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Make your Bioretention Smaller

A case study using MUSIC
(Model for Urban Stormwater Improvement Conceptualisation)

Introduction

It is generally accepted that using gully pit inserts as pre-treatment can reduce the needed maintenance frequency of a bioretention device. However, the benefits of pre-treatment are not limited to maintenance as effective pre-treatment can allow a smaller bioretention device in the treatment train to meet regulatory pollutant removal requirements.

To demonstrate this, a conceptual MUSIC model was developed to illustrate that the addition of an EnviroPod200™ gully pit filter as a pre-treatment device to standard bioretention can reduce the required size (footprint) of a bioretention device by 33%.

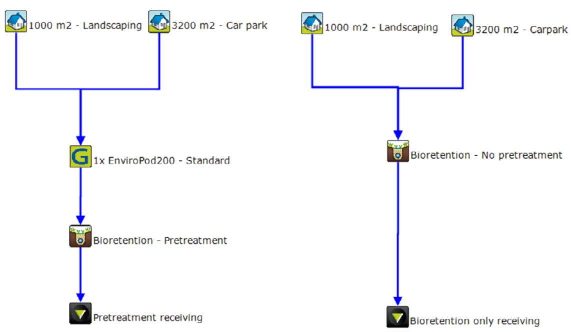


Figure 1. MUSIC models for a standard commercial lot with a bioretention system that is pre-treated (left), and non-pre-treated (right).

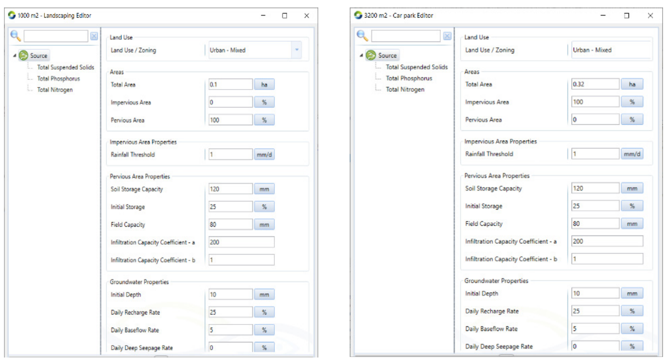


Figure 2. Source node parameters.

Source Nodes

The two source nodes include a 1000 m^2 landscaping section with 100% pervious area and a 3200 m^2 car park with 100% impervious area. The sizing and properties used for the land use are shown in Figure 2. Both sources include MUSIC X's standard stochastically generated pollutant levels for Urban–Mixed land use. Runoff from these source nodes will flow straight into a bioretention or be pre-treated by EnviroPod200™ filters installed in the car park's gully pits and then flow to a Bioretention system. The Node diagram is shown in Figure 1.

Pre-treatment Node

The EnviroPod200™ was modelled with a high flow bypass of 20 L/s with pollutant removals shown in Figure 3. The EnviroPod200™ performance node was developed from field and lab studies across Australia and New Zealand and is available from Enviropod International Ltd.

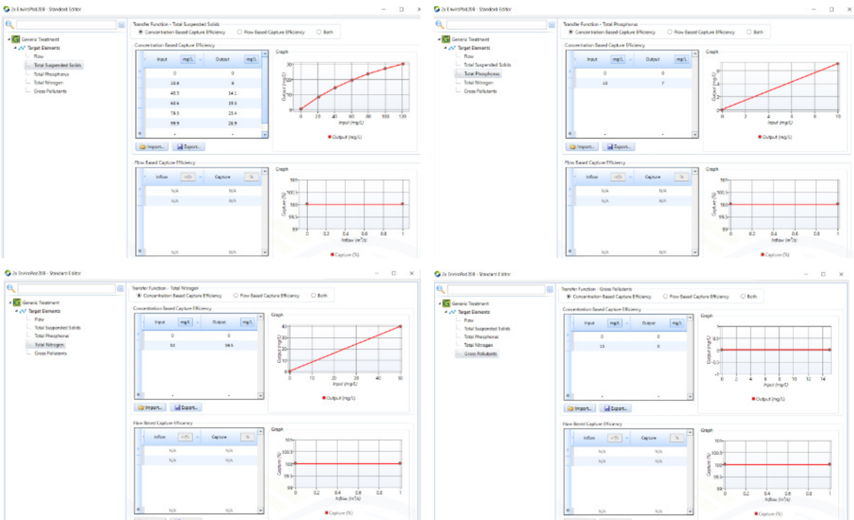


Figure 3. TSS, TP, TN, and gross pollutant removal parameters of the EnviroPod200™ standard node.

The EnviroPod200™'s mean annual load reduction in the conceptual model is shown in Figure 4. It is an effective sediment removal device preventing sediment accumulation in the bioretention system and the system is a moderate remover of nutrients. While effective at removing sediment and particulate material, it has no mechanism for removing dissolved factions of phosphorus and nitrogen. However, reducing the nutrient concentration through the EnviroPod200™ increases the treatment train's removal.

Mean Annual Load

Latest Run : Mean Annual Load : 1x EnviroPod200 - Standard

	Inflow	Outflow	% Reduction
Flow (ML/yr)	1.779	1.779	0
Total Suspended Solids (kg/yr)	638.5	122	80.89
Total Phosphorus (kg/yr)	1.028	0.7227	29.71
Total Nitrogen (kg/yr)	4.194	3.322	20.79
Gross Pollutants (kg/yr)	62.92	0.6608	98.95

Figure 4. Mean annual load and removal for the EnviroPod200™

Bioretention Node

Two bioretention designs were considered in the model. The first Bioretention system has a 12 m^2 filter area (no pre-treatment) and another with an 8 m^2 surface area (pre-treatment). The 8 m^2 Bioretention system received EnviroPod200™ pre-treated flows. All other parameters were kept consistent with the two bioretention designs. Figure 5 shows all the input parameters used for each bioretention system.

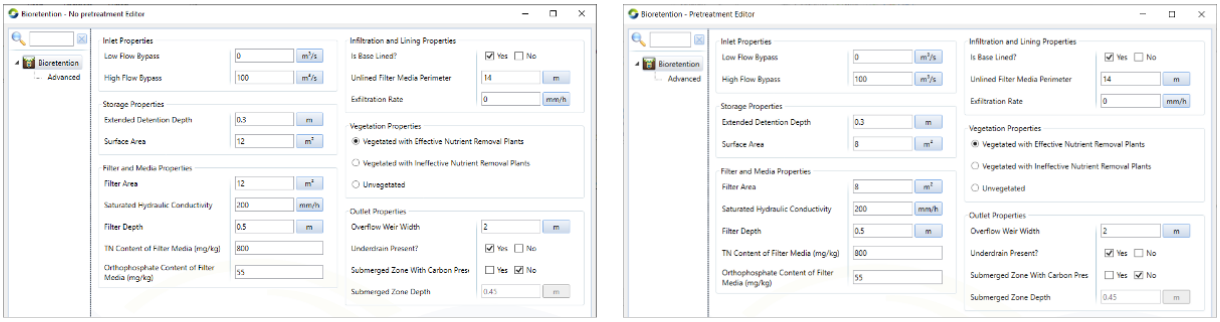


Figure 5. Bioretention node parameters.

The tables in Figure 6 show the mean annual load removal percentages for the pre-treated bioretention system and the untreated system as stand-alone systems. The 8 m^2 system meets the performance requirements for TP. However, it does not meet the criteria for TSS and TN due to the bypass flows. The 12 m^2 system allows a greater capture of the annual runoff allowing all parameters to meet the requirements.

Mean Annual Load

Latest Run : Mean Annual Load : Bioretention - Pretreatment

	Inflow	Outflow	% Reduction
Flow (ML/yr)	1.779	1.761	1.017
Total Suspended Solids (kg/yr)	115.6	43.63	62.24
Total Phosphorus (kg/yr)	0.7311	0.3826	47.66
Total Nitrogen (kg/yr)	3.341	2.209	33.88
Gross Pollutants (kg/yr)	0.6608	0	100

Mean Annual Load

Latest Run : Mean Annual Load : Bioretention - No pretreatment

	Inflow	Outflow	% Reduction
Flow (ML/yr)	1.779	1.752	1.506
Total Suspended Solids (kg/yr)	595.7	110.9	81.39
Total Phosphorus (kg/yr)	1.037	0.3921	62.17
Total Nitrogen (kg/yr)	4.315	2.332	45.95
Gross Pollutants (kg/yr)	62.92	0	100

Figure 6. Mean annual load effectiveness for the pre-treated (left) and non-pre-treated (right) Bioretention systems.

The Treatment Train Performance

MUSIC allows the evaluation of a treatment train. The concentration of the influent flows primarily influences the performance of a treatment device. MUSIC considers the concentration reduction of each step of the treatment train. This reduces the device's efficiency as the influent concentration is reduced. However, the overall efficiency is increased by passing stormwater runoff through numerous steps in a treatment train.

Figure 7 compares the 8 m^2 bioretention system with pre-treatment to a 12 m^2 non-pre-treated system for the proposed project. The tables show the increased TSS removal from an Enviropod pre-treated smaller bioretention system than a 50% larger stand-alone system.

Adding the EnviroPod200™ to the site's gully pits reduces the sediment load to the bioretention system from 595.7kg/yr to 115.6kg/year. Capturing sediment in the gully pits extends the life of the bioretention system before corrective and costly remedial maintenance is required (media and plant replacement). The addition of pre-treatment also provides additional resilience to the system by creating an extra barrier for unforeseen events such as spills that may occur in the catchment. The EnviroPod200™ requires routine maintenance that can be undertaken by hand or vactor truck.

Treatment Train Effec

Latest Run : Treatment Train Effectiveness : Pretreatment receiving

	Sources	Residual Load	% Reduction
Flow (ML/yr)	1.779	1.761	1.017
Total Suspended Solids (kg/yr)	638.5	46.82	92.67
Total Phosphorus (kg/yr)	1.028	0.3799	63.05
Total Nitrogen (kg/yr)	4.194	2.173	48.18
Gross Pollutants (kg/yr)	62.92	0	100

Treatment Train Effec

Latest Run : Treatment Train Effectiveness : Bioretention only receiving

	Sources	Residual Load	% Reduction
Flow (ML/yr)	1.779	1.752	1.506
Total Suspended Solids (kg/yr)	595.7	110.9	81.39
Total Phosphorus (kg/yr)	1.037	0.3921	62.17
Total Nitrogen (kg/yr)	4.315	2.332	45.95
Gross Pollutants (kg/yr)	62.92	0	100

Figure 7. Total treatment train effectiveness for the pre-treated (left) and non-pre-treated (right) systems.

Discussion and Conclusion

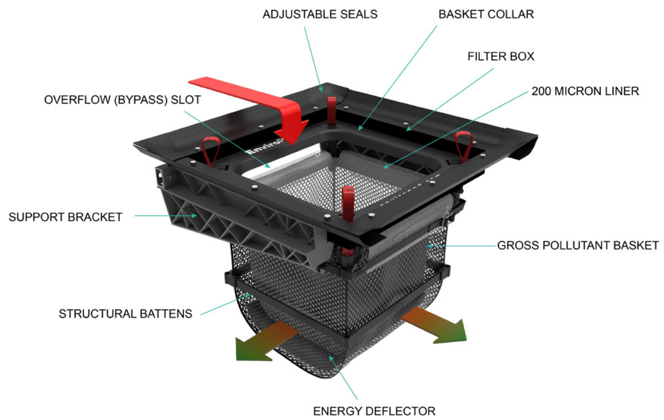
Stormwater professionals have long supported the treatment train concept to improve the effluent quality of stormwater discharges. However, the cost of additional steps in the treatment train has often resulted in a single stand-alone device being adopted.

The principle of a treatment train involves targeting different contaminants with different particle sizes and speciation with treatment devices with other pollutant removal mechanisms.

This discussion document has demonstrated that an effective sediment pre-treatment device such as the EnviroPod200™ filter with a bioretention device can remove dissolved pollutants and deliver greater efficiency with lower capital and operational costs.

Water-sensitive design (WSD) has multiple benefits beyond water quality. The use of treatment with WSD elements will allow significant uptake of WSD and provide improved urban environments. However, WSD systems are often susceptible to high sediment and gross pollutant loads, which can cause clogging and increase the need for expensive rehabilitation work over time.

Enviropod MUSIC Nodes and modelling support are available from EnviroPod International Ltd.



EnviroPod200™ Gully Pit Filter

Note: The diagrams in this document were taken from screen grabs – if you require more information or require clearer images, contact Enviropod directly.

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