Evaluation of Hydraulic Control Approaches for Bioretention Systems

Stormwater Action Monitoring

Effectiveness Study

Lead Entity

Washington Stormwater Center

Washington State University

Partners

Geosyntec consultants

Stormwater Action Monitoring (SAM) is a collaborative, regional stormwater monitoring program that is funded by more than 90 Western Washington cities and counties, the ports of Seattle and Tacoma, and the Washington State Department of Transportation.

SAM's goal is to improve stormwater management by measuring stormwater impacts on the environment and evaluating the effectiveness of stormwater management actions.

Highlights

- Outlet control has little additional effect on water quality of bioretention discharges for the traditional stormwater pollutants over media control.
- Outlet control has the potential to provide substantial value where project design goals call for:
  - increased residence time for pollutant removal
  - increased contact with complete bioretention media bed
  - predictable flow characteristics for flow control design goals.

Stormwater study background

Under the Stormwater Management Manual for Western Washington (SWMMWW), bioretention systems are commonly used to provide on-site stormwater management, runoff treatment, and flow control. Sites with poorly infiltrating soil often require underdrains to keep the water moving through the bioretention system. For bioretention systems that are under-drained, there can be two different hydraulic control approaches to control flow rate through the system. Bioretention systems can be designed to rely on the permeability of filtration media to restrict flow rates (i.e., "media control") or incorporate flow-restricting devices (valves or orifices) on the underdrain outlets to throttle flow rates through the system (i.e., "outlet control"). The hydraulic control approach used in bioretention systems has the potential to change the operations and performance of these systems. This research compares outlet-controlled and media-controlled designs.

Figure 1: Mesocosm Testing Facility at WSU-Puyallup

Study goals

- Compare performance between outlet-controlled and media-controlled configurations for: water quality treatment, plant vigor, and hydraulic fluctuation (flow rate, stage, and discharge volumes)
- Compare hydraulic performances of bioretention relationships over time for each configuration and to model predictions.

Project findings

When effluent stormwater pollutant concentration is of primary concern, an outlet control approach provides limited benefit. This approach moderately improved treatment performance for some pollutants but may increase the risk of leaching nutrients and dissolved copper from bioretention media, particularly for compost-based media that already have the potential to leach. An outlet control approach could be beneficial for applications where (1) more predictable and longer residence times are desired to target specific analytes, or (2) there is concern about short-circuiting through a portion of the media bed and exhausting the treatment capacity along the short-circulate pathway, and the selected bioretention media has limited risks for nutrient and dissolved copper leaching, and/or (3) accurate predictions of flow control performance are desired to meet bioretention performance goals. Outlet control effectively slows the water down, increases residence time, and saturates the full media bed more often. This study shows no impact on O&M or plant health associated with this outlet control bioretention designs.

Figure 2: Orifice control on underdrain outlet

Recommendations

An outlet control approach would provide the most benefit, where greater flow control predictability and precision are desired to meet bioretention performance goals. This research has shown that hydraulic conductivity through the media alone (media control) is variable. Flow control via an orifice on the underdrains reduces the variability and is more accurately simulated via the Western Washington Hydrology Model. This approach using an orifice is already allowed in Ecology's Stormwater Management Manuals for Washington State.

Why does this study matter?

Bioretention soil media is designed to filter stormwater at a relatively fast rate. This study evaluated the impacts to water quality and flow rate changes when that flow-through rate was slowed down using an orifice on the underdrain.

What should stormwater managers do with this information?

When designing bioretention facilities, the choice between media control and outlet control bioretention should be based on the project goals. For facilities built solely to achieve effluent pollutant concentration reduction, outlet control design does not provide additional benefit compared to media control. However, outlet control designs provide more consistent, predictable, and significant flow control benefit and should be considered if these benefits are relevant to meeting project goals.

What will Ecology do with this information?

Ecology continues to allow outlet controls in bioretention designs to further control discharge rates and residence times.

For more information see the completed project at ecology.wa.gov/SAM Effectiveness Studies or contact the study leads: Dr. Ani Jayakaran anand.jayakaran@wsu.edu, Dr. John Stark john.stark@wsu.edu, Aaron Poresky aporesky@geosytec.com and Leon Li YLi@Geosyntec.com