetation set down at least 60mm below the edge beam/ flush kerb
- Maintenance access provided to invert of swale

**Bioretention component**
- Design documents bioretention area and extended detention depth as defined by treatment performance requirements
- Overflow pit crest set up at top of extended detention
- Maximum ponding depth and velocity will not impact on public safety (velocity x depth < 0.6, or < 0.4 in high risk areas, i.e. where pedestrians can be expected)
- Bioretention media specification includes details of filter media, drainage layer and transition layer (if required)
- Design saturated hydraulic conductivity included in specification
- Transition layer provided where drainage layer consists of gravel (rather than coarse sand)
- Perforated pipe capacity > infiltration capacity of filter media
- Selected filter media hydraulic conductivity > 10 times the hydraulic conductivity of surrounding soil
- Maximum spacing of collection pipes is < 1.5 m (centre to centre)
- Collection pipes extended to surface to allow inspection and flushing
- Liner provided if selected filter media hydraulic conductivity < 10 times the hydraulic conductivity of surrounding soil

**Landscape**
- Plant species selected can tolerate periodic inundation and design velocities
- Bioretention swale landscape design integrates with surrounding natural and/ or built environment
- Planting design conforms with acceptable sight line and safety requirements
- Street trees conform to BCC’s Approved Street Tree list
- Top soils are a minimum depth of 300 mm for plants and 100 mm for turf
- Existing trees in good condition are investigated for retention
- Detailed soil specification included in design
Construction Checklist

This checklist notes the key features of a bioretention swale that are to be checked during and after construction is completed.

Preliminary works
- Erosion and sediment control plan adopted
- Traffic control measures in place
- Location same as plans
- Site protection from existing flows
- Critical root zones (0.5 m beyond drip line) of nominated trees are protected

Earthworks
- Existing topsoil is stockpiled for reuse
- Level bed of swale
- Batter slopes as per plans
- Dimensions of bioretention area as per plans
- Confirm surrounding soil type with design
- Provision of liner
- Perforated pipe installed as designed
- Drainage layer media as designed
- Transition layer media as designed
- Filter media specifications checked
- Compaction process as designed
- Appropriate topsoil on swale

Structural components
- Location and levels of pits as designed
- Safety protection provided, e.g. dense planting around raised field inlet pits and no check dams where pedestrian access is required.
- If required, check dams located as designed
- Swale crossings located and built as designed
- Pipe joints and connections as designed
- Concrete and reinforcement as designed
- Inlets appropriately installed
- Inlet erosion protection installed
- Set down to correct level for flush kerbs

Vegetation
- Stabilisation immediately following earthworks
- Planting as designed (species and densities)
- Test and improve topsoil (if required) to ensure survival of vegetation
- Weed removal before stabilisation

Final inspection
- Confirm levels of inlets and outlets
- Traffic control measures in place, e.g. bollards intermixed with tree planting
Practice Note 3
Bioretention Swales

- Structural elements are sized as per design
- Check batter slopes
- Vegetation as designed
- Check for uneven settling of soil
- Inlet erosion protection working
- Maintenance access provided
- Construction generated sediment removed

Maintenance Checklist
This checklist notes the key features that should be inspected during operation of a bioretention swale. Inspections should occur every 1 - 6 months, depending on the size and complexity of the system.

- Sediment accumulation at inflow points
- Litter within swale
- Erosion at inlet or other key structures (e.g. crossovers)
- Traffic damage present
- Evidence of dumping (e.g. building waste)
- Vegetation condition satisfactory (density, weeds etc.)
- Replanting and/ or mowing required
- Clogging of drainage points (sediment or debris)
- Evidence of ponding
- Set down from kerb still present
- Damage/ vandalism to structures present (e.g. tyre tracks visible)
- Surface clogging visible
- Drainage system (i.e. perforated underpipes) inspected
- Remulching of trees and shrubs required (note no mulching within the drainage area)
- Soil additives or amendments required
- Pruning and/or removal of dead or diseased vegetation required
- Resetting (i.e. complete reconstruction) of bioretention elements required
Asset Transfer Checklist

This checklist notes the key features to be checked by the proposed owner of the bioretention swale prior to handover/transfer.

**Treatment**
- System appears to be working as designed visually
- No obvious signs of under-performance

**Maintenance**
- Maintenance plans provided for each asset
- Inspection and maintenance undertaken as per maintenance plan
- Inspection and maintenance forms provided
- Asset inspected for defects

**Asset information**
- Operational Works Assessment Checklist provided
- As constructed plans provided
- Copies of all required permits (both construction and operational) submitted
- Proprietary information provided (if applicable)
- Digital files (e.g. drawings, survey, models) provided
- Asset listed on asset register or database
Other Practice Notes

This Practice Note is one in a series on WSUD, which includes:

- An Introduction to Water Sensitive Design (Practice Note 1a)
- Application of WSUD at a Subdivision Scale (Practice Note 1b)
- Application of WSUD at a Lot Scale (Practice Note 1c)
- Application of WSUD at a Street Scale (Practice Note 1d)
- Application of WSUD at a Commercial or Industrial Scale (Practice Note 1e)
- Swales (incorporating Buffer Strips) (Practice Note 2)
- Sedimentation Basins (Practice Note 4)
- Bioretention Basins (Practice Note 5)
- Constructed Wetlands (Practice Note 6)
- Infiltration Measures (Practice Note 7)
- Sand Filters (Practice Note 8)
- Other Measures (Practice Note 9)
- Aquifer Storage and Recovery (Practice Note 10)
- Other Measures (Practice Note 11)
- Plant Selection for WSUD Systems (Practice Note 12)

Plant Selection for WSUD Systems (Practice Note 12)

Useful websites

- Brisbane City Council WSUD Engineering Guidelines: Stormwater
- Australian Water Association
  http://www.awa.asn.au/
- Cooperative Research Centre for Catchment Hydrology
- National Water Quality Management Strategy
- Melbourne Water
- Stormwater Industry Association
  http://www.stormwater.asn.au
- Water Sensitive Planning Guide for the Sydney Region
  http://www.wsud.org/
- IEAUST- Australian Runoff Quality
- NSW Stormwater Trust
- Lower Hunter & Central Coast Regional Environmental Management Strategy
- Auckland Regional Council
  http://www.arc.govt.nz/arc/environment/water/stormwater-tp10.cfm