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 in the series. The reader is also encouraged to use the Introductory Practice Notes (Practice Notes 1a – 1e) which refer to the ‘Treatment Train’.

Overview of Sand Filters

Sand filters operate in a similar manner to bioretention systems, with stormwater percolating downwards through a filter media and then being intercepted by perforated pipes located at the base of the media for conveyance downstream. Prior to entering the filter media (typically sand), flows must be subjected to pre-treatment to remove litter, debris and coarse sediments. This is typically achieved via an ‘inlet chamber’, which is designed as part of the system. During higher flows, water may pond on the surface of the sand filter increasing the volume of water that can be treated. Very high flows however, are diverted to protect the sand media from scour.

Unlike bioretention systems, sand filters do not incorporate vegetation. The filter media does not retain sufficient moisture to support plant growth, and as they are often installed underground, light for plant growth is limited. The absence of vegetation and associated biologically active soil layer typically created around the root zone of vegetation planted in bioretention systems, means sand filters have a reduced stormwater treatment performance compared to bioretention systems.

Sand filters can be varied to suit site constraints and maintenance access, provided each of the chambers is adequately sized. They should only be considered where site conditions, such as space or drainage grades, limit the use of bioretention systems.

Sand filters require more regular maintenance than bioretention systems to ensure the surface of the sand filter media remains porous and does not become clogged with accumulated sediments.

Key functions of sand filters are:

- pre-treatment to remove gross pollutants (where an inlet chamber is part of the system design)
- pre-treatment through sedimentation of particles larger than 125 µm (very coarse to very fine sand) within a sedimentation chamber for flows up to a 1 year ARI (Average Recurrence Interval) (unattenuated) peak discharge
- filtration of stormwater through a sand filtration layer.
Design Considerations

Sand filters typically consist of three chambers (Figure 1) – sedimentation (inlet) chamber, sand filter chamber and overflow chamber.

Sedimentation Chamber

- Stormwater enters this chamber either via a conventional side entry pit or through an underground pipe network and provides pre-treatment by removing gross pollutants and coarse to medium sized sediments that are larger than 125 µm.
- The chamber can be designed to have either permanent water between events or to drain between storm events via the provision of weep holes.
- Weep holes must be designed such that they can continue to drain as material accumulates and the holes do not block.
- Having a permanent water body reduces the likelihood of resuspension of sediments at the start of subsequent rainfall events, as inflows do not fall and scour collected sediments.
- Allowing the sedimentation chamber to drain during inter-event periods reduces the likelihood of pollutant transformation from a particulate to dissolved form, which can lead to water quality problems downstream.
The sediment chamber should be sized to retain 70% of sediment larger than 125 µm (clay through to very fine sand) for the design flow (1 year ARI peak discharge) and to have adequate storage capacity to minimise cleanout to once a year or less.

To prevent resuspension of sediment, a maximum flow velocity of 0.2 m/s through the sedimentation chamber is required before bypass occurs and 0.5 m/s should be used for the overflow design flow rate.

Sand Filter Chamber
- Inflows are via the sedimentation chamber (Figure 1). The maximum discharge capacity from the sedimentation chamber is to be equal to the maximum infiltration rate of the sand filter.
- The surface of the sand filter should be set at the crest of the weir to minimise scouring of the sand surface as water is conveyed into the filter chamber.
- The filter chamber consists of a sand filtration layer (typically 400 – 600 mm deep) and a drainage layer (maximum 200 mm deep) that encases the perforated under-drains and conveys treated flow from the base of the filter media into the perforated under-drainage system.
- The drainage layer consists of either coarse sand or fine gravel depending on the slot sizes of the perforated pipe system. Slots are to be adequate to pass the maximum infiltration rate of the sand layer (or the maximum required outflow) unless the specific intention is to increase detention time.
- Fine gravel is to be used if the slot sizes are large enough that sand will be washed into the slots. A transition layer between the filter media and drainage layer will be required when using fine gravel to prevent the filter media being washed thorough the voids of the drainage layer and into the perforated under-drains.
- The maximum spacing of the slotted or perforated collection pipes is to be 1.5 m (centre to centre) so that the distance water needs to travel through the drainage layer does not hinder drainage of the filtration media. Maximum diameter is to be 100 mm.
- Provision for temporary ponding is required within the sand filter chamber. The high saturated hydraulic conductivity (SHC) (ranging from 360 – 3600 mm/hr depending on the particle size) of the sand filtration media means that only a small temporary ponding depth (approximately 200 mm) is required.
- Where significant structures, sodic soils and/or shallow groundwater is present, and the SHC of the surrounding soils is less than 10 times the SHC of the filtration media, an impervious liner, e.g. flexible membrane or a concrete casing, is to be used.

Overflow Chamber
- When water levels in the sedimentation and sand filter chambers exceed the extended detention depth, water overflows the weir into the overflow chamber and is conveyed into the downstream drainage system.
- The overflow weir is sized to ensure that it has sufficient capacity for the design discharge from the sedimentation chamber (typically the 2 year ARI).
- Water levels in the overflow chamber must remain underground when operating at the design discharge for the minor stormwater drainage system (typically the 2 year ARI).
Maintenance Design Considerations

- Direct physical access to the entire surface of the sand filter chamber is required to remove fine sediments from the surface layer of the filter media.
- A drainage valve or gate must be incorporated into systems that have no weep holes so that the sediment chamber can fully drain. Alternatively, water in the sediment chamber can be pumped into the sand filter prior to removal of coarse pollutants.
- Under-drains should be extended to the surface of the sand filter to allow for inspection and maintenance when required. The vertical section of the under-drain should be either solid pipe or wrapped in impermeable geotextile and a cap placed on the end of the pipe to avoid short circuiting of flows directly into the drain.
- A temporary filter sock or equivalent should also be placed over the outlet pipe in the overflow chamber to capture flushed sediment during maintenance activities.

Operational Works Assessment Checklist

This checklist notes key design features to be reviewed when assessing the design of sand filters.

**Treatment**

- Treatment performance verified from curves

**Inlet zone/ hydraulics**

- Station selected for Intensity Frequency Duration (IFD) appropriate for location
- Sediment chamber dimensions sufficient to retain 125 µm particles
- Drainage facilities for sediment chamber provided
- Overall flow conveyance system sufficient for design flood event
- Velocities at inlet and within sand filter will not cause scour
- Bypass sufficient for conveyance of design flood event

**Collection System**

- Slotted pipe capacity > infiltration capacity of filter media (where appropriate)
- Maximum spacing of collection pipes <1.5 m
- Drainage layer >200 mm
- Transition layer provided to prevent clogging of drainage layer

**Filter Basin**

- Maximum ponding depth will not impact on public safety
- Selected filter media hydraulic conductivity > 10 times the hydraulic conductivity of surrounding soil - if not, impermeable liner provided
- Maintenance access provided to base of filter media (where reach to any part of a basin > 6 m)
- Sand media specification included in design
Construction Checklist
This checklist notes key features of sand filters to be checked during and post construction.

Preliminary works
- Erosion and sediment control plan adopted
- Traffic control measures
- Location same as plans
- Site protection from existing flows

Earthworks
- Level bed
- Side slopes are stable
- Provision of liner
- Perforated pipe installed as designed
- Drainage layer media as designed
- Sand media specifications checked

Pre-treatment
- Adequate maintenance access
- Invert level correct
- Ability to freely drain (weep holes)

Structural components
- Location and levels of pits as designed
- Safety protection provided
- Pipe joints and connections as designed
- Concrete and reinforcement as designed
- Inlets appropriately installed

Filtration system
- Provision of liner
- Adequate maintenance access
- Inlet and outlet as designed

Final inspection
- Confirm levels of inlets and outlets
- Traffic control in place
- Confirm structural element sizes
- Filter media as specified
- Sedimentation chamber freely drains
- Check for uneven settling of sand
- No surface clogging
- Maintenance access provided
- Construction generated sediment and debris removed
Maintenance Checklist

This checklist notes the key features that should be inspected during operation of a sand filter. Inspections should occur every 1 - 6 months depending on the size and complexity of the system. Regular maintenance involves removing the accumulated layer of sediments using a flat bottomed shovel or vacuum machinery and removal of debris/litter. Clean out of sediment and/or gross pollutants in the sedimentation chamber is required annually.

- Litter within filter
- Scour present within sediment chamber or filter
- Traffic damage evident
- Evidence of dumping (e.g. building waste)
- Clogging of drainage weep holes or outlet
- Evidence of ponding (in sedimentation chamber or sand filter)
- Damage/vandalism to structures present
- Surface clogging visible
- Drainage system inspected
- Removal of fine sediment required

Asset Transfer Checklist

This checklist notes key features to be checked by the proposed owner of a sand filter prior to handover/transfer.

Treatment
- System visually appears to be working as designed

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
- Design 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 is one of a series of WSUD Practice Notes, which includes:

- An Introduction to Water Sensitive Urban Design (Practice Note 1a)
- Application of WSUD at Subdivision Scale (Practice Note 1b)
- Application of WSUD at Lot Scale (Practice Note 1c)
- Application of WSUD at Street Scale (Practice Note 1d)
- Application of WSUD at Commercial or Industrial Scale (Practice Note 1e)
- Swales (incorporating Buffer Strips) (Practice Note 2)
- Bioretention Swales (Practice Note 3)
- Sedimentation Basins (Practice Note 4)
- Bioretention Basins (Practice Note 5)
- Constructed Wetlands (Practice Note 6)
- Infiltration Measures (Practice Note 7)
- Other Measures (Practice Note 9)
- Aquifer Storage and Recovery (Practice Note 10)
- Ponds/ Lakes (Practice Note 11)
- 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