Gonzaga Bioretention Soil Media Thickness Effectiveness Study

Spokane County WASHINGTON

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Study Goal

Bioretention research by others suggests that TSS and dissolved metals removal typically occurs in the top 6-inches of the bioretention soil media (BSM) mix. Additionally, studies have indicated that the Ecology 60:40 BSM leaches nutrients and that the higher the content of compost the higher the concentration of nutrients leaching from the media. Because of these findings and a desire to reduce the cost of constructing bioretention BMPs if the additional BSM depth is not needed, there is an interest in reducing the BSM depth from the 18-inches required by Ecology to a 12-inch depth. **The goal of this study was to justify development of a modified bioretention BMP that uses the existing 60:40 bioretention mix to a minimum depth of 12-inches (rather than the current required 18-inch depth) for providing treatment of TSS and dissolved metals.** Effectiveness evaluation of the modified BMP will be based upon:

- Pollutant removal efficiency of the 60:40 BSM mix at a depth of 18-inches compared to 12-inches.
- Change in the infiltration rate and saturated hydraulic conductivity of each cell over the duration of the study.
- Achievement of treatment performance goals for basic (TSS), metals (dissolved Cu and Zn), and oils, by comparing study results to the Technology Assessment Protocol Ecology (TAPE) treatment performance goals.

Study Description

The goal of this study was accomplished through field monitoring and sampling following the TAPE protocol as summarized in the Eastern Washington Effectiveness Study QAPP Template for Structural BMPs. The test site consists of a dual-cell bioretention area that contains 18-inches and 12-inches of the 60:40 mix in each cell shown in Figure 1. The test site was constructed in 2014, the automated monitoring equipment was installed in 2017, and field testing was conducted from Fall 2018 to Spring 2021.

The automated monitoring system collected flow weighted composite samples, rainfall depth, and flow rate (influent and effluent). The primary work associated with field monitoring and sampling included: daily monitoring of the weather forecast to identify when qualifying rainfall events are likely to occur, operating and maintaining the equipment, collecting three composite flow weighted water quality samples for each rainfall event (one influent and two effluent), as well as duplicates for 10% of the samples, delivering the samples to the lab for analysis, and downloading data from the data logger (precipitation depth and runoff flow rate). The influent and effluent water quality samples were tested for TSS, dissolved metals (Cu and Zn), total phosphorus, oils, PSD, Orthophosphate, Hardness, and pH. Samples of the BSM mix were collected when the site was constructed and from the ponds in 2018. The samples were submitted to an Ecology certified lab for analysis to evaluate changes in the physiochemical properties. Data was collected from 17 qualifying and potentially qualifying storm events over two wet seasons starting in 2018.

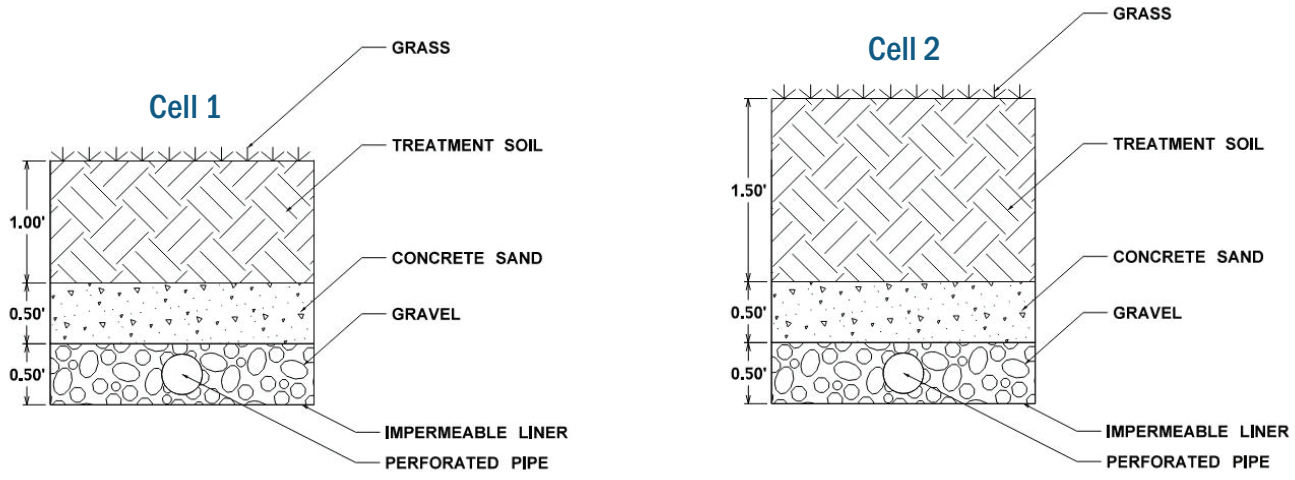

Figure 1. Cross Section of the Bioretention Cells: 12-inch BSM (cell 1) and 18-inch BSM (cell 2)

Study Location

The test site location is in the City of Spokane on the campus of Gonzaga University located south of the Rudolf Fitness Center, east of Luger Soccer Field, and north of the Law School. The location of the test site is shown in Figure 2. The contributing basin area is 0.53 acres of a paved parking lot and 0.08 acres from sidewalks and the access road to the parking lot.

Study Objectives

Objective 1: Determine the pollutant removal efficiency of the BSM mix at a depth of 18-inches compared to 12-inches.

No statistically significant difference was noted between the treatment performance of the 18-inch BSM depth compared to the 12-inch depth for TSS, dissolved copper, or dissolved zinc. A statistically significant difference was measured for leaching of TP; the 18-inch BSM depth leached more TP (-381%) on average than the 12-inch depth (-198%). As shown in Table A, TSS and dissolved zinc were removed by the cells, while dissolved copper was observed to be leaching from the cells. Oils were not evaluated as the concentrations were not detectable. The physiochemical properties of the BSM were measured when the cells were constructed and approximately five years after installation. A comparison of the data indicates that copper was not being retained in the BSM, while zinc was retained. The measurements of copper and zinc retained in the BSM support the water quality findings that dissolved copper is leaching from the BSM while dissolved zinc is removed by the BSM shown in Table A.

Objective 2: Determine whether the TAPE treatment performance goals were achieved.

The bootstrap statistical method was used to assess whether the TAPE treatment performance goals were met by the 12-inch cell and 18-inch cell shown in Table A. Both the 12-inch cell and 18-inch cell met TAPE treatment performance goals for TSS (influent concentrations were below 100 mg/L), but neither met the treatment performance goals for dissolved copper and zinc. The treatment performance goal for oils was not assessed due to the number of non-detect results received during the study.

Objective 3: Determine change in infiltration rate and saturated hydraulic conductivity of each cell over study duration.

Changes in the infiltration rate and saturated hydraulic conductivity of each cell was measured by performing modified falling head tests and examining effluent flow rates, respectively. Saturated hydraulic conductivity decreased for both cells (60% for the 12-inch cell and 78% for the 18-inch cell) from 2014 to 2019. Results from the infiltration testing indicate that the rate appeared to slightly increase from 2018 to 2020. These results may be due to the freeze thaw cycle, which has been reported to increase infiltration rates over time. However, infiltration rate data was only collected following the installation of the monitoring equipment in 2017, missing the initial years after the BSM was installed and when infiltration rates are reportedly highest. It is possible that if a similar number of storm events were collected prior to the installation of the equipment as were collected after installation, the trend in infiltration rate would show a decline over the lifespan of the bioretention cells (consistent with the saturated hydraulic conductivity results).

Future Action Recommendations

Recommendations for future actions focused on additional research based on the findings from this study. Specifically, analysis of influent concentrations in EWA, research of the effects of cold climate conditions on bioretention treatment and infiltration performance, development of BSM to reduce leaching and support non-vegetated cells, revaluation of qualifying storm event guidelines (minimum influent concentration limit and storm duration criteria) that are better suited for EWA conditions, and research alternative PSD laboratory analysis methods that maybe more readily available than the method defined in TAPE.

Figure 2. Summary of Influent & Effluent Concentrations Statistical Comparison

Table A. Summary of Results

Pollutant	Percent Reduction		Statistically Significant Difference?	Treatment Goals Achieved?
	12-inch	18-inch		
TSS	74.5%	71.1%	No	Yes
Dissolved Copper	-50.3%	-93.4%	No	No
Dissolved Zinc	39.5%	34.9%	No	No
TP	-198.4%	-381.4%	Yes	N/A

LEAD ENTITY:
Spokane County

CONTRIBUTING ENTITY:
City of Pullman
City of Moses Lake
City of Pasco
City of Spokane Valley
City of Yakima
Wall Walla County
Yakima County

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