GUIDELINES FOR SOIL FILTER MEDIA IN BIORETENTION SYSTEMS (Version 2.01)
March 2008

The following guidelines for soil filter media in bioretention systems have been prepared on behalf of the Facility for Advancing Water Biofiltration (FAWB) to assist in the development of bioretention systems, including the planning, design, construction and operation of those systems.

NOTE: This is a revision of the previous FAWB guideline specifications (published in 2006). It attempts to provide a simpler and more robust guideline. FAWB acknowledges the contribution of EDAW Inc., Melbourne Water Corporation, Dr Nicholas Somes (Ecodynamics), Alan Hoban (SEQ Healthy Waterways Partnership), and STORM Consulting to the preparation of the revised guidelines.

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1 GENERAL DESCRIPTION

The bioretention filter media guidelines require three layers of media: the filter media itself (400–600 mm deep or as specified in the engineering design), a transition layer (100 mm deep), and a drainage layer (50 mm minimum underdrainage pipe cover). The bioretention system will operate so that water will infiltrate into the filter media and move vertically down through the profile.

The filter media is required to support a range of vegetation types (from groundcovers to trees) that are adapted to freely draining soils with occasional flooding. The material should be based on natural soils or amended natural soils and can be of siliceous or calcareous origin. In general, the media should be a loamy sand with an appropriately high permeability under compaction and should be free of rubbish, deleterious material, toxicants, declared plants and local weeds (as listed in local guidelines/Acts), and should not be hydrophobic. The filter media should contain some organic matter for increased water holding capacity but be low in nutrient content.
Maintaining an adequate infiltration capacity is crucial in ensuring the long-term treatment efficiency of the system. The ability of a bioretention system to detain and infiltrate incoming stormwater is a function of the filter surface area, extended detention (ponding) depth, and the hydraulic conductivity of the filter media (Figure 1). Most importantly, design of a bioretention system should optimize the combination of these three design elements.

For a bioretention system in a temperate climate with an extended detention depth of 100–300 mm and whose surface area is approximately 2% of the connected impervious area of the contributing catchment, the prescribed hydraulic conductivity will generally be between 100–300 mm/hr in order to meet best practice targets (Figure 2). This configuration supports plant growth without requiring too high a land space. In warm, humid (sub- and dry-tropical) regions the hydraulic conductivity may need to be higher in order to achieve the required treatment performance using the same land space (i.e., ensuring that the proportion of water treated through the media meets requirements).

Where one of these design elements falls outside the recommended range, the infiltration capacity can still be maintained by offsetting another of the design elements. For example, a filter media with a lower hydraulic conductivity may be used, but the surface area or the extended detention depth would need to be increased in order to maintain the treatment capacity. Similarly, if the available land were the limiting design element, the system could still treat the same size storm if a filter media with a higher hydraulic conductivity were installed. Where a hydraulic conductivity greater than 300 mm/hr is prescribed, potential issues such as higher watering requirements during the establishment should be considered. Bioretention systems with a hydraulic conductivity greater than 600 mm/hr are unlikely to support plant growth due to poor water retention, and may also result in leaching of pollutants. However plant survival might be possible if the outlet pipe were raised to create a permanently submerged zone.

![Figure 1. Design elements that influence infiltration capacity](image)

*Bioretention Filter Media Guidelines (Version 2.01), Prepared by the Facility for Advancing Water Biofiltration (FAWB), March 2008.*
The infiltration capacity of the bioretention system will initially decline during the establishment phase as the filter media settles and compacts, but this will level out and then start to increase as the plant community establishes itself and the rooting depth increases (see Appendix A). In order to ensure that the system functions adequately at its eventual (minimum) hydraulic conductivity, a safety co-efficient of 2 should be used: i.e., designs should be modelled using half the prescribed hydraulic conductivity. If a system does not perform adequately with this hydraulic conductivity, then the area and/or ponding depth should be increased. It may also be desirable to report sensitivity to infiltration rate, rather than simply having expected rate. This is important when assessing compliance of constructed systems as systems should ideally meet best practice across a range of infiltration rates.

2 TESTING REQUIREMENTS

2.1 Determination of Hydraulic Conductivity

The hydraulic conductivity of potential filter media should be measured using the ASTM F1815-06 method. This test method uses a compaction method that best represents field conditions and so provides a more realistic assessment of hydraulic conductivity than other test methods.

Note: if a hydraulic conductivity lower than 100 mm/hr is prescribed, the level of compaction associated with this test method may be too severe and so underestimate the actual hydraulic conductivity of the filter media under field conditions. However, FAWB considers this to be an appropriately conservative test, and recommends its use even for low conductivity media.

2.2 Particle Size Distribution

Particle size distribution (PSD) is of secondary importance compared with hydraulic conductivity. A material whose PSD falls within the following recommended range does not preclude the need for hydraulic conductivity testing i.e., it does not guarantee that the material will have a suitable hydraulic conductivity. However, the following composition range (percentage w/w) provides a useful guide for selecting an appropriate material:
Clay & Silt <3% (<0.05 mm)
Very Fine Sand 5–30% (0.05–0.15 mm)
Fine Sand 10–30% (0.15–0.25 mm)
Medium to Coarse Sand 40–60% (0.25–1.0 mm)
Coarse Sand 7–10% (1.0–2.0 mm)
Fine Gravel <3% (2.0–3.4 mm)

Clay and silt are important for water retention and sorption of dissolved pollutants, however they substantially reduce the hydraulic conductivity of the filter media. This size fraction also influences the structural stability of the material (through migration of particles to block small pores and/or slump). It is essential that the total clay and silt mix is less than 3% (w/w) to reduce the likelihood of structural collapse of such soils.

The filter media should be well-graded i.e., it should have all particle size ranges present from the 0.075 mm to the 4.75 mm sieve (as defined by AS1289.3.6.1 – 1995). There should be no gap in the particle size grading, and the composition should not be dominated by a small particle size range. This is important for preventing structural collapse due to particle migration.

2.3 Soil Properties

2.3.1 AS4419 – 2003 (Soils for Landscaping and Garden Use)

Filter media that do not meet the following specifications should be rejected:

i. Organic Matter Content – less than 5% (w/w). An organic content higher than 5% is likely to result in leaching of nutrients.

ii. pH – as specified for ‘natural soils and soil blends’ 5.5 – 7.5 (pH 1:5 in water).

iii. Electrical Conductivity (EC) – as specified for ‘natural soils and soil blends’ <1.2 dS/m.

iv. Phosphorus – <100 mg/kg. Soils with phosphorus concentrations >100 mg/kg should be tested for potential leaching. Where plants with moderate phosphorus sensitivity are to be used, phosphorus concentrations should be <20 mg/kg.

Optional testing:

v. Dispersibility – this should be carried out where it is suspected that the soil may be susceptible to structural collapse. If in doubt, then this testing should be undertaken.
2.3.2 Soil Nutrition

Potential filter media should generally be assessed by a horticulturalist to ensure that they are capable of supporting a healthy vegetation community. This assessment should take into consideration delivery of nutrients to the system by stormwater. Any component or soil found to contain high levels of salt (as determined by EC measurements), high levels of clay or silt particles (exceeding the particle size limits set above), or any other extremes which may be considered retardant to plant growth should be rejected.

3 TRANSITION AND DRAINAGE LAYERS

Transition layer material shall be a clean, well-graded sand/ coarse sand material containing little or no fines.

The drainage layer is to be clean, fine gravel, such as a 2–5 mm washed screenings.

Geotextile fabrics are not recommended for use in bioretention systems due to the risk of clogging. An open-weave shade cloth can be placed between the transition layer and the drainage layer to help reduce the downward migration of smaller particles if required, however this should only be adopted where there is insufficient depth for transition and drainage layers.

4 INSTALLATION

It is recommended that filter media be lightly compacted during installation to prevent migration of fine particles. In small systems, a single pass with a vibrating plate should be used to compact the filter media, while in large systems, a single pass with roller machinery (e.g. a drum lawn roller) should be performed. Under no circumstance should heavy compaction or multiple-passes be made.

Filter media should be installed in two lifts unless the depth is less than 500 mm.

5 FIELD TESTING

It is recommended that field testing of hydraulic conductivity be carried out at least twice: 1. one month following commencement of operation, and 2. in the second year of operation to assess the impact of vegetation on hydraulic conductivity.

The hydraulic conductivity of the filter media should be checked at a minimum of three points within the system. The single ring, constant head infiltration test method (shallow test), as described by Le Coustumer et al. (2007), should be used. Given the inherent variability in hydraulic conductivity testing and the heterogeneity of the filter media, the laboratory and field results are considered comparable if they are within 50% of each other. However, even if they differ by more than 50%, the system will still function if both the field and laboratory results are within the relevant recommended range of hydraulic conductivities.
References


Appendix

Figure A.1 illustrates the change in hydraulic conductivity during the establishment phase of a Melbourne bioretention system containing a sandy loam filter media. The hydraulic conductivity initially declines as the filter media is compacted under hydraulic loading, but recovers back to the design value (as indicated by the dashed horizontal line) as plant growth and increased rooting depth counters the effects of compaction and clogging.

![Evolution of hydraulic conductivity during the first 20 months of a bioretention system](image)

**Figure A.1** Evolution of hydraulic conductivity during the first 20 months of a bioretention system