Fact Sheet: How does stormwater biofiltration work?

What is biofiltration?

Compared to undeveloped catchments, urban areas generate stormwater runoff that is magnified in flow volume, peak and pollutant load. The poor water quality and altered hydrology are both highly detrimental to the health of receiving waters (e.g. streams, estuaries, bays). Water biofiltration is the process of improving water quality by filtering water through biologically influenced media (Figure 1). Stormwater biofiltration systems (also known as biofilters, bioretention systems and rain gardens) are just one of a range of accepted Water Sensitive Urban Design (WSUD) elements. They are a low energy treatment technology with the potential to provide both water quality and quantity benefits. The technology can be applied to various catchment sizes and landscape settings, from street trees and private backyards to street-scale applications and car parks, up to larger regional stormwater treatment systems, including in public parks and forested reserves (Figure 2). Further, biofilter design can be tailored to optimise performance for local conditions and specific treatment objectives.

A typical biofilter consists of a vegetated swale or basin overlaying a porous, sand-based filter medium with a drainage pipe at the bottom. Stormwater is diverted from a kerb or pipe into the biofilter, where it flows through dense vegetation and temporarily ponds on the surface before slowly filtering down through the filter media (Figure 1). Depending on the design, treated flows are either infiltrated to underlying soils, or collected in the underdrain system for conveyance to downstream waterways or storages for subsequent re-use.

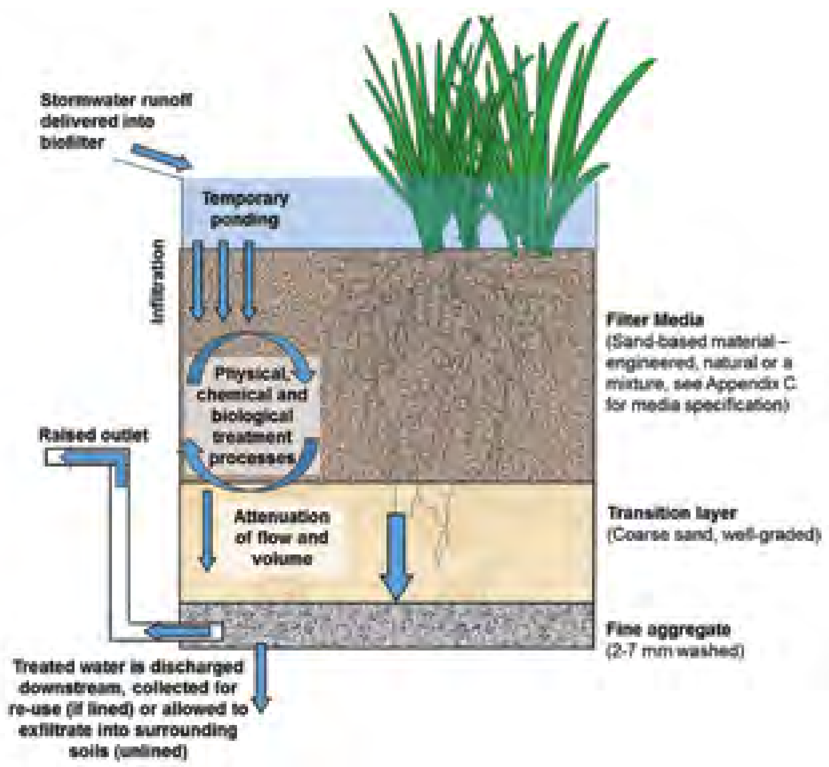

Figure 1. Key principles of stormwater biofiltration

For full details please refer to the Adoption Guidelines for Stormwater Biofiltration, CRC for Water Sensitive Cities (2015)

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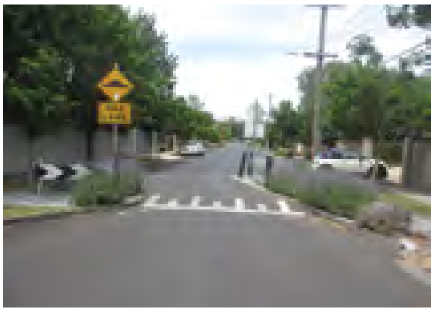

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Figure 2. Examples of stormwater biofilters, which can vary widely in their scale, appearance and design to suit treatment objectives and local site conditions. Photos supplied by Krish Seewraj and Antonietta Torre, Department of Water and Emily Payne, Monash University

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Key components

All biofilters operate using the same basic principles and some features are essential and common to all biofilters (Figure 3). Each component contributes to system functioning (Table 1). Configurations are flexible though and some characteristics will be tailored (Figure 4), allowing each system to be adapted for optimised performance, depending upon performance objectives and local site conditions.

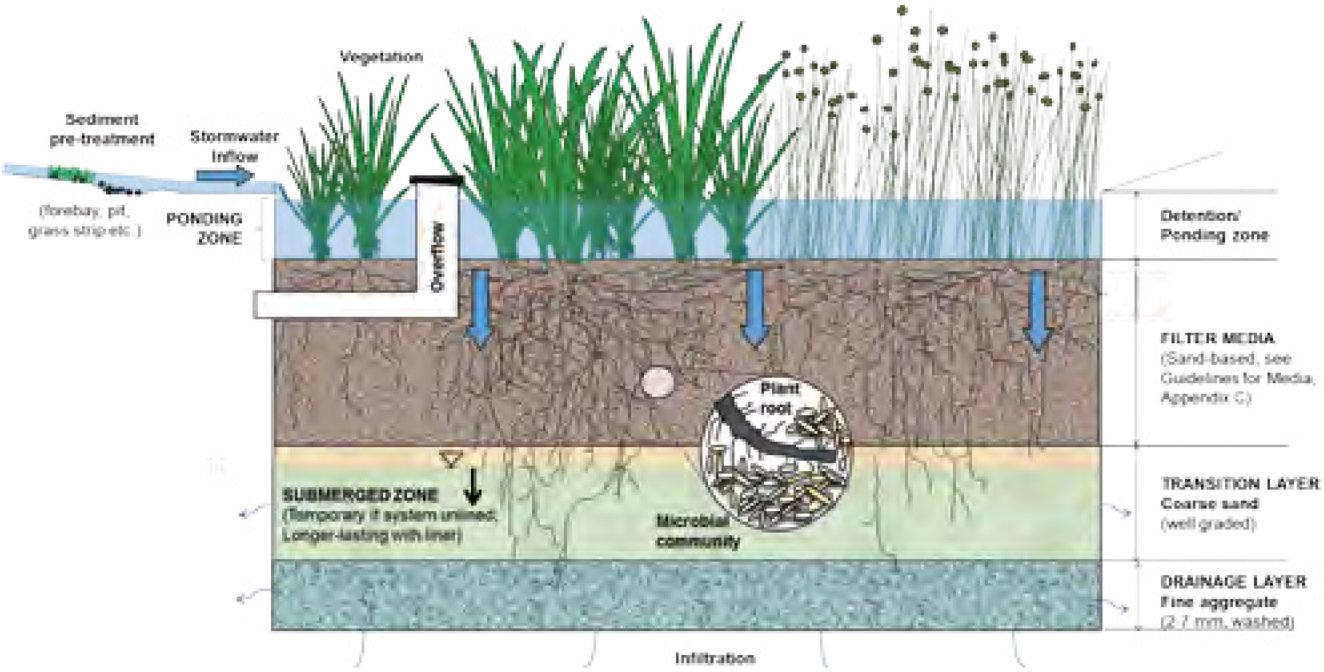

Figure 3. Essential components for stormwater biofilters (although their configuration can vary from the illustration shown above)

Table 1. Key components of stormwater biofilters and their functional roles

Essential components and function	Key information can be found within Biofilter Adoption Guidelines (CRC for Water Sensitive Cities, 2015), Section...	
Inflow	Delivers stormwater into biofilter	3.6.3
Overflow	Allows high flows to bypass to avoid damage to system	3.6.3
Ponding	(or detention zone) Increases treatment capacity by allowing stormwater to pond before infiltration	3.6.2
Vegetation	Serves multiple roles in water treatment via uptake, transformation to organic forms, carbon provision to microbes, transpiration reducing stormwater volume, stabilising media surface, helping to maintaining infiltration rates, provides cooling to surrounding environment, amenity and aesthetics. The microbial community associated with plant roots facilitates uptake, decomposition and transformation of stormwater pollutants and plant litter.	3.6.5
Filter media	Provides physical filtration of particulates, physiochemical pollutant removal processes such as adsorption, fixation, precipitation, supports vegetation growth and the infiltration of stormwater attenuates and reduces the magnitude of the outflow hydrograph (providing stream health benefits)	3.6.4
Transition layer	Coarse sand. Provides a bridging layer to prevent migration of fine particles from the upper filter media to the gravel drainage layer	3.6.4
Drainage layer	Gravel. Allows the system to drain, either into a collection pipe and outflow point or infiltration into surrounding soils, also provides higher porosity to temporarily store stormwater between pores	3.6.4
Unlined	Allows infiltration into surrounding soils, either for the entire or only part of the system	3.6.3
Pre-treatment	Collects coarse sediment and litter, helping to protect the biofilter itself from premature clogging and blockages, and facilitating maintenance. Recommended for all systems except those < 2ha in size without identifiable sediment sources, or systems only receiving roof runoff (Water by Design, 2014).	3.6.3
Additional components (depending upon treatment objectives and site conditions)		
Collection pipe	Underdrain formed with slotted pipe and used to drain and collect effluent from the system. May not be needed for small systems, nor for those with only exfiltration and no outflow pipe.	3.6.3
Raised outlet; creates temporary submerged zone	Strongly recommended, providing multiple benefits for water treatment and plant survival. Allows ponding in the lower portion of the biofilter, increasing moisture availability for plants and providing larger retention capacity for the temporary storage of stormwater. If the system is unlined, the raised outlet promotes exfiltration and creates a temporary submerged zone. Alternatively, if combined with an impermeable liner, it provides a longer-lasting submerged zone which benefits nitrogen removal via denitrification.	3.6.3
Submerged zone (or Saturated zone)	Created using a raised outlet, but may be temporary (if system unlined) or longer-lasting (if lined). Serves multiple roles: i.) provides a water supply to support plant and microbial survival across dry periods; ii.) benefits N removal, particularly following dry periods; iii.) provides anaerobic conditions for denitrification; iv.) provides prolonged retention for a volume of stormwater – which allows longer processing time.	3.6.3
Liner; creates long-lasting submerged zone	Prevents infiltration and may fully or only partially line the system	3.6.3
Carbon source	(wood chips) Mixed throughout the submerged zone when a liner is present. As the carbon source decomposes, it provides electrons to drive denitrification	3.6.4

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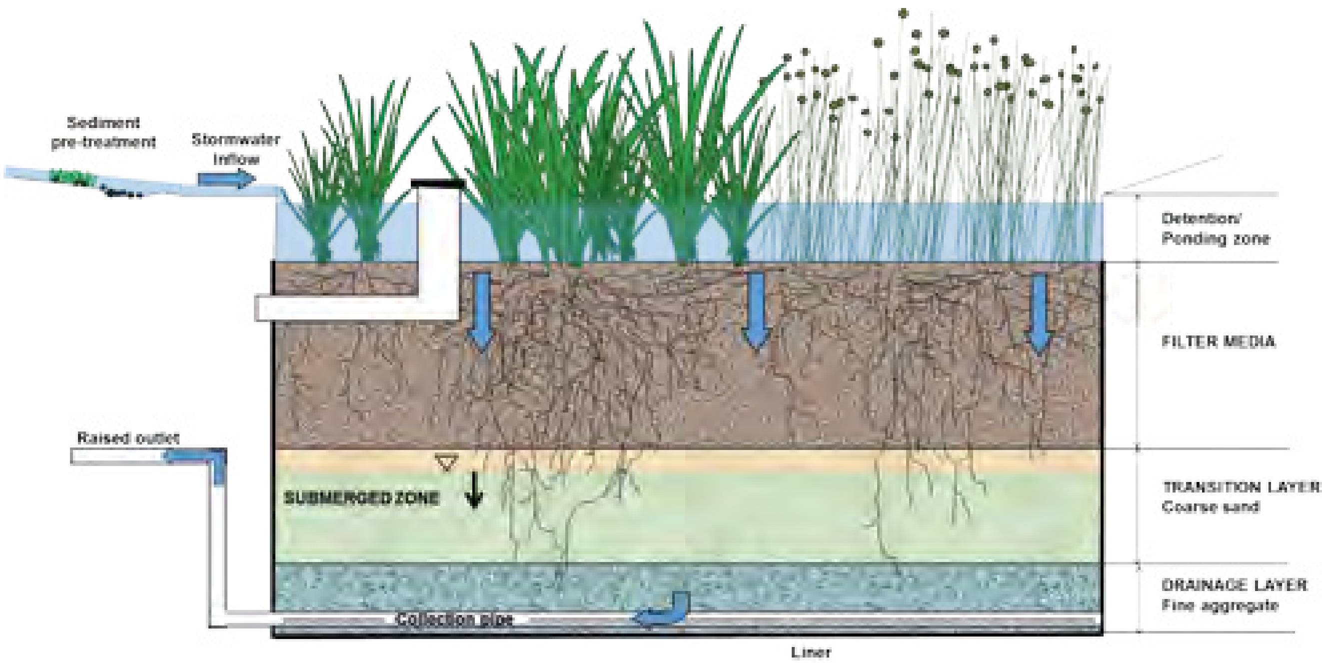

Figure 4. Typical biofilter configuration recommended for dense urban areas and/or where prolonged dry spells are experienced

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Pollutant processing in biofilters

A wide range of processes act to retain or transform incoming stormwater pollutants. The plants, filter media and microbial community all play important roles in pollutant processing as stormwater enters the biofilter, infiltrates through the filter media and comes into contact with plant roots and the microbes (Table 2 and Figure 4):

Table 2. Key processes involved in the removal or transformation of stormwater pollutants

Stormwater pollutant	Key processes
Sediment	• Settlement during ponding • Physical filtration by media
Nitrogen	• Nitrification • Denitrification • Biotic assimilation by plants and microbes • Decomposition • Physical filtration of sediment-bound fraction • Adsorption
Phosphorus	• Physical filtration of sediment-bound fraction • Adsorption • Biotic assimilation by plants and microbes • Decomposition
Heavy metals	• Biotic assimilation by plants and microbes • Physical filtration of sediment-bound fraction • Oxidation/reduction reactions
Pathogens	• Adsorption-desorption • Physical filtration by media • Die-off (either natural or due to competition or predation)
Organic micropollutants (hydrocarbons, pesticides /herbicides, polycyclic aromatic hydrocarbons (PAHs), phenols, phthalates)	• Adsorption • Biodegradation

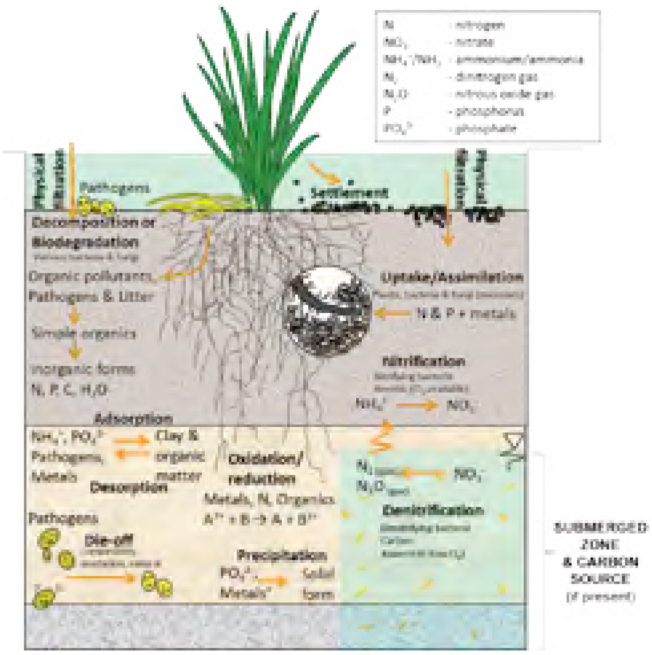

Figure 4. Key processes involved in pollutant attenuation, removal or transformation in stormwater biofilters