Appendix K: Maintenance requirements for biofiltration systems: plan and checking tools

CRC for
Water Sensitive Cities

Australian Government
Department of Industry and Science

Business
Cooperative Research
Centres Programme

CRC for
Water Sensitive Cities

Biofiltration systems maintenance plan

Example April 2015

Australian Government
Department of Industry and Science
Business
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Centres Programme

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Table of Contents

1 Biofilter functions

This is a sample maintenance plan only. When preparing a maintenance plan for a specific site, consideration should be given to the individual site requirements to ensure all the elements within a particular design are incorporated in to the plan.

A sketch or drawing should be provided (as seen in Figure 1) to help maintenance personnel and asset managers understand the function and features of a particular asset. The drawing should provide enough information about the function of a system to enable appropriate management/maintenance decisions to be made.

Biofiltration systems (also known as biofilters, bioretention systems and rain gardens) are designed with the primary intent of removing pollutants from stormwater before the water is discharged to the local waterway or reused for other applications (e.g. irrigation). They are typically constructed as basins, trenches or tree pits (Figure 1). Stormwater runoff generally enters the biofiltration system through a break in a standard road kerb where it temporarily ponds on the surface before slowly filtering through the soil media. Treated stormwater is then collected at the base of the biofiltration system via perforated pipes located within a gravel drainage layer before being discharged to conventional stormwater pipes or collected for reuse. Note that, in some cases, the drainage pipe is up-turned to create a permanent pool of water, or submerged zone, in the bottom of the biofiltration system. Conventional stormwater pipes also act as an overflow in most designs, taking flows that exceed the design capacity of the biofiltration system.

The inclusion of biofiltration systems into the stormwater drainage system does not affect other conventional drainage elements. Stormwater discharge that exceeds the capacity of the biofiltration system may continue down the kerb to be collected in a conventional side entry pit or may overflow into a pit located within the biofiltration system that is directly connected to the conventional drainage system.

Biofiltration systems provide stormwater treatment as well as landscape amenity. An additional benefit is that the passive irrigation from stormwater reduces the demand for irrigation from other sources, such as potable water.

The tree and/or understorey species need to be relatively hardy, and tolerant of both freely draining sandy soils and regular inundation. The soil filter media into which the trees are planted generally has a specified hydraulic conductivity of 100 – 300 mm/hr, depending on the local climate and the configuration of the system. Healthy vegetation cover across the biofilter is vital to the system function, helping to i.) significantly improve stormwater treatment, ii.) reduce the likelihood of clogging at the surface of the media, and iii.) reduce erosion..

Figure 1 illustrates the intended flow pathways for stormwater through a typical biofiltration system (a tree pit, in this case) and shows some of the subsurface infrastructure that requires consideration for maintenance. It should be noted that stormwater biofilters share many common design features, although their configurations will vary to suit site conditions and the performance objectives.

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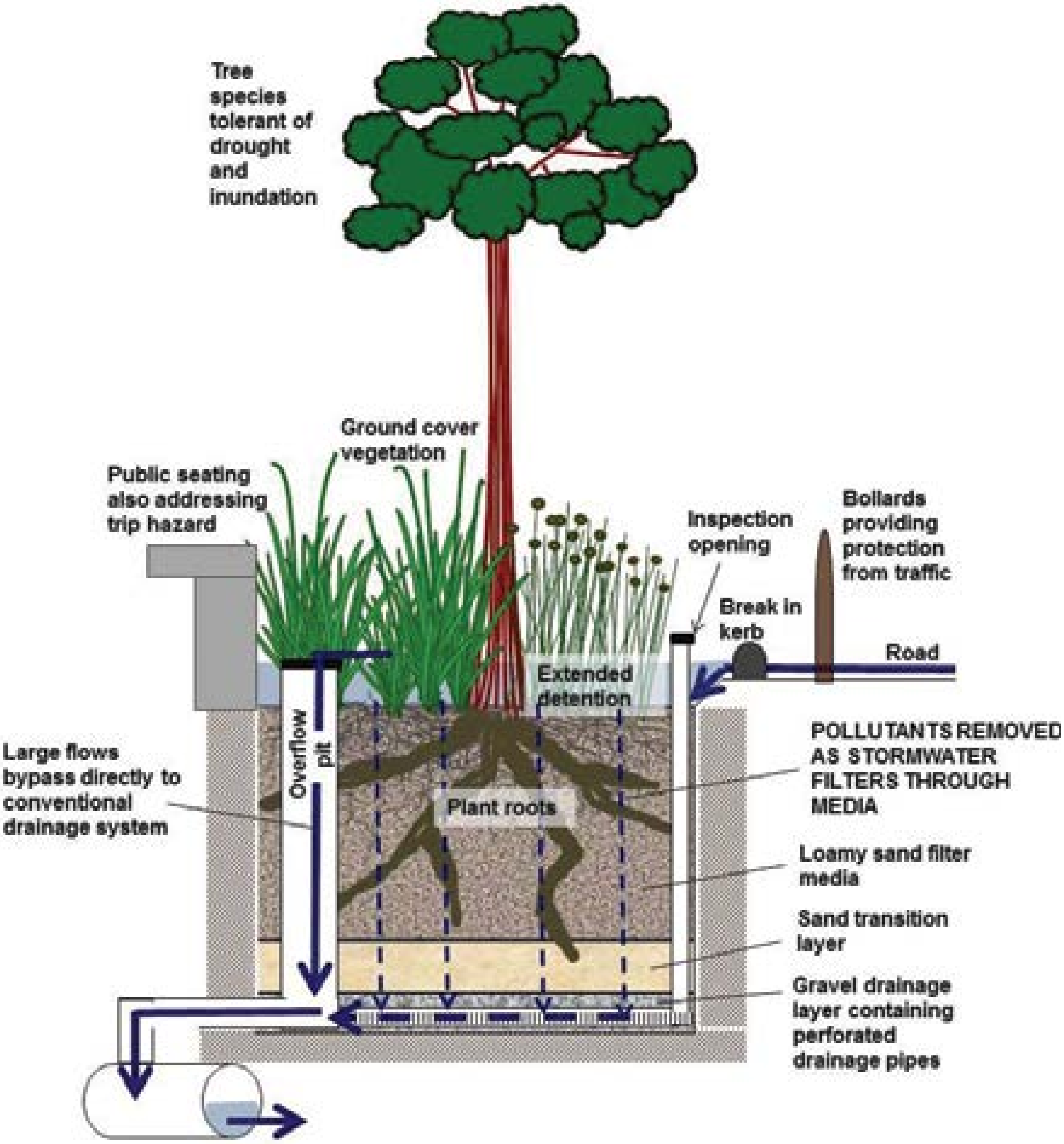

Figure 1. Conceptual drawing of a biofiltration system illustrating stormwater flow pathways and subsurface infrastructure requiring maintenance. Note that biofilters share many features but configurations can vary from the design above to suit site conditions and objectives.

2 Minimising the long term maintenance

Four key elements in the design and construction of raingardens and biofiltration tree pits have been identified that strongly influence the amount of long-term maintenance that is required. Adequately addressing these key elements ensures that the long-term maintenance of these systems is predictable, and therefore minimal. The elements are:

- Correct filter media specification and installation;
- Dense vegetation cover;
- Correct design and construction of the hydraulic components (i.e. components that channel, direct, pond or drain flow within the biofilter), and keeping these free from blockages; and
- Protection during construction phases.

The importance of these key elements is described in more detail below.

2.1 Filter media

The filter media for the biofiltration system must meet certain specifications. It is crucial that the filter media maintains its hydraulic conductivity (i.e., it's ability to pass water through the media) in the long term. When an inappropriate filter media is installed (eg. it contains high levels of fine silt and/or clay materials), it may result in compaction or even structural collapse of the media. This leads to a substantial reduction in the treatment capacity of the system because water will not filter through the media; instead it will pond on the surface and spill out through the overflow. A symptom of this compaction is often the loss of vegetation within the biofiltration system.

Similarly, filter media must be correctly installed with an appropriate level of compaction during installation. Guidelines currently recommend that filter media be lightly compacted during installation to prevent migration of fine particles. It is important to avoid heavy compaction with machinery as this will reduce the infiltration capacity and reduce the volume of stormwater treated.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 (FAWB, 2009).

2.2 Vegetation cover

Nutrients have been identified as a key pollutant in stormwater, particularly nitrogen and phosphorus. The nutrient removal efficiency of biofiltration systems is related to the root characteristics and density of the plants within the system. Further, as plants mature and their roots penetrate the filter media, they play a role in maintaining the hydraulic conductivity of the media because root growth helps to maintain the surface porosity and the infiltration capacity of the filter media. As a result, it is important that dense vegetation cover is established at an early stage to prevent compaction or surface sealing. Some biofiltration tree pits are designed without understorey vegetation. In these instances, it is likely that additional maintenance will be required to maintain the porosity of the surface of the filter media (e.g. physical removal of any fine sediments that accumulate on the surface).

2.3 Hydraulic components

The function of a biofilter is dependent upon appropriate hydraulics. This requires good design and construction of the components (inlet/s overflow pits, outlets, depth of ponding zone, underdrains and surface gradient). It is most important to ensure invert levels are correct and to design to minimise the risk of blockages of key flow structures. Regular inspection and maintenance of these components is critical to allow stormwater flows to continue to enter the biofilter, distribute across the surface, temporarily pond, infiltrate downwards and drain from the base (either into surrounding soils or collected in underdrainage pipes), or for high flows to overflow/bypass the biofilter.

The hydraulic components are prone to blockage from sediment accumulation or litter, and the surrounding media can suffer from erosion or scour. Blockage of the inlet, outlet or overflow will compromise stormwater treatment, and may lead to widespread plant death either due to drought conditions (if the inlet is blocked) or prolonged flooding (if the outlet or overflow is blocked).

2.4 Protection during construction phases

Protection of biofiltration systems during construction allows for good plant establishment and prevents disturbance or scour of the filter media surface. It is also important to protect the biofiltration system from heavy sediment loads (including contamination of the biofilter media with on-site soils), or other wash off (e.g. cement washings), during any construction in the catchment to prevent clogging of the surface of the filter media (see Section 3 for more detail).

3 Construction and establishment phase maintenance

A number of maintenance activities have been identified that are, in most cases, only required during the establishment phase of a biofiltration system. The end of the establishment phase can be defined by the completion of both of the following:

(i) The plant establishment – where plants are suitably established to no longer require irrigation and are close to their mature height and/or when larger trees no longer require tree stakes for support. This period is typically 18 to 24 months; and

(ii) The biofiltration system is completely connected to its intended catchment and the catchment is no longer under construction (therefore there is less risk of high sediment loads or other contaminants, such as cement washings or fine clay sediments, being washed onto the surface of the filter media and causing clogging). It is also important that the entire catchment is connected to ensure adequate water availability for plants under normal climatic conditions.

This section contains considerations that are important during construction and establishment. Sign-Off forms for these phases are included in Water by Design's Construction and Establishment Guidelines. For more detailed information on the risks, common pitfalls and tips for the construction phase see Section 4.2 of the Biofilter Guidelines.

3.1 Protection of filter media during construction

Construction sites usually generate very high loads of sediment in stormwater runoff. These exceptionally high loads can cause the filter media within a biofiltration system to become clogged or blocked. Blockage may occur as a result of the accumulation of fine sediment on the surface; this can sometimes be manually removed. Accumulation of fine sediment may also occur in a layer deeper within the filter media, usually resulting in the need to remove and replace the filter media.

During construction of the biofilter itself, it is vital to protect the filter media from sediment in the surrounding area that can be washed into the pit, or from cross-contamination with on-site soils if the media is stockpiled before it is laid. This can be avoided by:

1. Protecting the biofilter construction pit from runoff using flow diversions, sediment traps or bunding;
2. If possible, timing construction of the biofilter to avoid the highest rainfall months; and,
3. Ensuring materials for the biofilter media layers are either tipped directly into the pit or deposited on a hard surface for stockpiling (thus preventing possible contamination with on-site soils).

To protect the filter media while construction activities are occurring in the catchment, at least one of the following precautions should be taken:

1. Keep the biofiltration system off-line during this period to prevent any stormwater entering – Note: adequate alternative sediment control measures must also be installed during construction to prevent heavy sediment loads being discharged directly to the stormwater system while the biofiltration system is off-line;
2. Delay final landscaping and protect the system by covering the entire biofiltration surface with geotextile (and turf or gravel if desired for aesthetic purposes) as shown in Figure 2 (left); or
3. Temporarily partition the biofiltration system, creating a sacrificial sediment forebay. This allows the vegetation to establish in the rest of the system while the sacrificial sediment forebay at the inlet is protected using textile and turf, as described above and shown in Figure 2 (right). This approach is best suited when the overflow pit is located close to the inlet zone.

Figure 3. Concept illustration showing how Ag pipes installed for tree watering can result in short circuiting and reduced stormwater treatment.

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3.3 Tree stake removal

Tree stakes are often used to support young trees planted into the filter media of biofiltration systems. The stakes should be removed once the trees are adequately established and the holes filled in with filter media. Failure to fill in the holes will result in the creation of a short-circuit pathway, or preferential flow path, for stormwater. Instead of ponding on the surface of the raingarden, the holes left behind after the stakes are removed allow water to bypass the filter media and drain directly into the drainage layer at the base of the cell, effectively bypassing any pollutant removal processes.

4 Asset handover

4.1 Asset Transfer

Land ownership and asset ownership are key considerations prior to construction of a stormwater treatment device. A proposed design should clearly identify the asset owner and who is responsible for its maintenance.

If ownership of the asset is to be transferred (commonly from a developer to local council or government authority), the proposed owner should be responsible for performing the asset transfer checklist. Handover is a key opportunity for the identification and rectification of problems that may compromise long-term system performance (e.g. poor plant health, bare zones, inappropriate hydraulics, excessive sediment accumulation). For details on asset transfer specific to each council, contact the relevant local authority to obtain their specific requirements for asset transfer. The example below provides an indicative asset transfer checklist.

4.2 Asset Transfer Checklist

BIOFILTRATION SYSTEM ASSET TRANSFER CHECKLIST		
Asset ID:		
Asset Location:		
Constructed by:		
'On-maintenance' period:		
TREATMENT	Y	N
System visually appears to be working as designed?		
No obvious signs of under-performance?		
MAINTENANCE	Y	N
Maintenace plans and indicative maintenance costs provided for each asset?		
Vegetation establishment period (two years) completed?		
Inspection and maintenance undertaken as per maintenance plan?		
Inspection and maintenance forms provided?		
ASSET INSPECTED FOR DEFECTS AND/OR MAINTENANCE ISSUES AT TIME OF ASSET TRANSFER	Y	N
Sediment accumulation at inflow points?		
Litter within system?		

Erosion at inlet or other key structures?		
Traffic damage present?		
Evidence of dumping (eg. building waste)?		
Vegetation condition satisfactory (density, weeds, etc.)?		
Water of vegetation required?		
Replanting required?		
Mowing/slashing required?		
Clogging of drainage points (sediment or debris)?		
Evidence of overly long periods of ponding?		
Damage/vandalism to structures present?		
Surface clogging visible?		
Drainage system inspected?		
Weir/up-turned pipe is clear of debris (if applicable)?		
Water level in saturated zone as designed (if applicable)?		
COMMENTS/ACTION REQUIRED FOR ASSET TRANSFER		
ASSET INFORMATION	Y	N
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 (eg. drawings, surveys, models) provided?		
Asset listed on asset register or database?		

5 OPERATIONAL MAINTENANCE TASKS

5.1 Schedule of visits

5.1.1 Schedule of Site Visits (Regular Inspection & Maintenance)	
Purpose of visit	**Frequency**
Inspection	Regular inspection and maintenance should be carried out to ensure the system functions as designed. It is recommended that these checks be undertaken on a three monthly basis during the initial period of operating the system. A less frequent schedule (e.g. 6 monthly) might be determined after the system has established.
Maintenance	

5.2 Tasks

The scope of maintenance tasks should include verifying the function and condition of the following elements:

- Filter media
- Horticultural
- Drainage infrastructure
- Other routine tasks

Further discussion of monitoring and maintenance of biofilters is provided in Section 4.3 of the biofilter guidelines.

5.2.1 Filter media tasks	
Sediment accumulation / clogging	Inspect for the accumulation of an impermeable surface layer (such as oily or clayey sediment), ponding of water for more than a few hours following rain (including the first major storm after construction), or widespread moss growth. Repair minor accumulations by scarifying the surface between plants and if feasible, manual removal of accumulated sediment. Investigate the cause of any poor drainage. **Frequency - 3 MONTHLY, AFTER RAIN**
Holes, erosion or scour	Check for erosion, scour or preferential flow pathways, particularly near inflow point/s and batter slopes (if present). May indicate poor flow control e.g. excessive inflow velocities or inadequate bypass of high flows. Repair and infill using compatible material. Add features for energy dissipation (e.g. rocks and pebbles at inlet), or reconfigure to improve bypass capacity if necessary. **Frequency - 3 MONTHLY, AFTER RAIN**
Filter media surface porosity – sediment accumulation and clogging	Inspect for the accumulation of an impermeable layer (such as oily or clayey sediment) that may have formed on the surface of the filter media. Check for areas of increased sediment deposition, particularly near inlet/s. A symptom of clogging may be that water remains ponded in the biofilter for more than a few hours after a rain event, or the surface appears 'boggy'. Repair minor accumulations by raking away any mulch on the surface and scarifying the surface of the filter media between plants. Accumulated sediment can be manually removed using rakes and shovels, if the system is not too large or only certain areas require attention. If excessive loads of sediment, investigate the source and install pre-treatment device if necessary. For biofilter tree pits without understorey vegetation, any accumulation of leaf litter should be removed to help maintain the surface porosity of the filter media. **Frequency - 3 MONTHLY, AFTER RAIN**
Damage	Check for damage to the profile from vehicles, particularly streetscape systems alongside parking or street corners. Also check for signs of pedestrian traffic across the filter surface, such as worn pathways. Repair using compatible filter media material. **Frequency – 6 MONTHLY**

Litter control	Check for anthropogenic litter and significant accumulations of organic litter, particularly in sediment pits, inlets, outlets and overflows. Remove litter to ensure flow paths and infiltration through the filter media are not hindered. Systems are particularly vulnerable to accumulations of organic litter during establishment, which can smother seedling growth and re-release nutrients as it breaks down. Litter can be removed manually and pre-treatment measures (such as a gross pollutant trap) can be used if it is a significant problem. **Frequency - 3 MONTHLY OR AS DESIRED FOR AESTHETICS**
Moss growth	Moist systems or those with deep shading of the surface may have excessive moss growth across the surface. This can act to bind the surface, contributing to clogging. Manual scraping can remove the moss, but the underlying cause should be investigated and rectified if possible. **Frequency – 6 MONTHLY, ESPECIALLY DURING WETTEST MONTHS**
5.2.2 Horticultural tasks	
Establishment	The initial period after construction (up to the first 2 years) is critical to long-term success or failure of the biofilter. Additional monitoring and maintenance works are required to ensure a healthy and diverse vegetation cover develops, and that stormwater flows move through the system as the design intended (i.e., flows enter freely, covering the entire surface, ponding occurs to the design depth, high flows bypass and the infiltration rate is acceptable). Careful attention can avoid costly replanting and rectification works. New seedlings will require regular watering and irrigation, protection from high sediment loads and high flows. Refer to Water by Design's 'Construction and Establishment Guidelines'.**Frequency – WEEKLY IF ESTABLISHING ACROSS DRY SEASON, HIGH FREQUENCY DURING FIRST 3 MONTHS IN PARTICULAR, INCLUDING AFTER FIRST LARGE RAIN EVENT. AFTER THIS, BIMONTHLY IN WETTER MONTHS AND MORE FREQUENTLY DURING THE COURSE OF ANY LONG DRY AND HOT SPELLS. UP UNTIL 2 YEARS.**
Plant health and cover	Reduced plant density reduces pollutant removal and infiltration performance. Inspect plants for signs of disease, die-back, pest infection, stunted growth or senescent plants and assess the degree of plant cover across the surface. If poor plant health or cover is widespread, investigate to identify and address the causal factor (e.g. poor species selection, shading, too dry (e.g. oversized, wrong inlet levels or level for ponding zone, dry climate, media with minimal water holding capacity, poor flow distribution, lack of irrigation), too wet (e.g. from clogging, undersizing) or smothering from litter. Treat, prune or remove plants and replace as necessary using appropriate species (species selection may need re-consideration in light of the level of water availability), aiming to maintain the original planting densities (6-10 plants/m^2 recommended). Provide watering or irrigation to support plants through long dry periods. **Frequency - 3 MONTHLY OR AS DESIRED FOR AESTHETICS, BUT ADDITIONALLY CHECK DURING LONG DRY SPELLS**
Weeds	Weeds should be identified and removed as they occur. If left, weeds can out-compete the desired species, possibly reducing water treatment function and diminishing aesthetics. Inspect for and manually remove weed species, avoiding the use of herbicides because biofilters are often directly connected to the stormwater system (if unavoidable apply in a targeted manner using spot spraying). **Frequency - 3 MONTHLY OR AS DESIRED FOR AESTHETICS**
Pruning and harvesting (if feasible)	It may be worth considering occasionally harvesting plants to permanently remove nutrients and heavy metals stored in aboveground tissues, and to promote new plant growth and further nutrient and metal uptake. Pruning may also benefit aesthetics.**Frequency – ONCE or TWICE A YEAR**
5.2.3 Drainage tasks	
Inlet pits/zones, overflow pits, grates and other stormwater junction pits	Ensure inflow areas and grates over pits are clear of litter and debris and in good and safe condition. A blocked grate would cause nuisance flooding of streets. Inspect for dislodged or damaged pit covers and ensure general structural integrity. Remove sediment from pits and entry sites, etc. (likely to be an irregular occurrence in a mature catchment). **Frequency - MONTHLY AND OCCASIONALLY AFTER RAIN , BUT 6 MONTHLY IF NO CONSTRUCTION ACTIVITY UNDERWAY IN THE CATCHMENT.**

Underdrain	Ensure that underdrain pipes are not blocked to allow the system to drain as designed and prevent waterlogging of the plants and filter media. A small steady clear flow of water may be observed discharging from the underdrain at its connection into the downstream pit some hours after rainfall. Note that smaller rainfall events after dry weather may be completely absorbed by the filter media and not result in flow. Remote camera (eg. CCTV) inspection of pipelines for blockage and structural integrity could be useful. **Frequency - 6 MONTHLY, AFTER RAIN**
Sediment forebay/pre-treatment zone **(if present)**	Removal of accumulated sediment and debris. **Frequency – TWICE A YEAR (or more frequent if accumulation is particularly rapid)**
Elevated outlet **(if submerged zone present)**	Check that the weir/up-turned pipe is clear of debris. **Frequency – 6 MONTHLY, AFTER RAIN**
Submerged zone **(if present)**	Although the submerged zone helps to sustain the biofilter through dry periods, if drying persists for long enough it will become drawn down and require replenishment. Check that the water level in the submerged zone is at the design level and top this up as required. **Frequency – MONTHLY THROUGHOUT DRY SEASON (i.e., only when rain is infrequent), or AS REQUIRED (refer to Equation 1 in Section 3.6.7 to estimate the required time for re-filling)**
5.2.4 Other routine tasks	
Inspection after rainfall	Occasionally observe biofiltration system after a rainfall event to check infiltration. Identify signs of poor drainage (extended ponding on the filter media surface). If poor drainage is identified, check land use and assess whether it has altered from the design capacity (eg. unusually high sediment loads may require installation of a sediment forebay). **Frequency – TWICE A YEAR, AFTER RAIN**

The following example form should be developed and used whenever an inspection is conducted and kept as a record on the asset condition and quantity of removed pollutants over time. Inspections should occur every 1 – 6 months depending on the size, complexity and location of the system. For example systems will require more frequent inspection if they are located in a highly visible place, or if the catchment contributes high sediment or litter loads. More detailed site specific maintenance schedules should be developed for major biofiltration systems and include a brief overview of the operation of the system as well as key aspects to be checked during each inspection.

5.2.5 FORM (REGULAR INSPECTION & MAINTENANCE)							
Location	Raingarden/Tree Pit						
Site Visit Date:		Site Visit By:					
Weather:							
Purpose of the Site Visit	Routine Inspection	☐	Complete section 1 (below)				
	Routine Maintenance	☐	Complete sections 1 and 2 (below)				
NOTE: Where maintenance is required ('yes' in Section 2), details should be recorded in the 'Additional Comments' section at the end of this document.							
1. Filter media							
*In addition to regular inspections, it is recommended that inspection for damage and blockage is made after significant rainfall events that might occur once or twice a year.	Section 1		Section 2				
	Maintenance Required?		Maintenance Performed				
	Yes	No	Yes	No			
Filter media (CIRCLE – pooling water or evidence of overly long water ponding/ accumulation of silt & clay layer/scour/holes/sediment build up/traffic damage)	☐	☐	☐	☐			
Litter (CIRCLE - large debris/accumulated vegetation/anthropogenic/dumping of building waste or rubbish)	☐	☐	☐	☐			
2. Vegetation							
Vegetation health (CIRCLE - signs of disease/pests/poor growth - watering required – mowing/trimming required)	☐	☐	☐	☐			
Vegetation densities (CIRCLE – low densities- infill planting required)	☐	☐	☐	☐			
Build up of organic matter, leaf litter (CIRCLE - requires removal)	☐	☐	☐	☐			
Weeds (CIRCLE - isolated plants/infestation) (SPECIES - ……………………………………………………………..)	☐	☐	☐	☐			

3. Pits, pipes and inflow areas				
*In addition to regular inspections, it is recommended that inspection for damage and blockage is made after significant rainfall events that might occur once or twice a year.	Section 1		Section 2	
	Maintenance Required?		Maintenance Performed	
	Yes	No	Yes	No
Perforated pipes (CIRCLE – full blockage/partial blockage/damage)	☐	☐	☐	☐
Inflow areas (CIRCLE – erosion/excessive sediment deposition/litter blockage)	☐	☐	☐	☐
Overflow grates (CIRCLE – damage/scour/blockage)	☐	☐	☐	☐
Pits (CIRCLE – poor general integrity/sediment build-up/litter/blockage)	☐	☐	☐	☐
Other stormwater pipes and junction pits (CIRCLE – poor general integrity/ sediment build-up/litter/blockage)	☐	☐	☐	☐
4. Submerged zone (if present)				
*In addition to regular inspections, it is recommended that inspection for damage and blockage is made after significant rainfall events that might occur once or twice a year.	Section 1		Section 2	
	Maintenance Required?		Maintenance Performed	
	Yes	No	Yes	No
Weir/up-turned pipe (CIRCLE – full blockage/partial blockage/damage)	☐	☐	☐	☐
Water level (CIRCLE – at design level/drawn down) **SOME DRAWDOWN DURING DRY PERIODS IS EXPECTED**	☐	☐	☐	☐
5. Additional Comments				
Details of routine maintenance, renewal or resetting works required:				

REFERENCES

FAWB (2009). Guidelines for Filter Media in Biofiltration Systems (Version 3.01), Facility for Advancing Water Biofiltration, available at http://www.monash.edu.au/fawb/publications

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