spelstormwater

Technical Design Guidelines

Spel Basin®

Modular stormwater storage

SQIDEP VERIFIED

STORMWATER QUALITY IMPROVEMENT DEVICE EVALUATION PROTOCOL

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1 Introduction

1.1 Biofiltration

Biofiltration systems are one type of WSUD system that have been implemented in urban areas to manage stormwater by reducing peak flows and downstream pollution (Davis & Birch, 2009; Hunt et al., 2008; Le Coustumer et al., 2012). Biofiltration is also referred to as bioretention, biofilters and rain gardens in various literature. This report will use the terms interchangeably. Biofiltration systems have been popular because of flexibility in their design which assists with simple integration (retrofitting) into existing urban areas (Bratieres et al., 2008), as well as new developments. Biofiltration systems are also considered to add to the benefits of traditional stormwater quality by including aesthetic and social benefits (Mullaney et al., 2015).

Biofiltration relies on physical, chemical and biological processes that occur in the various zones including the extended detention depth, filter media and drainage layers as indicated in Figure 1. Design modifications can include a submerged zone beneath the drainage layer to retain water for enhanced plant survival during dry weather and denitrification. Stormwater is treated as it filters through the vegetated media, utilising plant uptake, microbial processing, adsorption and physical filtration to reduce pollutant loads.

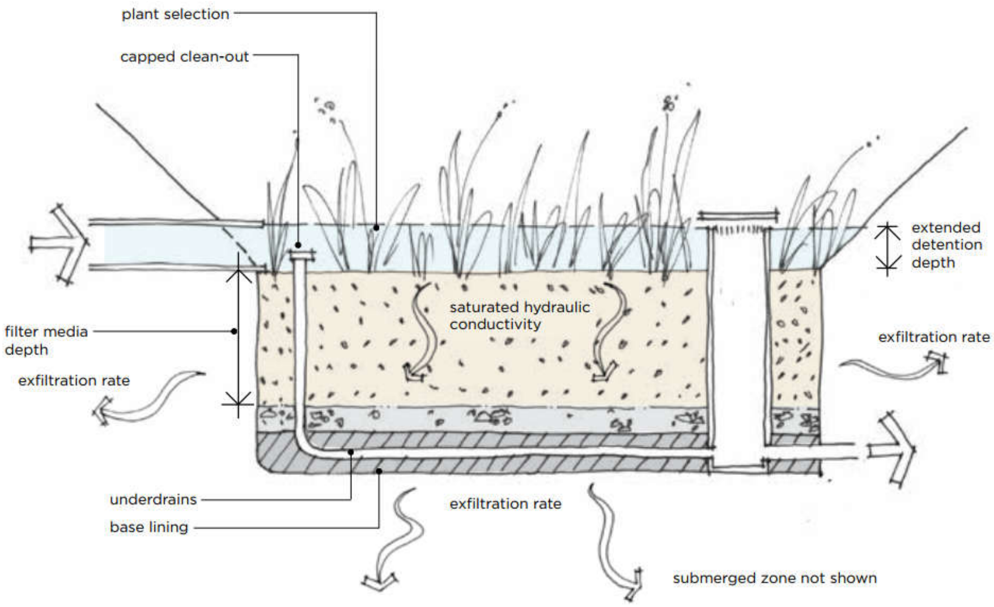


Figure 1. Schematic cross-section of a biofiltration system (Source: Water by Design, 2018)

To ensure effective functioning of the biofiltration system, standard specifications of the soil media have been developed (FAWB, 2009). These specifications require traditional biofiltration systems to implement three layers of media, as indicated in Figure 2. These three layers then have a detailed specification that describes the particle size distribution, nutrient content and desired permeability to achieve the stormwater treatment goals.

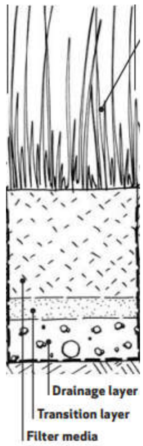


FIGURE 2. BIOFILTRATION MEDIA LAYERS SECTION (SOURCE: WATER BY DESIGN, 2014)

1.2 SPELBasin® Modular Biofiltration

The SPELBasin® modular biofiltration system has a number of similar design features to a traditional biofilter, however, differs in two key areas;

- the use of a proprietary media blend; and
- horizontal flow instead of top-down flow;

The treatment process provided by the SPELBasin® commences with runoff entering via a kerb inlet (1), grated inlet or pipe network, and passing through a coarse sediment screen in the pre-treatment chamber (2). Flow then enters the biofiltration chamber via a pipe located at the base of the structure, and is distributed throughout the filter media through a HDPE geo-grid fitted to the perimeter walls (3). Stormwater filters through the proprietary media blend horizontally and into the centrally-located, slotted collection pipes (4) that discharge to the outlet chamber (5). Flow finally enters the underground stormwater drainage system through a discharge pipe (6) that is controlled by an offset outlet from the base to create a permanently submerged zone. These are shown in Figure 3.

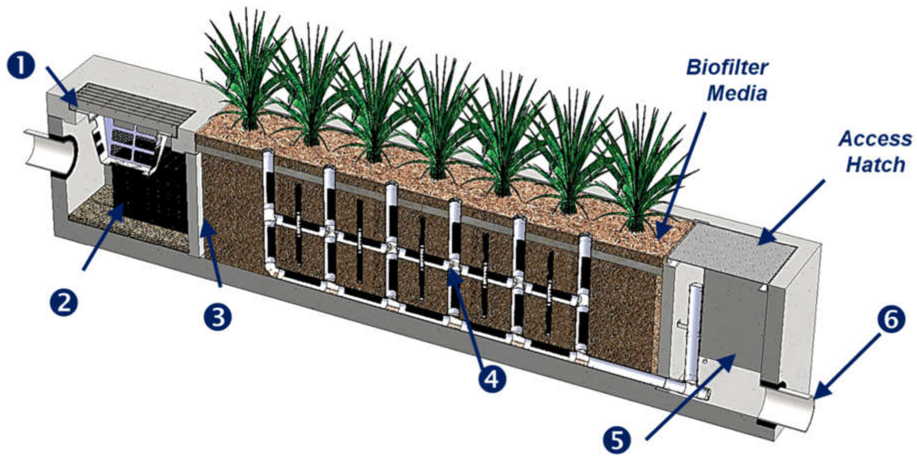


FIGURE 3. SPELBASIN® SCHEMATIC

1.3 Design Drawings/Dimensions

A standard drawing of the SPELBasin® is shown in Figure 4. The SPEL basin has an overall length, width and height of 6120 x 1340 x 1300 mm respectively. The system allows for stormwater runoff to enter via a kerb inlet, a grated inlet or underground pipe. The kerb-type inlet and grated inlet are fitted with a 600 x 600 mm SPEL StormSack which filters gross pollutants from stormwater inflow. Pre-filter cartridges are situated within the pre-treatment chamber to further remove coarse sediment from stormwater that bypasses the StormSack. Flow is horizontally dispersed through a 7.3 m3 biofiltration system with a proprietary biofiltration media blend which drains treated stormwater into the 1.56 m3 discharge chamber. Treated water is discharged through outlet pits and to street drainage.

2 SPELBasin® Applicability Guide

As a modular biofiltration system, there are some considerations that should be incorporated into the design process. These are indicated in Table 1 below.

Table 1. Applicability Guide for SPELBasin®

Design Consideration	Applicability	Information
At source stormwater treatment	✓	SPELBasin® systems are ideal for capturing runoff as it leaves a road, carpark and/or catchment surface.
Litter, sediment & nutrient capture	✓	Biofilters utilise physical, biochemical and biological processes to remove particulates and dissolved pollutants from stormwater.
Urban/civic landscaping	✓	The modular configuration allows landscaping to be incorporated into roadscapes and traditionally hard cityscapes.
Constrained sites	✓	SPELBasin® systems can be as small as 0.6% of the contributing catchment, and lifted into difficult to access locations.
Moderate to steep gradient sites	✓	The fibreglass and precast concrete chambers promote unique alternatives to retaining walls and features in steep sites.
Sites with <600mm gradient	✓	Designs can accommodate internal invert level increases to achieve discharge on very flat sites, provided a free surface can be achieved.
Tidal influence	×	SPELBasin® is not suitable for locations that are subject to tidal influence.
Tailwater	?	Tailwater can affect the treatment flow rate through the SPELBasin®, and should be avoided if possible. Check with SPEL Stormwater.
High velocity flowpaths	×	As a filtration and biological treatment system, high velocity flowpaths may cause damage to the SPELBasin®. An external bypass is recommended.
Greywater treatment	✓	SPELBasin® systems have been observed to remove nutrients and suspended solids from stormwater. They could equally remove nutrients from greywater.

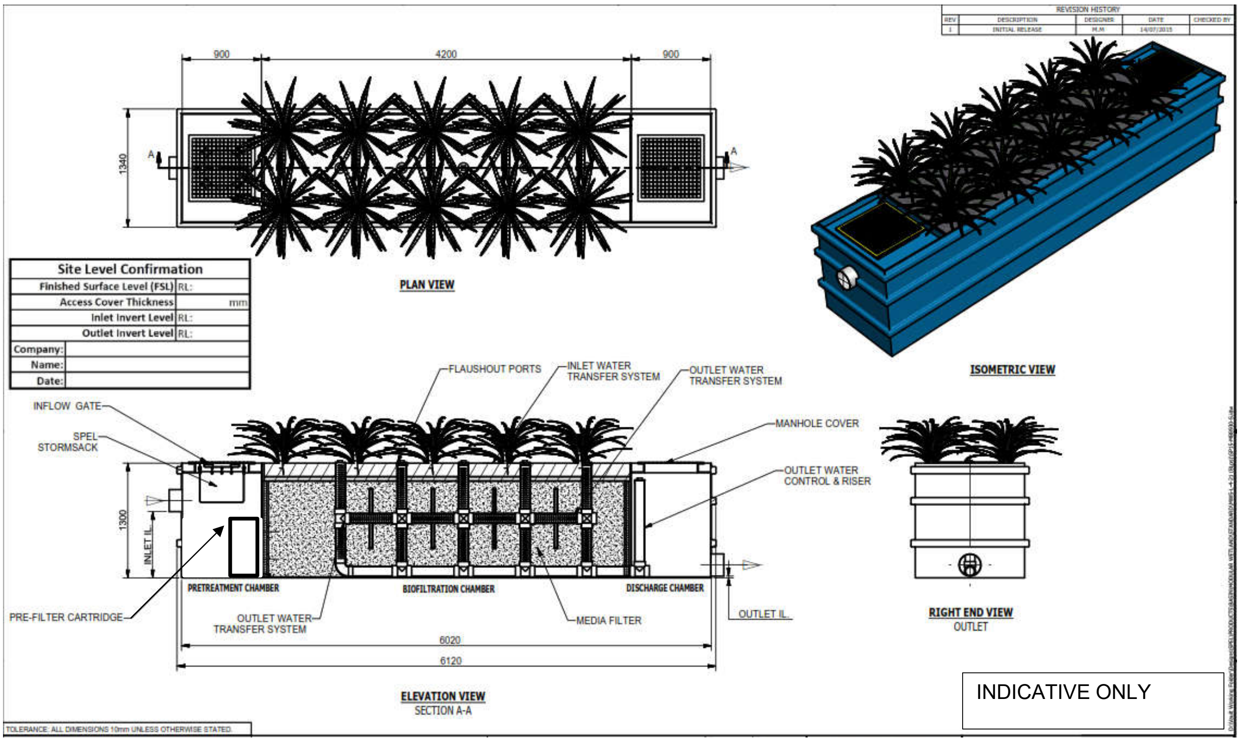


Figure 4. SPELBasin® Standard Drawing

3 SPELBasin® Functions

Similar to traditional biofiltration, the SPELBasin® improves water quality through several functional pathways.

3.1 Hydrology

The SPELBasin® system facilitates buffering of stormwater flows due to capillary action provided by the filtration media, and during dry periods plants draw the reserved water from the anaerobic (submerged) zone. This reserve volume is then retained during the next storm event.

3.2 Sediment

Several technologies and processes are incorporated into the SPELBasin® design to capture and retain sediment. For a grated inlet chamber, a Stormsack pit basket captures the coarse sediment as it enters. For a piped entry, a coarse filter cartridge settles sediment in the inlet chamber, minimising the chances of it entering the filter chamber. A proprietary blend of filter media maintains high hydraulic conductivity whilst filtering sediment from the treatment flow. As a final barrier, a geotextile surrounds the collection pipes to prevent sediment and filter media leaving the SPELBasin®.

3.3 Nutrient Removal

Nutrients are observed in stormwater in particulate and dissolved forms. The relative percentages remain subject to further research, however, both forms are targeted by the SPELBasin® system.

3.3.1 Particulate nutrient removal

Particulate nutrients are captured via the same pathways as sediment, since they are typically strongly adsorbed to sediment.

3.3.2 Dissolved nutrient removal

The SPELBasin® technology utilises a proprietary media blend that has been designed to target dissolved phosphorus and nitrogen. As well as the physico-chemical properties of the media, the biofilter plants remove nutrients from the stormwater and provide microbial communities to biologically remove dissolved nutrients. As with all living assets, an establishment period is typical. This may vary from 6 – 18 months depending on the plant growth cycle and climatic conditions. Once established, the SPELBasin® system should operate constantly and consistently for as long as the plants and media are viable.

4 SPELBasin® Design

Unlike traditional biofilter design, it is not necessary to utilise drainage, transition and filter media layers. The SPELBasin® system is delivered with the proprietary media pre-mixed ready for installation into the prefabricated chamber. Of importance, however, is that the geotextile protecting the outer geogrid and internal collection pipes is not damaged during the media installation.

4.1 Outlet invert level (Saturated Zone)

The SPELBasin® system is designed to accommodate up to 300mm reservoir of water as a saturated/anaerobic layer at the bottom. The levels from this outlet to the receiving drainage network should be checked to ensure the outlet is free-draining.

As a secondary guide, the Facility for Advancing Water Biofiltraton (FAWB, 2009) recommend calculating the saturated zone with the following equation;

$$D = 8x\ t$$

Where: D = depth of saturated zone (mm)
t = average of the longest annual dry period (days)

This level tends to determine the inlet level that runoff can enter the SPELBasin®.

4.2 Inlet invert level & type

The inlet level of the SPELBasin® system depends on the type of inlet structure;

- Kerb inlet;
- Grated inlet; and/or
- Pipe inlet.

Kerb and grated inlets have up to 150 mm of flexibility to match with surface levels. This also enables up to 150mm of extended detention within the SPELBasin® system.

Piped inlets have ~600 mm of flexibility to ensure the inlet pipe and outlet discharge to a free water surface. The exact dimensions will depend on the inlet pipe diameter, depth/cover and class.

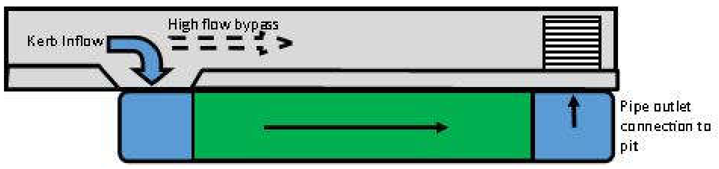
4.3 Bypass

The SPELBasin® system is designed for flows that exceed the design treatment flow rate (TFR) to be bypassed externally. This is typically achieved by ensuring that when the inlet cannot carry any additional flow, flow is re-directed to a nearby/adjacent inlet pit.

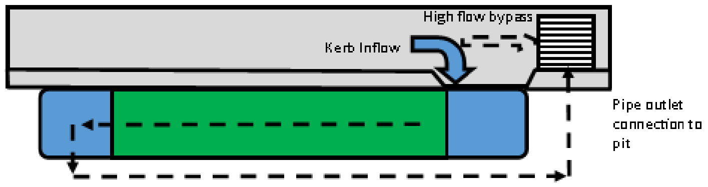
If the SPELBasin® requires an underground pipe inlet type, the bypass can be formed into the inlet chamber, or as a separate pit.

4.4 Inlet and outlet configurations

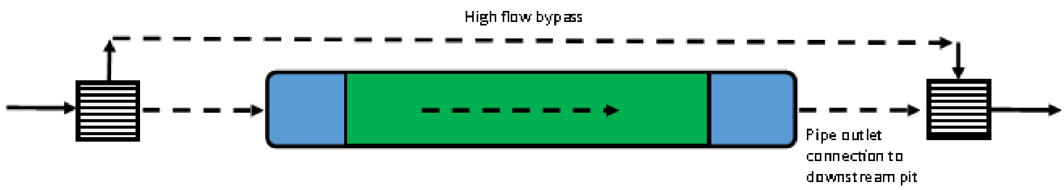
Multiple configurations are possible with the SPELBasin® depending on the site constraints. Some examples are indicated below.



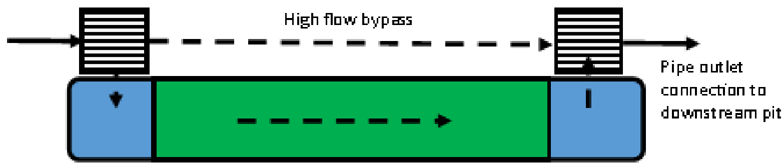
Kerb inlet Option



Kerb inlet Option



Pipe inlet Option



Pipe inlet Option

FIGURE 5. SPELBASIN® INLET AND OUTLET CONFIGURATIONS

4.5 SPELBasin® Surface level set-down

Pedestrian and vehicular safety is important when integrating the SPELBasin® into the roadscape and cityscape. Therefore, designers need to consider the interchange between the filter surface and surrounding landscape.

Application area	Surface level set-down
Roadscape	Maximum 200 mm
Footpaths/bikeways	Maximum 500 mm
Parkland, landscaping	Maximum 1000 mm where barriers or fencing are included

4.6 SPELBasin® edge interface

The SPELBasin® system is supplied in precast concrete or prefabricated fibreglass structures. This results in a vertical edge to the technology. Also, there is a defined inlet to the system. Designers should allow for surface gradients to transport flow to the inlet location, and provide edge treatments (barriers, vegetation, batters) to discourage pedestrian and/or vehicular access to the filter media and outlet chambers.

Edge treatments could incorporate treated-timber sleepers, rock blocks, fencing, bollards or barrier planting.

FIGURE 6. SPELBASIN® WITH TIMBER SLEEPER EDGE TREATMENT

4.7 SPELBasin® Plant selection

Plant selection for the SPELBasin® is very similar to that of a traditional biofilter. Wetland grasses and shrubs are most suitable with a core species list provided below.

Table 2. Recommended Plant Species for SPELBasin®

Species name	Common name	Plant habit
Banksia robur	Swamp Banksia	Small tree/shrub
Callistemon viminalis hybrids	Little John, Wee Johnnie, Harkness, Kings Park Special Bottlebrush	Small-medium tree/shrub
Ficinia nodosa (also known as *Isolepsis nodosa)*	Knobby club-sedge	Sedge/grass
Gahnia aspera	Red-fruited saw-sedge	Sedge
Imperata cylindrica	Blady grass	Grass
Juncus usitatus	Common Rush	Sedge/grass
Lomandra hystrix	River mat-rush	Grass
Lomandra longifolia	Spiny-headed mat-rush	Grass
Melaleuca thymifolia	Thyme honey myrtle	Shrub
Melaleuca linariifolia	“Snow in Summer”	Shrub
Melaleuca bracteata	Black tea-tree	Small tree

Due to the high permeability of the SPELBasin® filter media, it may be necessary to irrigate newly planted systems until they are established, or reliable, regular rainfall is received.

Planting density is recommended to be 6 plants/sqm, and a variety of species should be used, instead of a monoculture.

5 Maintenance

The SPELBasin® system requires regular, simple maintenance to ensure its long-term effectiveness.

5.1 Access

The inlet chamber and Stormsack are the areas of the SPELBasin® that will require the most attention for regular maintenance. These items are likely to capture the highest loads of sediment and litter (organic and anthropogenic) and therefore will need cleaning on a regular basis (eg. Quarterly). Whilst these are not large areas, a Stormsack full of sediment and organic matter can be heavy, and so access to the inlet chamber should be provided.

Suitable access could consist of a concrete or compacted crusher dust pathway, pavers, or permeable paving.

5.2 Inlet structures

The inlet to the SPELBasin® may be via a kerb inlet or surface grate. Regular inspections should check that these remain clear of debris and free-flowing.

Underground pipe inlets to the SPELBasin® should also be checked to ensure debris is not settling in the upstream pipe, and if observed, should be removed during the inlet chamber maintenance.

FIGURE 7. SPELBASIN® KERB AND GRATED INLET

5.3 Sediment & Litter removal

Removal of sediment and litter from the inlet chamber and Stormsack may require a small vehicle and hoist, as well as vacuum eduction to ensure optimal operation of the SPELBasin®. Since the inlet is a relatively small volume, a commercial wet/dry vacuum may be sufficient, removing the need for large eduction trucks. The inlet coarse sediment filter is the SPEL coalescer media cartridge. Annual removal of the cartridge and low pressure rinse will maintain the treatment flow rate. The coarse sediment filter cartridge should be replaced on a 10 year interval.

Depending on the design of the SPELBasin®, the material captured in the Stormsack and inlet chamber should be mostly dry.

5.4 Slotted-drainage pipes

Filtered stormwater is captured by slotted drainage pipes within the SPELBasin® filter media. These are installed within a geofabric sleeve, and protrude above the media surface. Each end of the drainage pipes is capped with an inspection fitting.

FIGURE 8. SPELBASIN® INSPECTION OPENINGS

Maintenance activities should ensure that sediment is not collecting in the slotted pipes, and flow to the outlet is not obstructed.

If treatment flow is reduced and occlusion due to sedimentation in the pipes is suspected, they can be jet-rodded and vacuum-cleaned at the outlet chamber. If this breakthrough of sediment is observed in the drainage pipes, it may be an indicator that replacement of the filter media is required.

5.5 Filter Media Hydraulic Conductivity

The proprietary filter media blend in the SPELBasin® has a high hydraulic conductivity compared with traditional biofilters. This allows the SPELBasin® to treat higher flows per square metre, whilst maintaining high pollutant removal rates. To ensure treatment flow rates are maintained, annual maintenance inspections should check that the water level of the SPELBasin® returns to the “standby” level after 2 hours. If the water level remains high after more than 2 hours, replacement of the media may be required.

Filter media infiltration rates (hydraulic conductivity) may be tested using the FAWB methodology, or the AS1547:2000 Australian Standard Constant Head test. This should be conducted in at least two locations, and boreholes at two depths (150mm & 400mm).

Contact SPEL Stormwater for more details.

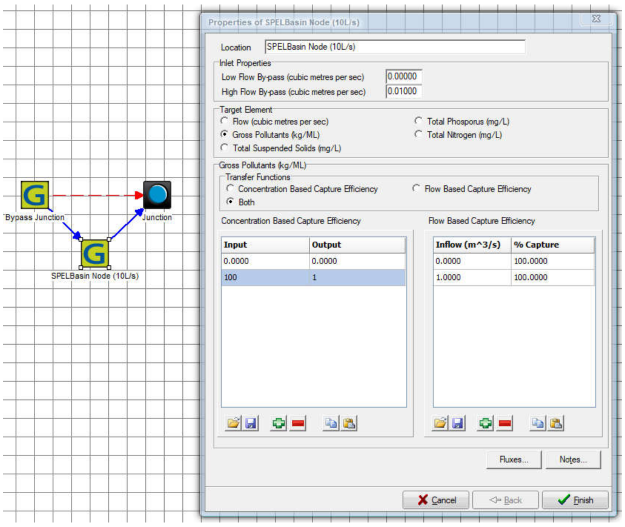
6 MUSIC Model Application

The Model for Urban Stormwater Improvement Conceptualization (MUSIC) is a software tool that simulates the behaviour of stormwater quality in urban catchments. This tool is widely used in the Stormwater Industry by professionals and this section provides a consistent and uniform approach for modelling SPELBasin® in all urban development projects. It is the aim here to provide a step by step guide for the assessment authorities to ensure the model is a correct representation of the ultimate installed products in the field.

SPELBasin® is represented in MUSIC using a **generic** node. Field research of the SPELBasin® found that the observed parameters were outside the algorithm bounds inside MUSIC and therefore to build a model that reflected the observed results required model inputs vastly different to those implemented onsite. Therefore, treatment efficiency of the SPELBasin® **generic** node is instructed by the observed field performance. The design treatment flow rate (TFR) of a standard SPELBasin® module is 10 L/s with removal rates of 99% GP, 86% TSS, 65% TP, 50% TN. The following inputs are recommended for the **Generic** node;

Pollutant	Input Concentration	Output Concentration	Removal %
Gross Pollutants	100	1	99
TSS	100	14	86%
TP	5	1.75	65%
TN	50	25	50%

FIGURE 9. SPELBASIN® MUSIC NODE FOR GROSS POLLUTANTS REMOVAL



7 Summary

The SPELBasin® modular biofiltration system provides treatment of stormwater in a package that can be quickly and simply installed. The SPELBasin® has been independently field tested in accordance with the Stormwater Australia SQIDEP protocol at Sippy Downs, Queensland. The SPELBasin® provides pollutant reductions of **86% TSS, 65% TP, 50% TN** and should provide the same 99% gross pollutant reduction of traditional biofilters. A **Generic MUSIC# node** for modelling SPELBasin® is recommended and scaling the technology in increments of **10L/s per module** should maintain the pollutant removal performance observed in the Australian Field monitoring.

Maintenance is required as per SPEL's Operation & Maintenance Manual to ensure optimal performance.

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