



INSIDE THIS ISSUE:

Introducing the 2013 “Off the Shelf” Watershed Treatment Model / 1
 An MS4 Partnership for Stormwater Retrofitting in the Upper Shenandoah, Virginia /2
 Outfall Bag Filters for Cost-Effective Nutrient Source Control /4

Introducing the 2013 “Off the Shelf” Watershed Treatment Model



The Center first introduced the Watershed Treatment Model (WTM) in 2011. The WTM, a spreadsheet-based tool designed for municipal or watershed managers that estimates the benefits of a wide range of management practices in urban watersheds, has gone through several iterations since then. The newly released WTM 2013 is able to track sediment, nutrients, bacteria and runoff volume on an annual basis. The most recent updates to the WTM also updates the methodologies used to calculate BMP efficiencies and runoff from urban turf. Users can choose between two versions:

The “Off the Shelf” WTM: this version provides a simplified interface and incorporates other features that make the tool more user friendly

The WTM “Custom:” this version is for users who intend to modify portions of the model for application in a particular watershed, or incorporate unique practices

The “Off the Shelf” WTM has three basic components. The *Pollutant Sources* component of estimates the load from a watershed without treatment measures in place. The *Treatment Practices* component estimates the reduction in this uncontrolled load from a wide suite of treatment measures. Finally, the *Accounting for Growth* component allows the user to account for future development in the watershed, assuming a given level of treatment for future development. The model incorporates

many simplifying assumptions that allow the watershed manager to assess various programs and sources that are not typically tracked in more complex models.

Both versions of the 2013 WTM are available for free download on the [Online Watershed Library](#) along with the model documentation and Users' Guide. Users of the WTM will also want to visit the [WTM User Community](#), a forum for discussion that brings together WTM users to post questions or comments, and share results and data with others.

The "Off the Shelf" WTM was developed in collaboration with Michael Baker, with funding from Wal-Mart Store, Inc. and Wallace Genetic Foundation

An MS4 Partnership for Stormwater Retrofitting in the Upper Shenandoah, Virginia



The Center is working with the Central Shenandoah Planning District Commission and three Virginia Municipal Separate Storm Sewer System (MS4) partners to conduct a stormwater retrofit inventory in the Upper Shenandoah Valley in northwestern Virginia. "Stormwater retrofitting" refers to the practice of installing stormwater management features in places where development has already occurred with little or no stormwater treatment. Within their next five-year permit cycle, the MS4 partners – the City of Harrisonburg, the Town of Bridgewater, and James Madison University (JMU) – must achieve 5% of their required total phosphorous (TP), total nitrogen (TN), and total suspended sediment (TSS) load reductions for the Chesapeake Bay total maximum daily load (TMDL) effort. The project is intended to determine the level to which structural stormwater retrofits on public properties can reduce urban

nutrients and sediment for the Bay clean-up deadline. It also estimates costs of constructing the retrofits proposed in the inventory.

In March 2013, field teams led by the Center and consisting of MS4 partner staff fanned out across the three jurisdictions to assess almost 100 publically-owned properties. The teams investigated how to use the landscape to reduce, capture, and filter runoff that otherwise flows directly to nearby streams using the Retrofit Reconnaissance Investigation protocol (Schueler, et al. 2007). The teams evaluated the stormwater retrofit potential of each candidate site by analyzing existing drainage patterns, drainage areas, impervious cover, available space, and site constraints (e.g., conflicts with existing utilities and land uses, site access, and potential impacts to natural areas). Unless there were obvious site constraints and/or evidence that a particular stormwater retrofit would offer few or no watershed benefits, a stormwater retrofit concept was developed for each candidate project site, including a sketch plan when appropriate.

A wide variety of stormwater retrofit options, such as bioretention, constructed wetlands, dry pond conversions and regenerative stormwater conveyance, were considered while inventorying these public properties. Since an important component of the project was to estimate each retrofit project's pollutant load reductions in the context of the Bay TMDL, it was important to be consistent with the latest guidance from EPA's Chesapeake Bay Program (CBP) on this subject. This project therefore also provided a chance to field-test recently released recommendations of a CBP Expert Panel on assigning pollutant removal values to stormwater retrofits (Schueler and Lane, 2012). Given the diversity of possible retrofit applications, the panel decided that assigning a single universal removal rate was not practical or scientifically defensible. Instead, the panel elected to develop a protocol whereby the removal rate for each individual retrofit project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides. The panel conducted an extensive review of recent BMP performance research and developed a series of *retrofit removal adjustor curves* to define sediment, nitrogen and phosphorus removal rates. Removal rates for new retrofits are derived from the adjuster curves based on the runoff depth captured by the practice and whether the BMP is defined as a "Runoff Reduction" or "Stormwater Treatment" practice.

The Panel defined four categories of retrofits:

1. New Retrofits: Retrofit projects that create storage to reduce nutrients from existing developed land that is not currently receiving any stormwater treatment.

2. **BMP Conversions:** Retrofits of older, existing stormwater ponds to employ more effective treatment mechanism(s), such as converting a dry pond to a constructed wetland.
3. **BMP Enhancements:** Retrofits that utilize the existing treatment mechanism in an existing BMP, but improve removal by increasing storage volume or hydraulic residence time.
4. **BMP Restoration:** Major maintenance upgrades to existing BMPs that have failed or lost their original treatment capacity. BMP Restoration was not included in the present study, since all projects involving an existing BMP aimed to maximize pollutant removal by including a conversion or enhancement of the existing practice.

After completion of the field inventory, Center staff ranked each project based on cost effectiveness, TP removal, maintenance burden, utility and site constraints, and aesthetics/safety. The estimated pollutant reductions were then compared to the required MS4 permit reductions.

The preliminary results show a positive picture for JMU and Bridgewater, who should be able to achieve the 5% goal by implementing some of the top-ranked retrofits. On the other hand, the preliminary results indicate that the City of Harrisonburg will fall short of their sediment and nutrient reduction goals even if all the identified retrofits are implemented. This is due in part to the focus on public land, which, proportionally speaking, is not as plentiful in Harrisonburg. To comply with the permit, the City of Harrisonburg will need to broaden their search to private lands and/or other types of (non-structural) BMPs. The exceedingly high reductions associated with the top-ranked retrofits in JMU and Bridgewater also leave the door open to possible trading opportunities with Harrisonburg. Currently, MS4 localities in Virginia are authorized to work with other nearby MS4s to collectively meet their combined wasteload allocations; however, the specifics of how this would work have not yet been developed.

Out of the three permit-holders, it appears that JMU may incur the most benefit for the least cost when it comes to constructing their top-ranked retrofits. This is due largely to the fact that the campus has many large dry ponds with good retrofit potential. As part of the retrofit ranking process, cost-effectiveness metrics were calculated based on unit construction costs derived from a variety sources, including CWP (2013), King & Hagan (2011), Schueler et al. (2007), and, where available, actual construction bids for retrofit projects. Table 1 presents the cost per cubic foot of runoff treated for each of the BMP types evaluated through this project. Although construction costs can be quite variable, even within the same BMP type, this study generally showed that conversion of dry ponds to wet ponds or wetlands is the most cost-effective type of retrofit.

Retrofit Practice	Construction Cost/Cubic Foot Treated
Bioretention	\$24.46
Constructed Wetlands	\$12.37
Dry Swale	\$20.00
Filtering Practice	\$11.60
Green Roof	\$170.00
Infiltration	\$12.68
Permeable Pavers	\$63.15
Wet Ponds	\$12.37
Wet Swale	\$12.37
Rain Tank	\$15.00
Stormwater Planter	\$38.05
Regenerative Stormwater Conveyance	\$45.00
Filter Strip	\$6.00
Stream Restoration	\$12.47
Conversion of dry pond to wet pond/wetland	\$3.59

While the costs used in Table 1 represent planning-level costs, it is important to note that these are construction costs and not BMP life-cycle costs. This is because construction costs are easier to ascertain and have less “scatter,” so represent a more reliable metric to compare projects. Life-cycle costs include project planning and permitting, administration, long-term inspection and maintenance, and other costs. See King and Hagan (2011) and CWP (2013) for more information about life-cycle costs of stormwater management practices.

These stormwater retrofit inventories are not intended to sit on a shelf and collect dust. Bridgewater, JMU, and Harrisonburg staff are already looking at the top-ranked projects and thinking about ways to fund and implement them—either through grants, capital improvement project dollars, or other sources. It is our hope that many of these retrofits will ultimately become automatically incorporated into construction plans as public properties come up for renovation or expansion.

For more information about this project, contact David Hirschman at djh@cwp.org. This project was made possible through a grant from the National Fish and Wildlife Foundation’s Chesapeake Bay Local Government Assistance Program.

References

Center for Watershed Protection (CWP). 2013. [Cost-Effectiveness Study of Urban Stormwater BMPs in the James River Basin](#). Revised June 2013. Prepared for the James River Association. Center for Watershed Protection. Ellicott City, MD.

King, D., and P. Hagen. 2011. [Costs of Stormwater Management Practices in Maryland Counties](#). Prepared for Maryland Department of the Environment by the University of Maryland Center for Environmental Services. Technical Report Series No. TS-626-11 of the University of Maryland Center for Environmental Science.

Schueler, T., Hirschman, D., Novotney, M., and J. Zielinski. 2007. [Urban Stormwater Retrofit Practices Version 1.0](#). Center for Watershed Protection. Ellicott City, MD.

Schueler, T. and C. Lane. 2012. [Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects](#). Prepared by the Chesapeake Stormwater Network. Final Approval by the Water Quality Goal Implementation Team on October 9, 2012.

Outfall Bag Filters for Cost-Effective Nutrient Source Control

The Center recently completed a 15-month monitoring project in Talbot County, Maryland to evaluate the cost-effectiveness of bag filters as a nutrient management strategy. The study was intended to address water quality issues in the Tred Avon watershed, whose upper reaches are highly impacted by urban stormwater runoff. The study design involved estimating baseline gross solids patterns, type and loads in the watershed and operation and maintenance costs of the bag filters. The findings of this project are summarized in *Gross Solids Characterization Study in the Tred Avon Watershed Talbot County, MD* (Stack et al., 2013).

Gross solids are an emerging pollutant of concern that is comprised of trash and litter, coarse sediment, and organic debris (primarily leaf litter). Unlike other pollutants, gross solids have not been well characterized or quantified in terms of their source areas and associated pollutants, in part due to the limited ability of automated samplers to collect particles sizes larger than 75 µm. Research studies indicate that the levels of metals, nutrients and toxic pollutants associated with these particles are potentially significant (ASCE, 2010; Rushton 2006). Nutrient loadings from leaf litter may be detrimental to urban impacted streams such as the Tred Avon, which already have elevated nutrients and reduced biological processing as a result of high storm flows that readily transport organic debris downstream instead of allowing for decomposition and uptake by stream microorganisms (Walsh et al 2005, Meyer et al. 2005, Wallace et al. 2008).

The Center collaborated with the Talbot County Department of Public Works and the Town of Easton to reduce gross solids in the Tred Avon watershed and to collect data to better define pollutant loads associated with leaf litter and removal efficiencies associated with bag filters. Four stormwater outfalls in the watershed were fitted with Kristar Enterprises Nettek© bag filters. The gross solids captured in these bag filters were removed, drained, and the wet

material weighed. A subset of samples were dried and analyzed for total nitrogen, total phosphorus total solids dry, total volatile solids, and biological oxygen demand.

The majority of gross solids collected through this study consisted of leafy organic material, which is consistent with findings from other studies. On average, the percent contribution by weight¹ was 93% leafy material (and sediment), 3% woody debris and 4% litter. According to Dr. Neely Law, who was the Center lead on the study, these findings were not unexpected, but the quantities of leaf litter collected were surprising because the study area canopy cover was less than twenty-five percent. The bag filters picked up more leaves than expected and less trash. According to Neely: "the study confirmed that there is a lot of leaf litter from catchments that are going through the storm drains and reaching the waterways. Natural recycling of nutrients that you see on a forest floor with the leaves isn't happening in the waterways. The question is, what nutrients are breaking down into the waterways? The next step in the research is to determine what happens with these nutrients." Neely stated that these results point to the evaluation of better management of trees and other vegetation in urban areas. "This study is not trying to discourage the use of trees and vegetation; we just need to appreciate the impacts and effects of vegetation on impacted and currently degraded urban streams."

The study of the Tred Avon watershed also determined that bag filter technology is highly cost-effective compared to other stormwater controls for nutrient removal. Calculated as an annualized cost per pound of pollutant removed per impervious acre treated, the cost effectiveness metric used in the study took into account capital costs and operation and maintenance. For nitrogen removal, bag filters were found to be 2.2 times more cost-effective than street sweeping, 4.5 to 8.6 times more cost-effective than bioretention, and 9.9 times more cost effective than wet ponds.

This project concluded that the bag filters are a cost-effective source control practice to remove nutrients associated with gross solids from streams. Additional research is needed to statistically quantify the impact of leaf litter on urban stream nutrient loadings and determine if there is a seasonal effect on composition of gross solids collected by the bag filters and associated nutrient loadings. This would develop a more comprehensive urban nutrient mass balance for watersheds and identify the most cost-effective management practices.

Funding for this study was provided by the 2010 Maryland Department of Natural Resources Chesapeake and Atlantic Coastal Bays Trust Fund and the Munson Foundation. To learn more about this study, contact Neely Law at nll@cwpa.org and look for the final project report to be posted soon on the Center's [Online Watershed Library \(OWL\)](#).

Works Cited:

- Environmental Water Resources Institute of the American Society of Civil Engineers (ASCE). 2010. *Guidelines for Monitoring Stormwater Gross Solids*. Urban Water Resources Research Council Gross Solids Technical Committee. ASCE
- Meyer, J. M. J. Paul, and W.K. Taulbee. 2005. Stream ecosystem function in urbanizing landscapes. *J. N. Am. Benthol. Soc.*, 24(3): 602-612.
- Rushton, B. 2006. *Broadway Outfall Stormwater Retrofit Project*. Southwest Florida Water Management District, Brooksville, FL.
- Stack, B., Law, N., and S. Drescher 2013. *Gross Solids Characterization Study in the Tred Avon Watershed Talbot County, MD*. Prepared for Talbot County Department of Public Works. Center for Watershed Protection. Ellicott City, MD.
- Wallace, T.A., G. G. Ganf, and J. D. Brookes. 2008. A comparison of phosphorus and DOC leachates from different types of leaf litter in an urban environment. *Freshwater Biology*, 53: 1902-1913.
- Walsh, C. J., A. H. Roy, J. W. Feminella, P. D. Cottingham, P. M. Groffman and R. P. Morgan II. 2005. The urban stream syndrome: current knowledge and the search for a cure. *J.N. Am. Benthol. Soc.* 24(3): 706-723

(Endnotes)

¹ Field or 'as-is' dry weight from the drying tables and no oven-dried from the lab