Appendix G: Detailed scientific monitoring

CRC for Water Sensitive Cities

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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 (NH4+), oxidised nitrogen (NOx), organic nitrogen (ON), and orthophosphate (PO43-, 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 4.4.7 for guidance on interpreting test results.

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 4.4.6.2 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.

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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 4.4.6.1 (Treatment Performance).

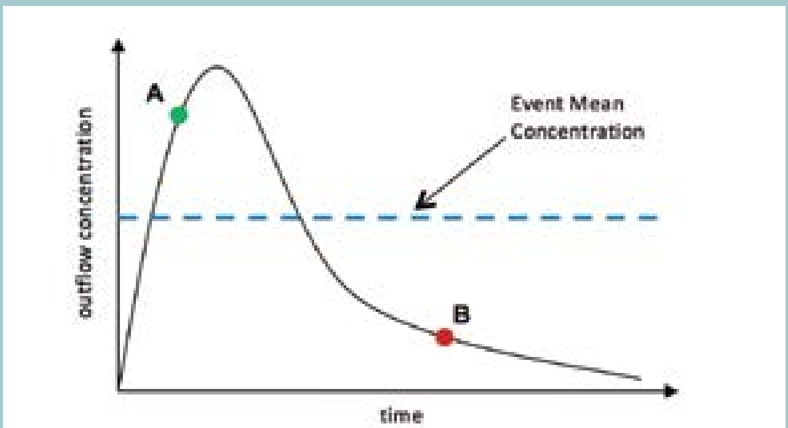
See Section 4.4.7 for guidance on interpreting test results.

Validation of biofilter performance under challenging conditions

The validation of biofilter performance is critical to the widespread adoption of the technology. Evidence of stormwater biofilter efficiency is provided in the many laboratory and field studies conducted (see chapter References and Appendix B Publications list). However, some studies have sought further confirmation of performance by testing biofilters under challenging operating conditions. This validation is particularly important for stormwater harvesting applications, when water re-use for a given purpose needs to ensure water quality targets are consistently met. Validation testing is commonly undertaken for traditional and highly engineered water treatment facilities (e.g. for drinking water or water recycling purposes). However, the adaptation of a validation framework developed for pathogen removal from wastewater (for non-potable reuse), to micropollutant removal by stormwater biofilters was undertaken by Zhang et al. (2013, 2014). The methodology and outcomes of challenge tests, as detailed by Zhang et al. (2014), has been summarised below:

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.



Three steps are involved: i.) the identification of target pollutants, challenge conditions and performance objectives in the pre-validation phase, ii.) validation monitoring testing, conducted under defined environmental conditions, and iii.) ongoing monitoring of the system in operation to confirm long-term performance. Zhang et al. (2014) investigated the removal of total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), glyphosate, triazines, phthalates, trihalomethanes and phenols. The study aimed to quantify hydraulic performance, micropollutant removal and the hypothetical potential for re-use of the water in a drinking water treatment scheme, all under challenging operational conditions.

Test site: The experiment was conducted on a well-monitored field system treating stormwater runoff from a car park at Monash University, Melbourne. The system contains separate cells with differing characteristics, and for this study two cells were used: 1.) a free-draining cell with media with relatively high nutrient and organic content, and 2.) a sandy low nutrient media and a submerged zone; both of which were vegetated.

Pre-validation preparation: Before the challenge tests were conducted it was necessary to characterise i. target concentrations of micropollutants in the inflows, ii. their removal dynamics and iii. hydraulic conditions within the system. These define the 'boundaries' for acceptance of the validation and the following information was gathered:

i. A literature review was conducted to gather data on micropolluta nt concentrations (using event mean concentrations (EMC) where possible and gathering at least 15 EMC values) and the 95th percentile concentrations were selected as the challenge concentrations. In some cases, these values already lay below the Australian Drinking Water Guidelines (ADWG), so to add further certainty stormwater inflows with micropollutant concentrations approximately twice the ADWG limits were tested; conditions which may eventuate from a spill or other extreme conditions.

ii. Knowledge of micropollutant removal in similar vegetated systems was reviewed (given the lack of information specific to stormwater biofilters) e.g. constructed wetlands. Adsorption and biodegradation were found to be the most likely removal processes. The review also suggested micropollutant removal is likely to be sensitive to the infiltration rate, the length of drying between inflow events, hydraulic loading (i.e. volume of water treated per event) and temperature. These formed the key operational variables.

iii. An understanding of the operational conditions of stormwater biofilters, as noted in the literature.

Next, a MUSIC model was used to determine challenging conditions for the identified operational variables i.e. the duration of dry weather, storm inflow volume in wet weather and the frequency of wet weather events (based on local climate).

Two wet weather challenge scenarios were selected and characterised using the MUSIC model:

i. The volume of a single wet weather event – the 95th percentile cumulative volume for a single event was adopted (and this was equivalent to 4 pore volumes – i.e. water holding capacity within the biofilter)

ii. The volume of two consecutive events, occurring within 12 hours of each other – the 95th percentile of two such events was adopted (equivalent to 3 pore volumes).

Challenge tests: In total six challenge tests were undertaken in two series of experiments; with three undertaken in winter and three in summer. Semi-synthetic stormwater was used for the tests (see Appendix X). Inflow and outflow samples were collected across the inflow and outflow hydrographs. The results allowed calculation of a water balance for each series of challenge tests.

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.

References

Zhang, K., Randelovic, A., Page, D., McCarthy, D. T. & Deletic, A. 2014. The validation of stormwater biofilters for micropollutant removal using in situ challenge tests. *Ecological Engineering,* 67, 1-10.

Zhang, K. F., Filip, S., Chandrasena, G. I., McCarthy, D. T., Daly, E., Pham, T., Kolotelo, P. & Deletic, A. 2012. Micro-pollutant removal in stormwater biofilters: a preliminary understanding from 3 challenge tests. *7th International Conference on Water Sensitive Urban Design*. Melbourne.

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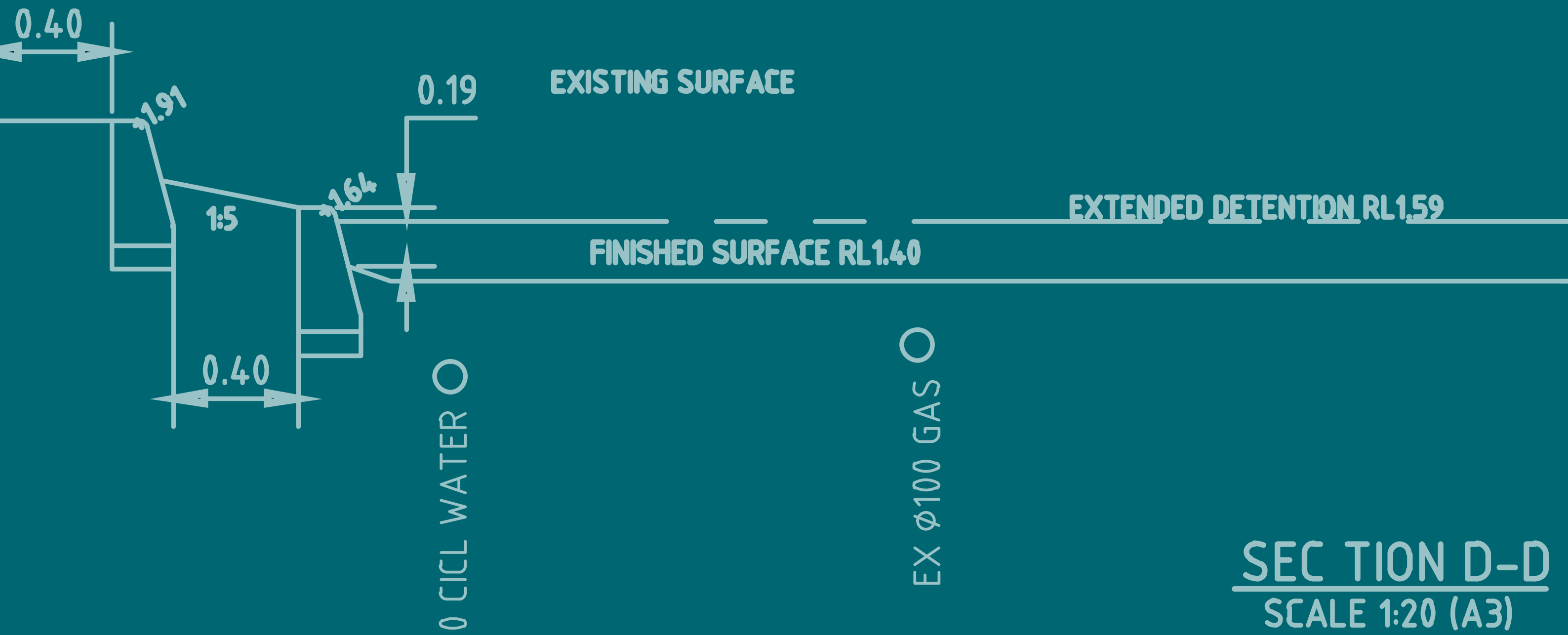

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