CHAPTER 4: PRACTICAL IMPLEMENTATION

4.1 INTRODUCTION

This chapter provides general guidance on the construction, establishment and monitoring of biofiltration systems in Australia. The recommendations are based on the experience and observations of ecologists and engineers who have been actively involved in the design, on-site delivery and monitoring of at-source and end-of-line biofiltration systems.

The document includes information on:

- Construction and establishment;
- Maintenance requirements;
- Monitoring requirements; and
- Checking tools (for designers and council development assessment officers).

The information presented in this document is intended to provide a broad, national approach to the construction and establishment of biofiltration systems, however reference should also be made to locally relevant and more detailed guidelines where available. Some of these guidelines are listed below, however contact your local council for the latest requirements and guidelines available:

- Healthy Waterways Partnership, v1 June 2006[4]. Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland
- Townsville City Council, in prep. Water Sensitive Urban Design for the Coastal Dry Tropics (Townsville): Technical Design Guidelines for Stormwater Management.
- Melbourne Water, 2005. WSUD Engineering Procedures: Stormwater. CSIRO Publishing
- Victorian Stormwater Committee, 1999. Urban Stormwater: Best Practice Environmental Management Guidelines. CSIRO Publishing
- LHCCREMS (Lower Hunter and Central Coast Regional Environmental Management Strategy) 2002, Water Sensitive Urban Design in the Sydney Region. LHCCREMS, NSW
- New South Wales Department of Environment and Climate Change. Managing Urban Stormwater: Urban Design. Department of Environment and Climate Change in association with the Sydney Metropolitan Catchment Management Authority (CMA)
- Stormwater Trust and the Upper Parramatta River Catchment Trust, 2004. Water Sensitive Urban Design Technical guidelines for Western Sydney.

4.2 CONSTRUCTION AND ESTABLISHMENT

The construction and establishment phase is generally accepted as being the critical phase for determining the success or failure of vegetated stormwater management systems. As such, careful construction and establishment procedures are key to ensuring long-term performance, avoiding expensive retrofits, and minimising future maintenance requirements.

[4] An update of the HWP WSUD Guidelines for SEQ was in progress at the time of writing this report.

IMPORTANT!

Significant quantities of sediment can be generated during the construction phase of urban developments, therefore comprehensive erosion and sediment control measures must be implemented to protect receiving waters. Biofiltration systems should not be assumed to provide environmental protection during this phase.

Water by Design, a program of the South East Queensland Health Waterways Partnership, released a new set of Construction and Establishment Guidelines for vegetated stormwater management systems in March 2009 (Water by Design, 2009) and FAWB refers industry practitioners to these guidelines. The guidelines were developed in collaboration with local government compliance officers, site superintendents, civil and landscape contractors, and practitioners with significant on-ground experience, and provide clear, practical and up-to-date guidance for constructing and establishing biofiltration systems. Of particular note are the step-by-step sequences for civil construction, building phase protection and landscape establishment for four alternative construction sequences. In addition, separate compliance procedures for both small and very large systems are identified (in accordance with a risk assessment approach) to ensure that smaller, distributed systems are not disadvantaged through onerous compliance requirements. These guidelines are nationally relevant and it is ***strongly recommended*** that they be consulted. The following is a summary of the key contents of the biofiltration system section of the guidelines (links with other sections of these guidelines are noted):

- *Roles and responsibilities* – provides clear definition of the roles and responsibilities of the various parties to ensure clear communication and that contractors are supported by designers and site superintendents.
- *Timing for construction and establishment* – outlines when biofilters should be constructed in the context of other works on a construction site, addresses issues such as coordination with erosion and sediment control activities during the construction phase and protecting the biofilters from stormwater inflows during the civil and landscape works stages, to avoid damaging both the biofiltration system and downstream waterways.
- *Civil considerations and specifications* – identifies a number of issues associated with the civil works, including:
    - Ordering materials and timing for supply to ensure efficient civil construction;
    - Construction tolerances and survey methods for each system element;
    - Design and construction requirements for hydraulic structures;
    - Underdrainage (note that this complements the guidance given in Section 3.5.10 of these Adoption Guidelines);
    - Installing and compacting filter media;
    - Construction issues with large systems;
    - Interaction with services (note that this builds on the discussion in Section 3.6.2 of these Adoption Guidelines);
    - Coarse sediment capture for easy and infrequent maintenance; and
    - Provision of maintenance access.
- *Filter media specification and certification* – there is significant overlap between this section and the guidance given in Chapter 3 of these Adoption Guidelines (largely because it refers to FAWB's Guidelines for Filter Media in Biofiltration Systems), however Water by Design's guidelines provide additional, good advice on certification and chain of custody, and compliance testing.

- *Landscape considerations and specifications* – offers clear, practical advice on plant procurement, pre-planting measures to aid plant establishment, planting procedures, establishment activities, and how to assess whether plants are successfully established.
- *Managing sediment* – contains a discussion of the challenges associated with the creation of a development site, in particular, managing sediment-laden runoff from the catchment during the building phase.
- *Staged construction and establishment methods* – explains how to integrate biofilter construction with other catchment works and outlines a number of staged construction and establishment methods that accommodate a range of scenarios. It is noted these alternative construction sequences offer varying benefits in terms of cost, environmental protection, contract administration, establishment timeframes and visual amenity. *Step-by-step sequence* field sheets for each staged construction and establishment method are also provided for the purposes of being laminated and used on construction sites.
- *Potential failure* scenarios and required actions for *rectification* (note that there is some overlap between this section and Section 4.3 of these Adoption Guidelines).
- *Certification and compliance* – there is often confusion about the responsibility for certification and asset handover because biofilters involve both civil and landscape works. This section provides guidance on who is responsible for certification, the required supporting documentation (including Construction and Establishment Sign-Off Forms), and when to schedule hold points in construction and compliance inspections.
- *Civil and landscape contracts* – gives advice on the content of contracts to ensure all parties are aware of construction responsibilities and certification requirements, as well as clarification of ownership and maintenance responsibilities during both the handover from civil contractor to landscape contractor and the building phase.
- *Sign-off forms* – these define the key items for delivering and inspecting biofiltration systems and form the basis of the certification and compliance requirements. They are intended to be used by contractors, construction site superintendents, designers and local authority compliance inspectors to ensure that biofiltration systems are constructed as designed.

4.3 MAINTENANCE REQUIREMENTS

Vegetation plays a key role in maintaining the porosity of the filter media of a biofiltration system and a strong healthy growth of vegetation is critical to its treatment performance. The most intensive period of maintenance is during the plant establishment period (i.e., the first two years), when weed removal and replanting may be required.

Inflow systems and overflow pits require careful monitoring, as these can be prone to scour and litter build up. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly, and debris should be removed whenever it is observed on a site. Where sediment forebays or other pre-treatment measures are adopted, regular inspection of the pre-treatment system is required (three monthly) with removal of accumulated sediment undertaken as required (typically once per year).

For larger biofiltration systems, a maintenance access track for maintenance vehicles (eg. 4WD ute) should be provided to the sediment forebay for maintenance efficiency and ease.

In addition to the vegetation establishment activities described in Water by Design's Construction and Establishment Guidelines (see Section 4.2), typical maintenance of biofiltration system elements will involve:

- Routine inspection of the biofiltration system profile to identify any areas of obvious increased sediment deposition, scouring from storm flows, rill erosion of the batters from lateral inflows, damage to the profile from vehicles and clogging of the biofiltration system (evident by a 'boggy' filter media surface);
- Routine inspection of inflows systems, overflow pits and underdrains to identify and clean any areas of scour, litter build up and blockages;
- Removal of sediment where it is smothering the biofiltration system vegetation;
- Where a sediment forebay or other pre-treatment measure is adopted, removal of accumulated sediment and debris;
- Repairing any damage to the profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match on-site soils) and revegetating;
- Regular watering/irrigation of vegetation until plants are established and actively growing;
- Removal and management of invasive weeds (manual weed removal is preferable to herbicide use, as discussed below);
- Removal of plants that have died and replacement with plants of equivalent size and species, as detailed in the plant schedule – Note: it may also be worth considering occasionally harvesting plants to open the canopy and promote groundcover growth;
- Pruning to remove dead or diseased vegetation material and to stimulate growth; and
- Vegetation pest monitoring and control.

The following additional maintenance tasks are required if a submerged zone is included in the design:

- Check that the weir/up-turned pipe is clear of debris; and
- Check that the water level in the submerged zone is at the design level (note that drawdown during extended dry periods is expected).

A more detailed description of maintenance tasks and recommended frequences is given in Table 4.

Resetting (i.e., complete reconstruction) of the biofiltration system will be required if the system fails to drain adequately or if it is determined that the filter media has reached it maximum pollutant retention capacity (the lifespan of filter media is expected to be in the order of 10 − 15 years). Maintenance should only occur after a reasonably rain free period, when the filter media in the biofiltration system is dry. Inspections are also recommended following large storm events to check for scour and other damage.

All maintenance activities must be specified in an approved Maintenance Plan (and associated maintenance inspection forms) to be documented and submitted to council as part of the Development Approval process (see Appendix D for an example maintenance plan). Maintenance personnel and asset managers will use this Plan to ensure the biofiltration systems continue to function as designed. An example operation and maintenance inspection form is included in the checking tools provided in Section 4.5. This form must be developed on a site-specific basis as the nature and configuration of biofiltration systems varies significantly. A maintenace requirements summary is provided in Appendix H; this summary could be laminated for on-site reference.

MAINTENANCE TIPS

- Delineate biofilter to define areas where maintenance is required
- Include a description and sketch of how the system works in the Maintenance Plan
- Identify maintenance jurisdictions
- Coordinate site inspection and maintenance activities with maintenance of surrounding landscapes (eg. parks, nature strips)
- If pressure jets are used to clear underdrains, care should used in perforated pipes to avoid damage

Table 4. Maintenance tasks and recommended frequencies.

Filter Media Tasks	
Sediment deposition	Remove sediment build up from forebays and other pre-treatment measures in biofiltration systems and from the surface of biofiltration street trees. **Frequency - 3 MONTHLY, AFTER RAIN**
Holes or scour	Infill any holes in the filter media. Check for erosion or scour and repair. Provide energy dissipation (eg. rocks and pebbles at inlet) if necessary. **Frequency - 3 MONTHLY, AFTER RAIN**
Filter media surface porosity	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. A symptom may be that water remains ponded in the biofiltration system for more than a few hours after a rain event. Repair minor accumulations by raking away any mulch on the surface and scarifying the surface of the filter media between plants. For biofiltration 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**
Litter control	Check for litter (including organic litter) in and around treatment areas. Remove both organic and anthropogenic litter to ensure flow paths and infiltration through the filter media are not hindered. **Frequency - 3 MONTHLY OR AS DESIRED FOR AESTHETICS**
Horticultural Tasks	
Pests and diseases	Assess plants for disease, pest infection, stunted growth or senescent plants. Treat or replace as necessary. Reduced plant density reduces pollutant removal and infiltration performance. **Frequency - 3 MONTHLY OR AS DESIRED FOR AESTHETICS**
Maintain original plant densities	Infill planting – between 6 and 10 plants per square metre should be adequate (depending on species) to maintain a density where the plants' roots touch each other. Planting should be evenly spaced to help prevent scouring due to a concentration of flow. **Frequency - 3 MONTHLY OR AS DESIRED FOR AESTHETICS**
Weeds	It is important to identify the presence of any rapidly spreading weeds as they occur. The presence of such weeds can reduce dominant species distributions and diminish aesthetics. Weed species can also compromise the systems long-term performance. Inspect for and manually remove weed species. Application of herbicide should be limited to a wand or restrictive spot spraying due to the fact that raingardens and biofiltration tree pits are directly connected to the stormwater system. **Frequency - 3 MONTHLY OR AS DESIRED FOR AESTHETICS**

Table 4 cont...

Drainage Tasks	
Underdrain	Ensure that underdrain pipes are not blocked to prevent filter media and plants from becoming waterlogged. If a submerged zone is included, check that the water level is at the design level, noting that drawdown during dry periods is expected. 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**
High flow inlet pits, overflow pits 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**
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 design capacity (eg. unusually high sediment loads may require installation of a sediment forebay). **Frequency – TWICE A YEAR AFTER RAIN**

IMPORTANT!

- Weeds pose a serious problem – in addition to diminishing the appearance of a biofiltration system, they compete with the intended plant community, potentially reducing the treatment capacity. Further, some weeds are “nitrogen fixers” and add nitrogen to the system. Therefore, weed removal is essential to ensure optimal performance.
- It is illegal to use some herbicides in aquatic situations. Given that treated water from biofiltration systems generally discharges directly to drainage and receiving waters, the potential for herbicide contamination of waterways must be considered. For guidance on using herbicides for weed control, please consult the following Cooperative Research Centre for Australian Weed Management guidelines:

  Herbicides: knowing when and how to use them

  http://www.weedscrc.org.au/documents/gl02_herbicide_use.pdf

  Herbicides: guidelines for use in and around water

  http://www.weedscrc.org.au/documents/gl01_herbicides_water.pdf

4.4 PERFORMANCE ASSESSMENT

This section discusses the need to monitor, how to match monitoring activities to management objectives, and the types of monitoring activities that could be carried out, including the frequency and level of expertise required for each activity. There are two main types of monitoring: qualitative and quantitative. There are several levels of quantitative monitoring; each of these is discussed and guidance on when these should be implemented is given.

The Institute for Sustainable Water Resources (ISWR) is currently preparing a Stormwater Monitoring Protocol that provides detailed guidance on designing, implementing and operating a monitoring program. This document is due to be completed in the second half of 2009. The following section draws on (but significantly abbreviates) this protocol, which should be referred to for further information.

4.4.1 Why monitor?

There are several reasons why monitoring of biofiltration systems might be desirable, including:

- To demonstrate compliance with legislative requirements (eg. load reduction targets);
- To assess overall and/or long-term performance (eg. large scale stormwater quality improvement);
- To collect data for model development; and
- To understand detailed processes.

Qualitative and preliminary quantitative assessment should always be carried out but detailed monitoring is not required if biofilters are designed according to FAWB guidelines, because this design guidance is based on rigorous testing. However, ***deviations from the recommended design*** (eg. alternative filter media, plant species, sizing) and biofilters that are used for stormwater harvesting ***should be carefully monitored***.

4.4.2 Setting monitoring program objectives

Performance monitoring can quickly become resource intensive, therefore it is crucial that monitoring objectives are clearly developed in order to best use the available resources. In general, the aim of a monitoring program will be to assess whether the system meets the management objectives, however there may sometimes be additional aims, such as model development or validation, which are more data intensive. An idea of the available budget is also necessary for developing realistic monitoring objectives.

> **IMPORTANT!**
>
> Biofilters require an establishment period of approximately two years to allow the filter media to settle and the vegetation to reach its design conditions. This ***must*** be taken into account when designing a monitoring program. For example, while the colour and clarity of outflows from a biofilter during the initial operating period should be monitored (to assess whether fines and leaching of organic matter might be problematic), detailed water quality monitoring during this period would not provide an assessment of the system's optimal treatment performance.

Once the objectives of the monitoring program have been agreed on, the type and quality of information required in order to achieve these aims can be determined, that is, the variables to be monitored, the level of uncertainty (accuracy) required and the temporal and spatial scale of the data. Guidance for selecting appropriate parameters for different objectives is given in Table 5.

Table 5. Monitoring objectives and parameters.

Objective	What to monitor
Pollution control	Concentrations in and out (important for lotic receiving waters) – nutrients, metals Inflows and outflows – use in conjunction with concentration for determination of loads (important for lentic receiving waters)
Flow management	Inflows and outflows – for determination of: • Runoff frequency reduction • Peak flow reduction • Reduction in runoff volume
Stormwater harvesting	Peak pollutant concentrations in the treated water (outflows) – metals, pathogens

4.4.3 Develop the monitoring program

The following types of information should be collected, where available:

- Catchment characteristics – catchment area, slope, nature and extent of imperviousness, geological charcteristics, land-use;
- Biofiltration system characteristics – layout (size, slope, elevation), design capacity, materials (filter media, vegetation, liner, submerged zone, underdrain), age and condition, maintenance practices (frequency, cost, etc.); and
- Climate – rainfall, temperature, evapotranspiration.

MONITORING TIP

- Development of a database of local biofilters that collates information on their catchments, design, maintenance logs and performance assessments would provide an invaluable source of information for design and operation of future systems.

As mentioned previously, there are two levels of monitoring:

- Qualitative – this should be carried out for ***every*** system; and
- Quantitative – of which there are three sub-levels:
  - Preliminary – this should be carried out for ***every*** system;
  - Intermediate – appropriate for assessing new design configurations where the available budget does not allow for detailed monitoring; and
  - Detailed – appropriate for assessing new design configurations, and for model development.

Each of these levels of monitoring is described in the following sections.

4.4.4 Qualitative monitoring

Qualitative monitoring largely consists of visual assessment and is largely carried out during routine maintenance. Elements that should be monitored, the problems they indicate and suggested management actions are summarised in Table 6.

IMPORTANT!

- Qualitative monitoring should ***always be carried out*** and ***thoroughly documented***; this can be done in conjunction with routine maintenance tasks. Photographs are invaluable accompaniments to written documentation.

4.4.5 Quantitative monitoring

There are three levels of quantitative monitoring: preliminary, intermediate and detailed. The amount of effort, expense and expertise required increases with each level of monitoring. In general, preliminary quantitative monitoring will be adequate for assessing the performance of biofilters that are designed according to these guidelines, however detailed assessment of different designs and biofilters used for stormwater harvesting should be undertaken. Intermediate assessment, through simulated rain events, offers a lower-cost alternative to detailed assessment, although there is a compromise on the amount of information gained.

Table 6. Qualitative monitoring tasks.

Parameter	Indicator of	Possible Cause	Possible Management Action(s)
Plant health	Too much water	System undersized	Replace filter media with that of a higher infiltration capacity
		Poor infiltration capacity (water logging)	As above
	Too little water	System oversized (eg. plants further from inlet are drier)	Consider installing a choke on outlet OR Replant with dry tolerant plants
		Inlet levels wrong (system is bypassing too early)	Reset inlet levels
	Poor flow control	Excessive inflow velocities (at inlet)	• Install/augment energy dissipation device • Relocate inlet
		Inadequate provision for bypass of high flows (damage throughout system)	• Install/augment energy dissipation device • Reconfigure inlet to prevent high flows entering system • Relocate inlet
Erosion	Poor flow control	Excessive inflow velocities	• Install/augment energy dissipation device • Relocate inlet
		Inadequate provision for bypass of high flows (damage throughout system)	Reconfigure inlet to prevent high flows entering system
Build-up of sediment on filter surface	Clogging	Excessive loads of sediment	• Install pre-treatment device (see Chapter 3 for ideas) • Scarify the filter surface between plants and/or densely vegetate to break up the clogging layer
		System undersized	
		Inadequate pre-treatment	

4.4.5.1 Preliminary monitoring

Preliminary quantitative assessment does not require specialised knowledge in order to be performed correctly. There are two aspects to preliminary assessment of biofilter performance:

- Monitoring of the hydraulic conductivity of the filter media; and
- Long-term accumulation of toxicants.

<u>Hydraulic conductivity</u>
The hydraulic conductivity of filter media should be monitored *in situ* using the method described in Practice Note 1: *In situ* measurement of hydraulic conductivity (Appendix E). The recommended monitoring frequency is as follows:

- One month after the system comes on-line;
- At the start of the second year of operation;
- Every two years from Year 2 onwards, unless visual assessment indicates that the infiltration capacity might be declining i.e., there is a visible clogging layer, signs of waterlogging, etc.

<u>Accumulation of heavy metals</u>
A FAWB field study of more than 18 biofilters showed that, for appropriately sized systems with typical stormwater pollutant concentrations, heavy metal levels are unlikely to accumulate to a level of concern, as compared to the National Environment Protection Council's health and ecological guidelines (NEPC, 1999) for 10 – 15 years.

Filter media samples should be collected and analysed for heavy metals during Year 5 of operation. For biofiltration systems with a surface area less than 50 m^2, the filter media should be sampled at three points that are spatially distributed (one should be located near the inlet). For systems with a surface area greater than 50 m^2, an extra monitoring point should be added for every additional 100 m^2. At each monitoring point, a sample should be collected at the surface and another at a depth of 10 cm to assess whether heavy metals are migrating through the filter media. In order to minimise the potential for sample contamination and achieve accurate results, soil samples should be collected according to standard protocol in appropriately prepared containers (see AS 1289.1.2.1 – 1998 and Box 1) and analysed by a NATA-accredited laboratory for at least copper, cadmium, lead and zinc, as well as any other metals that are deemed to be of potential concern. Consult with the analytical laboratory as to the amount of soil required to carry out the analyses.

See Section 4.4.6 for guidance on interpreting test results.

4.4.5.2 Intermediate monitoring

Intermediate quantitative assessment of biofilters involves simulating a rain event using semi-synthetic stormwater. This should be carried out using the methods described in Practice Note 2: Preparation of semi-synthetic stormwater (Appendix F) and Practice Note 3: Performance assessment of biofiltration systems using simulated rain events (Appendix G). The number of simulations that should be undertaken is flexible however more simulations give greater insights into the performance of the biofiltration system. Simulations in different seasons and after different lengths of preceding dry periods should also be considered.

Box 1. Quality control considerations.

Soil

- Sampling – bottles (cleanliness, appropriate material), sampling equipment (cleanliness, appropriate method), storage and preservation, labelling and identification of samples
- QC samples – bottle blanks, field blanks, replicates, spikes
- Analysis – NATA-accredited laboratory, close to sampling location, experienced in analysis, timely in reporting

Water Quality

- Sampling – bottles (cleanliness, appropriate material), sampling equipment (cleanliness, appropriate method), storage and preservation, labelling and identification of samples
- Field instruments – condition, calibration
- QC samples – bottle blanks, field blanks, replicates, spikes
- Analysis – NATA-accredited laboratory, close to sampling location, experienced in analysis, timely in reporting

Water Quantity

- Instruments – condition, calibration

Quality Assurance

- Sampling – careful documentation of time of collection, sampling person, location, storage temperature; identify each sample with a unique number
- Document training of staff, QC checks, equipment calibration and maintenance, sample storage and transport

In order to minimise the potential for sample contamination and achieve accurate results, water quality samples should be collected according to standard protocol in appropriately prepared bottles (see AS/NZS 5667:1 1998 and Box 1) and analysed by a NATA-accredited analytical laboratory. The pollutants that should be monitored will be determined by the system objectives and the type of receiving water. In general, the following parameters should be measured as a minimum:

- Total suspended solids (TSS);
- Total nitrogen (TN);
- Total phosphorus (TP); and
- Heavy metals – copper, cadmium, lead and zinc.

Physical parameters such as pH, electrical conductivity (EC, as a measure of salinity), temperature, and dissolved oxygen (DO) are relatively cheap and easy to measure using a field probe and could also be considered. The following water quality parameters might also be required:

- Nutrient species – ammonium (NH_4^+), oxidised nitrogen (NO_x), organic nitrogen (ON), and orthophosphate (PO_4^{3-}, commonly referred to as dissolved reactive phosphorus, FRP); and
- Other metals – aluminium, chromium, iron, manganese, and nickel.

Consult with the analytical laboratory as to the sample volume required to carry out the analyses.

See Section 4.4.6 for guidance on interpreting test results.

4.4.5.3 Detailed monitoring

Detailed quantitative assessment involves continuous flow monitoring (of inflows and outflows) and either continous or discrete water quality monitoring (depending on the water quality parameter). This type of monitoring is the most resource intensive and requires a substantial level of expertise, however it is ***strongly recommended*** that this be undertaken for biofilters whose design deviates from FAWB (i.e., tested) recommendations or where biofilters are used to treat stormwater for harvesting purposes.

This type of monitoring would need to be implemented and managed by an organisation with the capacity to undertake such a program. Further, the installation, calibration and maintenance of instrumentation requires a high level of expertise and should be undertaken by an organisation experienced in this type of activity.

The following are suggested approaches to this type of monitoring:

- Flow
  - Appropriate infrastructure for flow measurement includes weirs, flumes, and pipes in combination with water level or area/velocity meters.
- Water quality (see Section 4.4.5.2 for guidance on selection of water quality parameters)
  - Continuous – sensors; and
  - Collection of discrete samples – this is usually undertaken by automatic samplers during rain events, but occasional grab samples should also be collected in baseflow, as well as during rain events to verify samples collected by automatic samplers. The ***entire hydrograph should be sampled***, regardless of whether each sample is analysed or all samples are combined to assess the Event Mean Concentration.

Selection of monitoring equipment should be done in consultation with experienced operators, who should also be responsible for installing and maintaining the equipment. The following considerations should be made during the selection process:

- Environmental parameters need to be within the operational range for certain variables;
- Easy of calibration of instrumentation; and
- Instrumentation should not interfere with the hydraulic operation of the system (eg. it should not create backwatering problems) and must be able to cope with the full range of hydraulic conditions.

For guidance on selection of appropriate water quality parameters, see Section 4.4.5.1 (Treatment Performance).

See Section 4.4.6 for guidance on interpreting test results.

4.4.6 Data analysis and interpretation

It is very easy for data to be defective, therefore it is essential that data is checked for errors prior to evaluating results. Possible problems include noise, missing values, outliers.

4.4.6.1 Benchmarks for performance assessment

A number of state, territories, regions and municipalities stipulate performance targets for WSUD, which often include biofiltration systems (eg. Clause 56.07 of the Victoria Planning Provisions prescribes target pollutant load reductions of 80, 45, and 45% for TSS, TN, and TP, respectively). Where these exist, monitoring data should be compared against these targets. However, in the absence of mandated performance targets, the primary performance objective should be to ***maintain or restore runoff volumes to pre-development levels***, provided the standard of design for a biofiltration system is in accordance with Chapter 3 (*Technical Considerations*) of these guidelines. More specific guidance on soil and water quality benchmarks is given below.

Accumulation of heavy metals
Test results should be compared to both the raw filter media and the National Environment Protection Council's Guideline on the Investigation Levels for Soil and Groundwater; see Health (HIL) and Ecological Investigation Levels (EIL) in Table 5-A. The appropriate guideline will be determined by the location of the biofilter. The required frequency of further assessment should be based on the results of this first assessment: if the concentration of one or more of the measured heavy metals is half-way to either the HIL or EIL, then heavy metals should be monitored at two-year intervals; if all measured concentrations are well below this, levels should continue to be checked at five-year intervals.

Note: Accumulated heavy metals will be concentrated at the surface of the filter media. Therefore, when heavy metals accumulate to levels of concern, this should be managed by scraping off and replacing the top 100 mm of filter media.

Water quality
In the absence of stipulated performance targets, outflow pollutant concentrations could be compared to the ANZECC Guidelines for Fresh and Marine Water Quality. These guidelines provide water quality targets for protection of aquatic ecosystems; the targets to use should be selected according to the location of the biofilter and the state of the receiving water (eg. slightly disturbed, etc.). However, the reality is that, even using the best available technology, biofiltration systems will not necessarily always be able to comply with these relatively strict guidelines. The local authority may in this instance choose to rely on the national Load Reduction Targets provided in Chapter 7 of Australian Runoff Quality (Wong, 2006).

4.5 CHECKING TOOLS

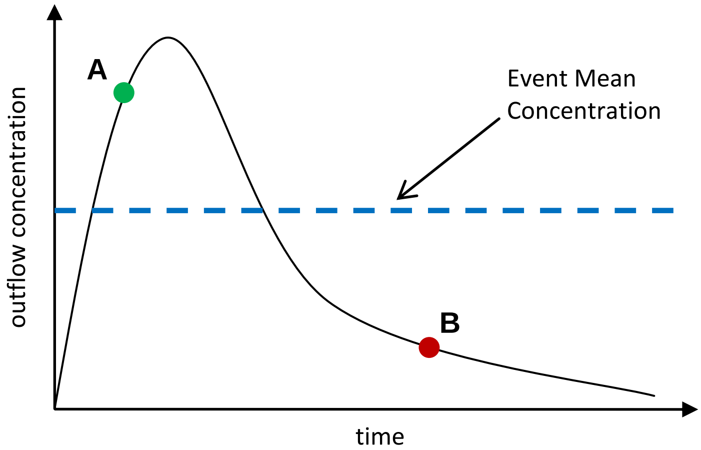
This section provides a number of checking aids for designers and local government development assessment officers. The following checking tools are provided:

- Operation and Maintenance Inspection Form; and
- Asset Transfer Checklist (following 'on-maintenance' period).

Construction and Establishment Sign-Off forms are included in Water by Design's Construction and Establishment Guidelines (see Section 4.2 for further details).

IMPORTANT!

- Water quality results obtained by collecting the occasional grab can only be used as a general indicator of treatment performance. Outflow concentrations of some pollutants have been shown to vary with flow rate or time, therefore collecting only one water quality sample during a rain event will not necessarily give a true measurement of the average outflow concentration for that event (Event Mean Concentration, EMC). An example of how the outflow concentration of a pollutant might vary with time is shown below, and the EMC is indicated by the dashed line. If a grab sample was collected at point A, where the pollutant concentration is higher than the EMC, this would under-estimate the treatment performance of the biofilter. On the other hand, a grab sample collected at point B would over-estimate the treatment performance of the biofilter. While neither of these sampling points give an accurate assessment of the treatment performance, they do provide a useful rough indication of the pollutant removal capacity.



4.5.1 Operation and Maintenance Inspection Form

The example form provided in Section 4.5.3 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 and complexity of the system. 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.

4.5.2 Asset Transfer Checklist

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. The proposed owner should be responsible for performing the asset transfer checklist. For details on asset transfer specific to each council, contact the relevant local authority to obtain their specific requirements for asset transfer. The table in Section 4.5.4 provides an indicative asset transfer checklist.

4.5.3 Biofiltration System Maintenance Inspection Checklist

BIOFILTRATION SYSTEM MAINTENANCE CHECKLIST				
Inspection frequency:	1 – 6 monthly	**Date of visit:**		
Location:				
Description:				
Asset ID:				
Site visit by:				

INSPECTION ITEMS	**Y**	**N**	**Action required (details)**
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.)?			
Watering 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?			
Resetting of system required?			
Weir/up-turn pipe is clear of debris (if applicable)?			
Water level in submerged zone as designed (if applicable)?			

COMMENTS

4.5.4 Biofiltration System 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		
Maintenace plans and indicative maintenance costs provided for each asset?	Y	N
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?		

4.6 REFERENCES

ANZECC and ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1, The Guidelines (Chapters 1-7). Available at: http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality

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