New WAter Ways

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Water sensitive urban design

Biofilters

Summary

Biofilters (also known as biofiltration systems, bioretention systems and rain gardens) are excavated basins or trenches that are filled with porous filter media and planted with vegetation to remove pollutants from stormwater runoff. They use natural and physical processes to treat stormwater.

This brochure is part of a series that explain various aspects of water sensitive urban design. Please see *Water sensitive urban design in Western Australia* for background information on water sensitive urban design.

Main benefits

- Work in a variety of climate, soil and groundwater conditions.
- Fexible design (linear, basins, tree pits, planter boxes) fits into many different locations.
- Soil and sand filters provide good removal of sediment and heavy metals.
- Specially selected soil filter media and appropriate vegetation selection improves nutrient removal rates.
- Require less space than other infiltration systems due to their higher infiltration rate.

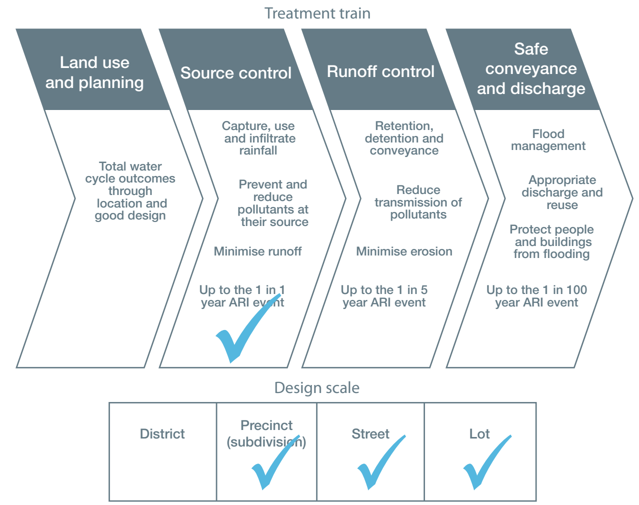
Design factors

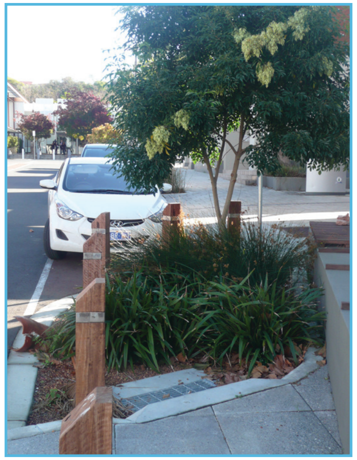
- Define the objectives of the biofilter project.
- Integrated into landscape design.
- Consider location as part of planning and design of roads, lots and parks.
- Design to infiltrate or connect to the larger stormwater system where appropriate.
- Size the surface area at least 2% of the constructed, directly connected impervious catchment for water quality treatment.
- Use vegetation appropriate to the climate and desired pollutant removal.
- Incorporate a submerged zone and carbon source to promote vegetation health and resilience during dry periods and aid nitrogen removal.
- Consider site constraints, e.g. shallow groundwater, contaminated soils and groundwater, acid sulfate soils, heavy soils, steep sites.

Target pollutants

- coarse sediment
- suspended solids
- phosphorus
- nitrogen
- heavy metals
- hydrocarbons
- pathogens

Where biofilters can be used in the water sensitive urban design process





Bioretention & tree pits, Stephen St, City of Bunbury

Bioretention & tree pits, Stephen St, City of Bunbury

Roadside biofilter retrofit, Busselton CBD

On-lot biofilter, Evermore Heights, Baldivis

Water sensitive urban design

Biofilters

Design function

Note: Depending on insitu soil, transition and drainage layers may not be required if direct infiltration of treated stormwater to surrounding soils is possible. See CRCWSC 2015 guidelines for diagrams demonstrating submerged zones, outlets, etc.

Aid aesthetics, assist in pollutant removal and maintain hydraulic conductivity of filter media

Sedimentation of primary sediments and metals

Soil filters fine sediments and colloidal particles

Soil layer for plants to grow in

Sorption of metals and nutrients by filter particles

Liner is required to:

- prevent exfiltration into surrounding soils and create a submerged zone (in conjunction with a raised outlet),
- ensure stormwater is treated through the biofilter media instead of lost to surrounding soils,
- prevent contamination of filter media from in situ soils and water (if this is an issue),
- if sensitive structures nearby require protection (i.e. form an impermeable barrier between the biofilter and the structure), or
- if interaction with shallow groundwater is not desirable.

Include a carbon source to improve chemical processes in soil and promote vegetation health

Nutrient sorption and pollutant decomposition by soil and bacteria

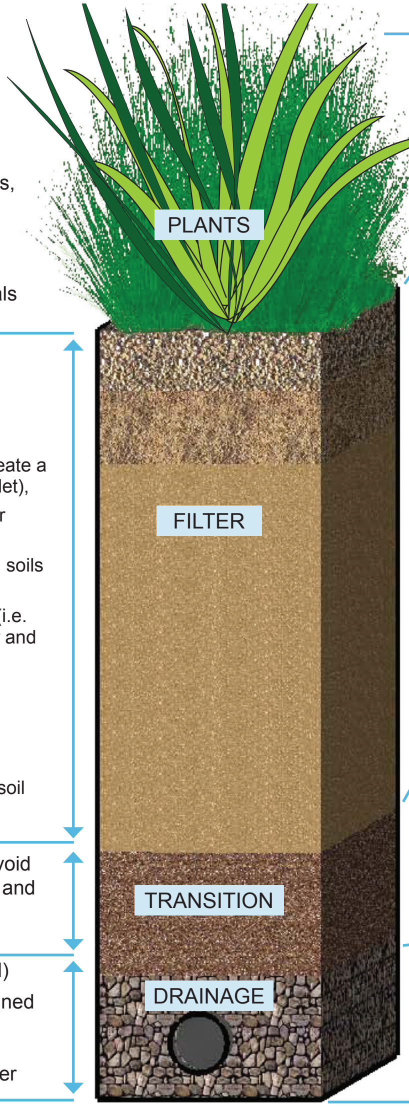
Separates filter layer from drainage layer to avoid clogging and stop transition of the filter media and leaching of the fine particles into the drainage layer

Free draining layer containing pipe (if required)

Subsoil pipe can aid in watertable control (unlined systems) and in the case of desirable shallow groundwater interaction. It is also required in impervious systems to collect and convey water

Infiltration from base if applicable

Biofilter elements



Design guidelines

Extended detention depth/plants

Choosing a diversity of plants is one of the most important principles in biofilter design

At least 50% of the plants to be effective at nutrient removal. Remainder to be local, native, ephemeral plants

6–12 plants per m^2, depending on species

Include a protective surface layer 100-150mm deep overlying the biofilter media consisting of a coarser particle size than the media. Once-off nutrient amelioration added manually to top 100mm once only. Particularly important for engineered media.

A washed, well-graded sand or naturally occuring sand, possibly a mixture

Saturated hydraulic conductivity in range 100–300mm/hr (higher in tropical regions but must be capable of supporting plant growth)

Clay and silt	<3% (w/w)	
Very fine sand	5–30%	
Fine sand	10–30%	(0.15–0.25mm)
Medium sand	40–60%	(0.25–0.50mm)
Coarse sand	<25%	(0.50–1.0mm)
Very coarse sand	0-10%	(1.0-2.0mm)
Fine gravel	<3%	(2.0–3.4mm)
pH	5.5–7.5	
Electrical conductivity	<1.2dS/m	
Organic matter nutrient-content	≤5%	
Available phosphate (Colwell)	<80mg/kg	
Total nitrogen content	<1000mg/kg	

Clean, well-graded sand e.g. A2 filter sand(0-9.5mm) <2% fine

Hydraulic conductivity - higher than the overlying filter media

Clean, fine gravel or crushed rock 2–5mm and carbon source, if submerged

Particle size distribution:

D_{15} transition layer ≤5 x D_{85} filter media

Bridging criteria only in designs where transition is omitted:

D_{15} drainage layer ≤5 x D_{85} filter media

D_{15} drainage layer =5 to 20 x D_{15} filter media

D_{50} drainage layer <25 x D_{50} filter media

D_{60} drainage layer <20 x D_{10} drainage layer

Perforated PVC subsoil pipe (if required) - perforations small enough relative to drainage layer material. Check: D_{85}drainage layer > diameter underdrain pipe perforation. Minimum 50mm cover over underdrain pipe.

Material - clean, fine aggregate 2-7mm washed screenings

hydraulic conductivity - must be higher than the hydraulic conductivity of the overlying transition layer

Particle size distribution:

D_{15} drainage layer ≤5 x D_{85} transition media

(Adapted from: Thompson McRobert Edgeloe Group 2008)

Required reading

Monash Water for Liveability Centre, Oversby, B., Payne, E., Fletcher, T., Byleveld, G., Hatt, B. 2014a. *Practice Note: Vegetation guidelines for stormwater biofilters in the southwest of Western Australia*. Clayton, Australia. Monash University, Clayton.

Monash Water for Liveability Centre, Oversby, B., Payne, E., Fletcher, T., Byleveld, G., Hatt, B. 2014b. *Vegetation guidelines for stormwater biofilters in the south-west of Western Australia*. Monash University, Clayton.

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Australian runoff quality: a guide to water sensitive urban design, 2006, Engineers Australia.

Construction and establishment guidelines: swales, bioretention systems and wetlands, 2009, Water by Design, South East Queensland Healthy Waterways Partnership,

Guideline specifications for soil media in bioretention systems, 2008, Monash University Facility for Advancing Water Biofiltration.

In situ monitoring of hydraulic conductivity, 2009, Monash University Facility for Advancing Water Biofiltration.

Stormwater management manual for Western Australia, 2004–07, Department of Water.

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