RECOMMENDATIONS OF THE EXPERT PANEL TO DEFINE REMOVAL RATES FOR URBAN FILTER STRIPS AND STREAM BUFFER UPGRADE PRACTICES

FINAL REPORT

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Executive Summary

<u>DISCLAIMER</u>: The recommendations included in this report do not address or revise the current urban forest buffer BMP nitrogen, phosphorus or sediment removal efficiencies or definition defined by the Chesapeake Bay Program.

The Urban Stormwater Work Group convened an Expert Panel to define and develop nutrient and sediment load reductions recommendations using urban filter strips and stream buffer upgrade as new best management practices (BMPs) to be adopted by the Chesapeake Bay Program (CBP). Urban filter strips and stream buffer upgrade BMP(s) are not currently defined by the CBP as a BMP available for credit towards Watershed Implementation Plans. The Expert Panel provided representation from the Bay jurisdictions, scientists, stormwater practitioners to review and evaluate the scientific literature and other data sources, review the Chesapeake Bay Watershed Model assumptions to simulate the impact of grass and forested filter strips and buffers and make recommendations to quantify and qualify these BMPs as well as information to verify their performance after implementation. The expert panel did not address or provide recommendations for the existing urban forest buffer BMP.

In its review of the recently approved methods to define removal rates of runoff reduction and stormwater treatment BMPs (SPS EP, 2013 and SRP EP, 2013), research-specific publications and the design of urban filter strips, the Expert Panel determined that a modification to the methods presented in SPS EP (2013a) was needed to quantify the nutrient and sediment load reduction from urban filter strips. A total of 27 publications were reviewed along with the State and District of Columbia stormwater design guidance for urban filter strips to form the basis of the Expert Panel recommendations. The recommendations are summarized in Table E-1 1 where pollutant removal efficiencies are given to urban filter strips as a runoff reduction (RR) and a stormwater treatment (ST) practice. The pollutant load reductions are available if the qualifying conditions are met and verified post-construction.

Table E-1 1. Recommendation nutrient and sediment removal (5) for urban filter strips as a runoff reduction and stormwater treatment practice

	TN[1]	TP[2]	TS[2]
Runoff Reduction	20%	54%	56%
Stormwater Treatment	n/a	n/a	22%

[1] TN removal is based on particulate-N only and assumes that particulate N removed is not converted to nitrate and leached to groundwater. No credit is provided for dissolved N.
[2] The percent pollutant removal is estimated using the 0.5" rainfall depth capture for the TP and TS performance adjustor curves provided in SPS EP (2013a).

The Expert Panel currently does not provide a recommendation for stream buffer upgrades as an urban BMP. The Expert Panel review of the scientific literature found insufficient data to evaluate the function of stream buffers within an urban area and the inability to differentiate this BMP from existing urban BMPs approved by the Chesapeake Bay Program.

In addition to the specific recommendations to define urban filter strips as an approved BMP for the Chesapeake Bay Program, the Expert Panel provides a set of future research and management needs to advance our understanding of this BMP and data to define stream buffer upgrades as a future BMP.

Section 1. Charge and Membership of the Panel

The roster for the Urban Filter Strip and Stream Buffer Upgrade Expert Panel is provided in Table 1. A copy of the meeting minutes are provided in Appendix A.

Table 1. Expert Panel Membership

Name	*Affiliation*
Joe Battiata	Center for Watershed Protection, Inc.
Sally Claggett	USFS, Chesapeake Bay Program Forestry Work Group Coordinator
Scott Crafton	Virginia Department of Environmental Quality
David Follansbee, PhD	New York Department of Environmental Conservation
David Gasper	New York Department of Environmental Conservation
Randy Greer	Delaware Department of Natural Resources and Environmental Control
Curtis Hardman	West Virginia Department of Environmental Protection
Tom Jordan, PhD	Smithsonian Environmental Research Center
Steve Stewart	Baltimore County , Environmental Protection and Sustainability
Al Todd	Alliance for the Chesapeake Bay
Ryan Winston	North Carolina State University
Jennifer Zielinski	Biohabitats, Inc.
Non-panelists: Neely L. Law (Coordinator, CWP & CBP Sediment Stream Coordinoar), Hannah Martin (CRC), Gary Shenk (CBPO), Matt Johnston (CBPO), Jeff Sweeney (CBPO)	

1.1 Background on Panel

The Expert Panel was convened by the Urban Stormwater Work Group of the Chesapeake Bay Program (CBP) to develop definitions and loading or effectiveness estimates for two new Best Management Practices (BMP), urban filter strips and stream buffer upgrade. Urban filter strips and stream buffer upgrades may be considered as separate practices or as a treatment train where the urban filter strip would be a pre-treatment practice and discharge groundwater and sheetflow surface-runoff to the stream buffer upgrade.

Urban filter strips (UFS), also referred to as vegetated filter strips (VFS) or grass filter strips, are designed to accept sheetflow from adjacent impervious and pervious areas, including roofs. To some extent, filter strips may provide similar functions as grass or riparian buffers that trap and filter sediment, uptake and infiltrate soluble nutrients. The six Bay States and District of Columbia include

UFS as an accepted stormwater BMP in their respective stormwater management manuals however, it is not an approved BMP by the CBP.

Currently, the stream buffer upgrade BMP is not defined by any of the Bay jurisdictions. Potential definitions for this BMP may include a change in land cover type from grass to forested land use, or be defined by a reduced minimum width requirement (e.g., less than 35 ft) to account for the space limitations and other conflicts (e.g. utilities, roads, stream crossings) in urban watersheds, or as combined stream buffer and UFS BMP treatment train.

1.2 Expert Panel Charge

The initial charge of the panel was to review all of the available science on the nutrient and sediment removal and runoff reduction performance associated with qualifying urban filter strips and/or stream buffer upgrade practices.

The panel was specifically requested to:

- Provide a specific definition of what constitutes effective urban filter strips and stream buffer upgrades as separate or combined practice(s) in the context of any nutrient, sediment and/or runoff reduction credit, and define the qualifying conditions under which such practices may be eligible to receive the credit.

- Review the current Chesapeake Bay Watershed Model (CBWM) assumptions to simulate the impact of grass buffers, forested and riparian buffers to agricultural and urban land uses and recommend how practice(s) should be represented in the CBWM.

- Define the information on implementation of retrofit and new practices implementation that local governments must report to the State to incorporate into the CBWM.

Beyond this specific charge, the panel is asked to:

- Determine whether to recommend interim treatment credits for UFS or urban stream buffer upgrade for watershed implementation plans (WIP).

- Determine the applicability of including conservation landscaping as part of the definition of this practice

- Recommend procedures for reporting, tracking and verifying any recommended urban filter strips/stream buffer upgrade credits over time.

- Critically analyze any unintended consequence associated with the credit and any potential for double or over-counting of the credit

While conducting its review, the panel shall follow the procedures and process outlined in the WQGIT BMP review protocol.

Section 2. Definitions and Qualifying Conditions

2.1 Definitions

Engineering Parameter: The volume of runoff from the contributing drainage area used to size stormwater best management practices (BMP). For structural BMPs with a storage volume, this represents the volume of stormwater retained by a BMP after a rain event. For non-structural BMPs such as vegetated filter strips or conservation areas, this represents the runoff volume that will be treated and potentially retained.

Impervious Flow Length: The length of the flow path of runoff through impervious cover toward the urban filter strip or other pervious area to which it drains for the purposes of promoting infiltration, filtration, and/or increase in the time of concentration of stormwater runoff.

Dimensions of urban filter strips (length and width): In reference to UFS described in this report:

> **Width** is perpendicular to the direction of flow and usually parallel to level spreader and equal to the length of the level spreader.
> **Length** refers to the distance of flow across the filter strip, and is usually perpendicular to the level spreader. *Note that the term "length" applied to an urban filter strip is referred to as the 'width' of a riparian buffers* (Figure 1).

Level Spreader: A device constructed to disperse concentrated runoff and create non-erosive sheetflow to a BMP or pervious area such as UFS and riparian buffers.

Runoff Reduction: The total runoff volume that is reduced through infiltration, canopy interception, or evaporation.

Runoff Reduction Credit: The portion of the annual runoff volume, measured as a percent that is reduced by a Runoff Reduction (RR) BMP.

Runoff Reduction (RR) BMP: A BMP that achieves at least a 25% reduction of the annual runoff volume through infiltration, canopy interception, or evaporation.

Stormwater treatment (ST) BMP: A BMP that is designed to reduce pollutants by sedimentation, filtration, plant uptake amongst other processes and achieves less than 25% reduction in the total annual runoff volume.

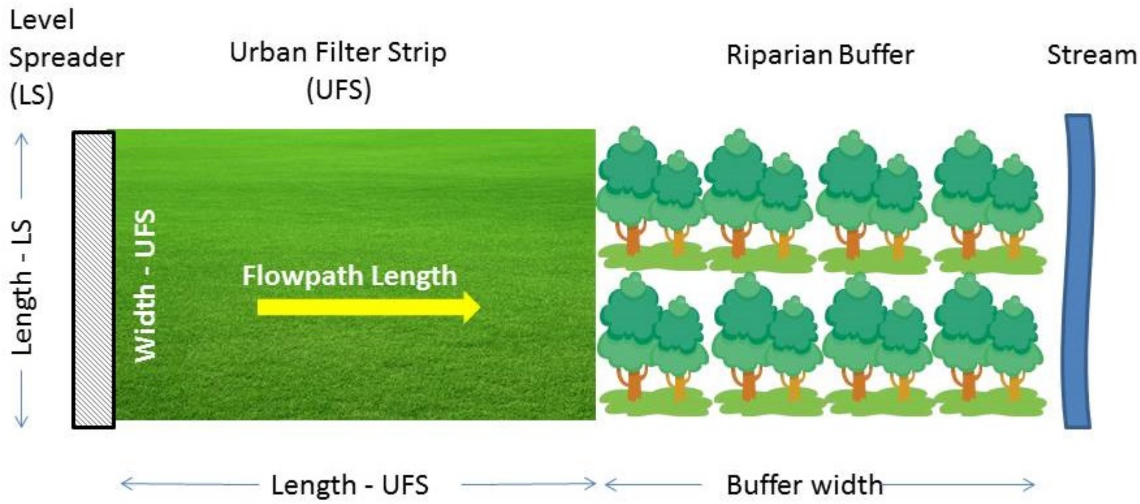


Figure 1. Dimensional elements of an urban filter strip.

Urban filter strip (UFS): A BMP designed to manage stormwater runoff draining from urban lands. Water quality benefits from urban filter strips are derived from both load reduction through infiltration and recharge as well as removal of pollutants through settling and filtration. UFS are stable areas with vegetated cover on flat to gently sloping land. Runoff entering the UFS must be in the form of sheetflow and at a non-erosive rate for the site-specific soil conditions. These are also commonly referred to as filter strips or vegetated filter strips. Refer to Sections 6.1 and 6.2 for detailed information on runoff reduction (RR) UFS and stormwater treatment UFS (ST).

2.2 Qualifying conditions

An urban filter strip may be used and receive pollutant load reduction as a stand-alone practice to treat relatively small impervious areas (e.g. 5,000 ft^2 or less) for new development, redevelopment or retrofit. Pollutant load reductions may also be applied to UFS if it were implemented as a pre-treatment practice as part of a retrofit. A list of qualifying conditions for this BMP (for both RR and ST UFS) includes the following:

- Sheetflow must enter the UFS and be maintained across the entire flow length to prevent the formation of preferential or concentrated flow and erosion.

- A 0.4 design ratio of filter strip length: impervious flow length is recommended for runoff reduction urban filter strips (Section 6.1) and 0.2 design ratio for stormwater treatment urban filter strips (Section 6.2). This applies to UFS that meet the maximum impervious flow length design criteria without use of an engineered level spreader or other flow dispersion device to dissipated concentrated flow (see Appendix C).

– Concentrated flow from a pipe, conveyance system or impervious cover lengths greater than 75 ft, must enter a low flow diversion or forebay and into a combination channel and level spreader (or other approved configuration) prior to discharging into the filter strip. These runoff conditions are likely to have runoff velocities that limit infiltration and/ or cause erosional channels within the UFS. Figure 2 illustrates an example of this design approach. This configuration is required in order to redirect concentrated flow when being channeled in line with the length of flow in the UFS and includes a trough or channel (similar structural element) to evenly distribute the flow along the lip of the level spreader.

– Level spreader (or other engineered flow dispersion device) length is based on 10ft for every 1 cfs (of the concentrated flow) with a maximum 100 ft length. This sizing criterion is based on basic hydraulic properties of weirs and a maximum desired flow velocity through grass. It is assumed that re-concentration of flow will not occur, or is minimized at flow rates lower then this permissible maximum flow velocity. Most recent research indicates that larger drainage areas cause nuisance conditions in the level spreader channel (sediment build-up, standing water and therefore, it is recommended that the level spreader be limited to 100 feet or less (Winston et al 2011). Appendix B explains the derivation of this qualifying condition.

- The maximum allowable drainage area to meet the above condition will vary depending on the percentage of imperviousness in the contributing drainage area and the volume of runoff requiring treatment by a particular jurisdiction. Therefore, the Panel was not able to recommend a universal sizing criterion for concentrated flow conditions based on drainage area

– Soils must be classified as Hydrologic Soil Group A, B, or C. Soil amendments are required for D soils or compacted (disturbed) soils to make their permeability equivalent to A, B, or C soils.

– Vegetated cover must be in good condition with minimal bare spots (i.e., 80% coverage uniformly distributed across the entire filter strip area).

– Minimize use of fertilizer and ensure its application rate is based on a site specific soil test.

– Not an applicable practice for hotspots[1] or where groundwater less than 3 feet from the surface (Winston et al. 2010).

This practice shall be designed and maintained in accordance with the qualifying conditions to receive pollutant removal credits for total nitrogen, total phosphorus and sediment and excludes the

[1] Stormwater hotspots are areas which produce higher concentrations of pollutants than normally found in urban runoff. Certain areas of the urban landscape are known to be hotspots of stormwater pollution. Examples include gas stations, parking lots, and auto recycling facilities. Generally, stormwater hotspots contribute 5 to 10 times higher concentrations of trace metals and hydrocarbons in stormwater runoff. These hotspots merit special management and pollution prevention activities.

use of conservation landscaping as part of the definition for this BMP. Manicured lawns, athletic fields, and other managed turf or pervious areas (that do not meet these conditions), cannot be used as UFS, however, other BMPs may be considered such as Urban Fertilizer Management (UNM, 2013).

It is important to consult your state stormwater reporting agency for state-specific design and hydraulic standards for UFS.

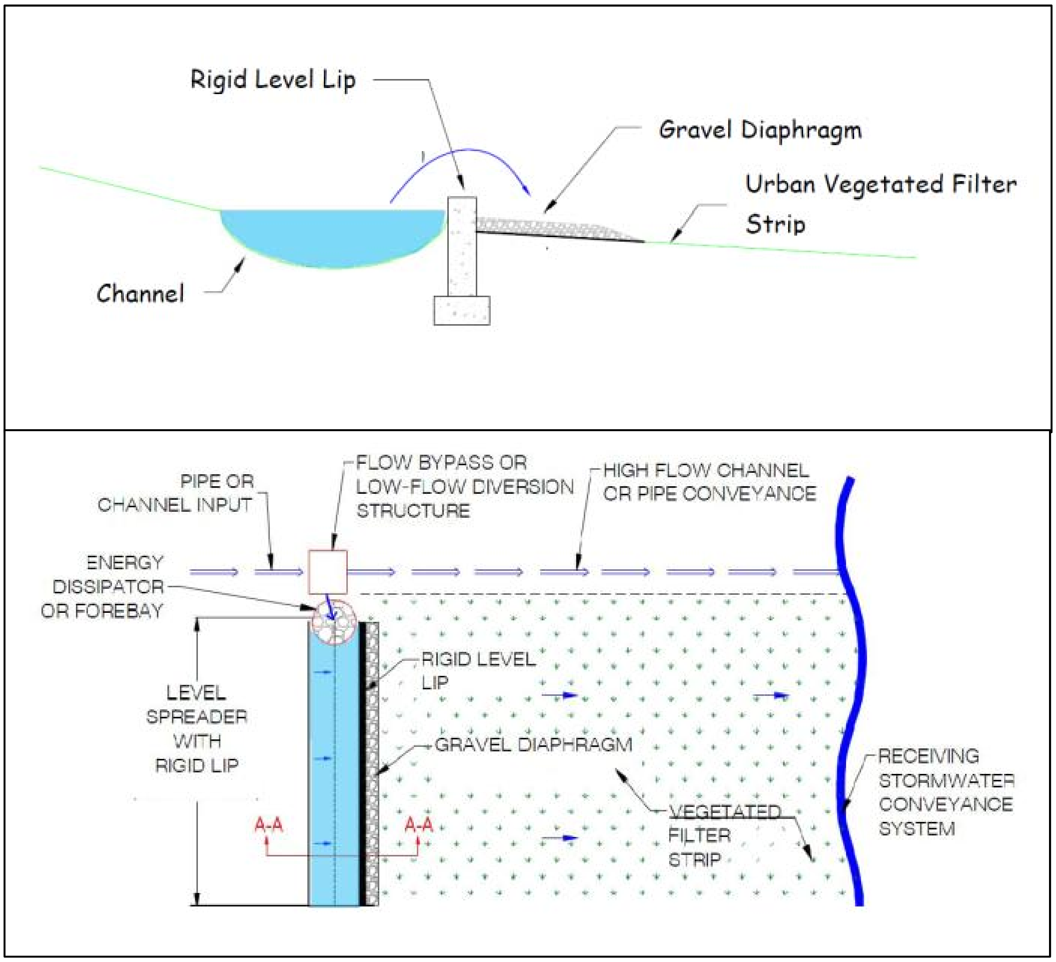


Figure 2. Example UFS design Plan and Section with water storage device to accept concentrated flow prior to discharge over level spreader. Adapted from: Winston et al. 2011, CWP 2012

Section 3. Background on Urban Filter Strips in the Chesapeake Bay

3.1 Application Urban Filter Strips

Urban filter strips are currently not available for pollutant load reduction credit from the CBP. Historically, filter strips were largely implemented in transportation land uses/highways (i.e., open section roads), used in combination with other BMPs as a pretreatment practice or as a recommended practice with riparian stream buffers (Magette et al., 1989). Compared to other runoff reduction practices, UFS can be used to treat smaller impervious areas (e.g. 1 acre) with relatively little engineering design specifications, yet provide effective runoff reduction. Consequently, UFS may have broader applications with increasing use of environmental site design for new development, or as a retrofit practice for redevelopment projects.

3.2 Chesapeake Bay Jurisdictions Stormwater Design Specifications

UFS are defined as a stormwater BMP in all of the six Bay States and the District of Columbia. Although, the specifications for UFS vary by jurisdiction, they have common characteristics which include: runoff must enter as sheetflow, concentrated flow converted to sheet flow with a level spreader or other flow dispersion device, low slopes (2-5%) with variable maximum slopes in order to maintain sheet flow conditions throughout the filter strip, and dense turfgrass or other vegetative cover. With the exception of Pennsylvania, all Bay States have similar limitations that specify a 75 ft maximum impervious flow length and 150 ft pervious flow path length that may drain to an UFS. Pennsylvania defines a maximum loading area ratio of 6:1 with a minimum 25ft length requirement for the UFS. The required dimensions of filter strips (i.e., length and width) differ amongst jurisdictions but are designed to treated impervious areas 5,000 ft^2 or less. The use of compost amendments to enhance infiltration capacity of hydrologic soil group (HSG) C and D soils is allowed in most of the Bay jurisdictions with the exception of Pennsylvania. However, Pennsylvania permits the use UFS on all HSG soil types. A summary of the design specifications included in each of the State's and the District of Columbia's stormwater management manuals is provided in Appendix C.

3.3 How nutrient loads from pervious areas are simulated in the context of the Chesapeake Bay Watershed Model (v.5.3.2)

The Chesapeake Bay Partnership models simulate the river flows, and associated transport and fate of nutrients and sediment that contribute to the Chesapeake Bay water quality. The Phase 5.3.2 Watershed Model (CBWM), in conjunction with an airshed, land use change models and Scenario Builder estimates nutrient reductions of various suites of management actions needed to protect water quality and restore living resources in the Chesapeake. Technical documentation for the CBWM and Scenario Builder can be found in USEPA (2010, 2012).

For modeling purposes, the Chesapeake Bay watershed is divided into land and river segments where edge-of-field pollutant loads from upland areas are reduced by management filters, or BMPs, before entering a simulated river (i.e., edge-of-stream loads). The load reduction from BMPs is based on approved pollutant removal efficiencies and/or land use conversions adopted by the CBP (see US EPA 2010 and updates at http://stat.chesapeakebay.net/). Currently, UFS or stream buffer upgrades do not have approved pollutant removal efficiencies. Load reductions from BMPs similar to UFS such as agricultural grass buffers receive a land use change conversion (e.g., from row crop to grass) and pollutant removal efficiency, whereas there is no load reduction gained from urban grass buffers because the practice is simulated as a conversion from grass to grass, or essentially no conversion. Documentation for these BMPs is provided in US EPA (2012).

The CBWM uses different submodels to simulate phosphorus (PQUAL), nitrogen (AGCHEM) and sediment. The sediment loss between the edge-of-field and edge-of-stream is incorporated into the CBWM as a sediment delivery ratio. Depending on the location of the river-basin segment in the watershed and the effect of reservoirs, as much as 70 to 85% of the edge-of-field sediment load is deposited before it reaches the main-stem of the Bay (U.S. EPA, 2010).

PQUAL simulates P dynamics within pervious lands, and AGCHEM is used to simulate N dynamics. The basic documentation for how the model simulates nutrient loadings and BMP reductions can be found in CBP (1998). The phosphorus simulation is fairly straightforward, and is represented in Figure 3. For each unit of pervious land, the model calculates the flow volume to surface runoff, interflow and groundwater.

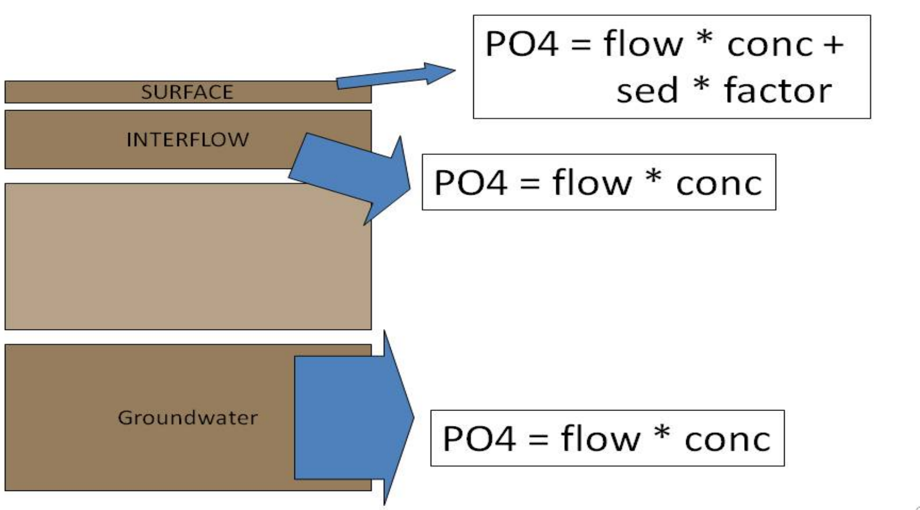


Figure 3. Representation of how P export is simulated in PQUAL module of the CBWM. Note: PO4 = phosphate. (Source: Presentation to Expert Panel by Matt Johnston, CBPO, February 19, 2013).

Atmospheric and fertilizer inputs are then applied, and the P export is defined based on the assumed concentration of phosphate and organic phosphorus for each of the three types of flows. The CBWM has a 50% sensitivity to P inputs, which basically means that only half of the fertilizer input is available for export (the rest is retained in the soil or by plant uptake). The P concentration factors are initially derived from literature and monitoring data, but are refined when the model is calibrated to regional water quality monitoring data.

The nitrogen simulation for pervious lands in CBWM operates in much the same fashion as phosphorus, with the exception that it includes the more complex N cycling process as different N species move through soils and plants and are modified by microorganisms (see Figure 4).
Atmospheric deposition and fertilizer are the two primary inputs, and exports are based on flow volumes and N concentrations in surface runoff, interflow and groundwater, respectively. The CBWM tends to be very retentive of fertilizer inputs, although they may be transformed into outputs of organic N under some circumstances.

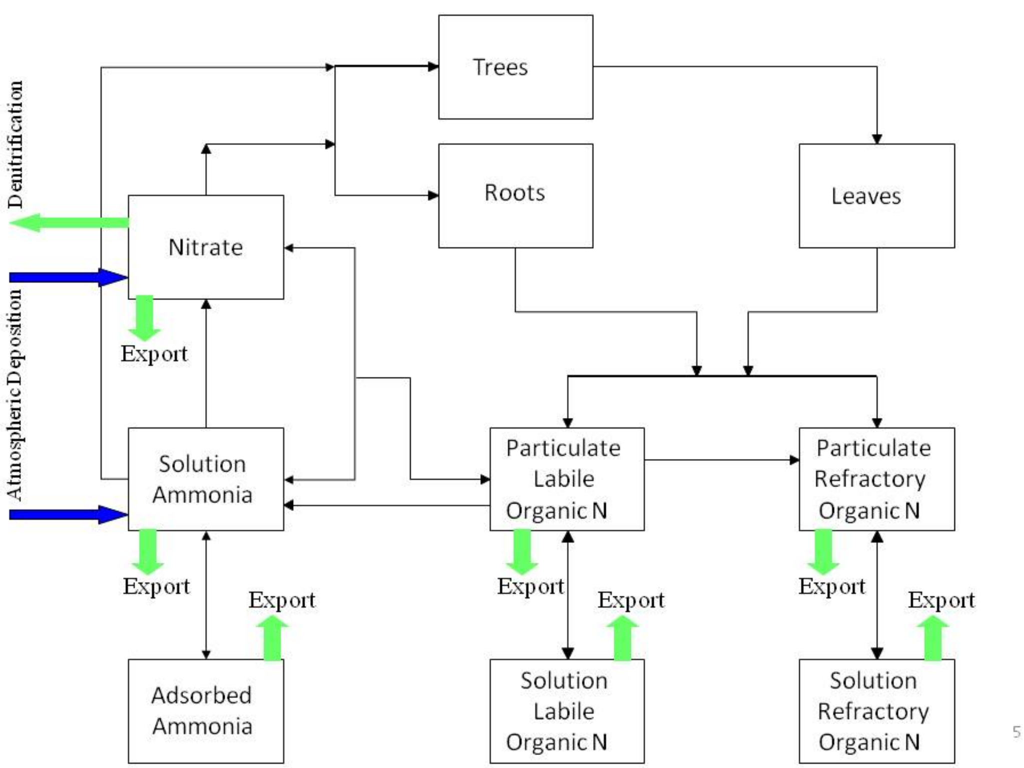


Figure 4. Conceptual diagram of nitrogen simulation for pervious lands in the AGCHEM module of CBWM (Shenk, 2012).

Section 4. Review of the Available Science for Urban Filter Strips

A total of 27 publications were reviewed by the Expert Panel to evaluate the pollutant removal effectiveness of the UFS, along with its runoff reduction capability. It was found that six publications were directly applicable to the scope of this expert panel (see Table 2). A majority of the applicable studies were field-based experiments and included the use of level spreaders to control the rate of inflow and create sheetflow conditions into the filter strip. Despite, the well-researched topic of vegetated filter strips in agricultural land uses, these findings were not directly considered in the panel recommendations given the differences in source area characteristics and design of the filter strips between agricultural and urban applications. Further, nutrient loading from agricultural land uses differ substantially from urban catchments. Research on turfgrass and agricultural filter strips, however, was considered in the panel's review of nitrogen leaching to groundwater as discussed in the following section.

4.1 Runoff Reduction

Vegetated filter strip studies focus on the runoff volume and surface runoff concentrations at the inlet and outflow of the BMP to estimate the percent runoff and mass load reductions. On average, UFS have moderate to high runoff reduction capabilities. Monitoring studies estimated runoff reduction volumes of 36% to 85% (Table 2) with individual events achieving negative to 100% runoff reduction (Hunt et al 2010, Knight et al 2013). The negative runoff reduction events were observed during high intensity storm events (Hunt et al. 2010), possibly from run-on from unaccounted drainage areas. In general, runoff reduction is attributed to high infiltration rates of the UFS (e.g. 5.1 cm/hr, Winston et al 2011); 14.2 cm/hr (Knight et al 2013) and well maintained vegetative cover that increases the flow resistance and slows the runoff velocity facilitating infiltration (Han et al 2005). However, this infiltration rate is dependent upon 1) the underlying soil type and 2) soil compaction imparted by construction equipment. The maintenance of filter strips is also critical to prevent the formation of gullies or erosional channels within the filter strip that may cause flow convergence, reducing runoff reduction, specifically in forested filter strips (Helmers et al 2005, Winston et al 2011). In some instances, the runoff reduction significantly increased with larger filter strip areas or lower hydraulic loading ratios (Hunt et al 2010, Knight et al. 2013) as well as soil characteristics that promoted infiltration. However, it appears that the area of the filter strip relative to the contributing drainage area (i.e., loading ratio) has a greater impact on runoff reduction compared to soil compaction or hydraulic conductivity (Table 3), where filter strips with loading ratios of 12 or 19 had higher runoff reduction compared to the loading ratios of smaller filters (i.e., 23 and 32). There were no significant differences in runoff reduction during periods of turfgrass dormancy versus growing season in the North Carolina Piedmont studies (Knight et al 2013).

Table 2. Reductions of runoff volume and event mean concentrations (EMC) of pollutants in runoff by urban filter strips. Reductions are expressed as percentages on the runoff input to the UFS. (*Bold items indicate outflow is significantly different compared to inflow as indicated in referenced paper)*

Reference	Loading ratio[1]	Runoff Reduction (%)	Load Reduction (%)			EMC Efficiency (%)		
		RR	TN	TP	TS	TN	TP	TS
Line and Hunt 2009	28	49	62	48		14	-11	70
Winston et al. 2011	51		49.2	45.6	73.1	-17	-27	51
	23		51.1	46.7	88.9	18	-2	67
	49					16	33	65
	26					32	40	72
Knight et al 2013	23	36	38	-42	82	13	-126	81
	12	59	62	22	93	15	-102	84
	32	42	58	53	90	40	2	89
	19	57	69	56	94	27	-46	91
Hunt et al. 2010	9	85						
Deletic and Fletcher 2006		20			74			
		60						
Han et al 2005	29				92			90
AVERAGE		51%	56%	33% (45%)[2]	86%			

[1] Loading ratio is the drainage area divided by the area of the filter strip
[2] The average mass removal increases from 33% to 45% if the negative value is not included. The -42% is attributed to the result of high soil P index values at the study site and relatively high loading ratio.

Table 3. Volume runoff reduction of four filter strips based on area and soil characteristics (from Knight et al. 2013)

	Runoff Reduction (%)	Soil Characteristics
Small FS[1], Unamended Soils	36	Compaction: 300 psi Hydraulic conductivity: 0.1 cm/hr (0.04 in/hr)
Large FS, Unamended Soils	59	
Small FS, Amended Soils	42	Compaction: 178 psi Hydraulic conductivity: 14.2 cm/hr (5.59 in/hr)
Large FS, Amended Soils	57	

[1] FS = filter strip

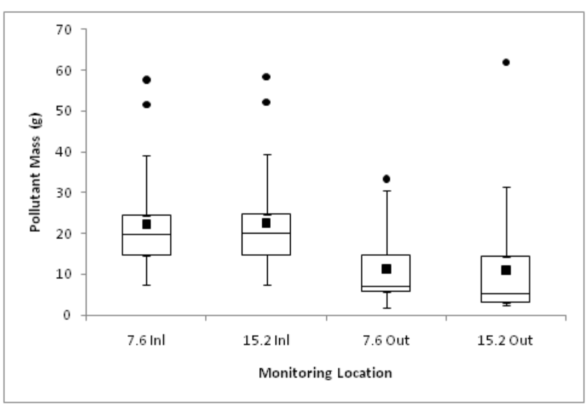
4.2 Water Quality

The major pollutant removal processes employed by UFS are deposition of particulate matter (and associated pollutants) and infiltration. This is based upon UFS research that limits monitoring to surface runoff and not subsurface hydrology or biological transformations. Biological uptake by plants and microbial immobilization, and denitrification, may provide additional pollutant removal of nutrients but there is limited research to quantify these processes in UFS. Research finds that vegetated filter strips do not effectively mitigate dissolved pollutants (Yu et al.1993). In general, the ability of UFS to trap sediment and infiltrate runoff is a function of the filter strip length, type and coverage of vegetation, soil type, slope, and flow rate of runoff. Maintaining dense coverage of vegetation is critical to the performance of UFS since it increases the flow resistance of runoff, which helps to reduce the flow velocity, enhances particle settling, and prevents resuspension of small particles (Han et al 2010, Deletic and Fletcher 2006).

In general, surface runoff loads are observed for UFS based on surface runoff volume measurements at the inlet and outlet of the BMP. The average runoff load reduction for sediment and nutrients is summarized in Table 2 with the highest load reduction for sediment, ranging from 73% to 94%. This is expected as vegetated filter strips are typically designed for sedimentation (Winston et al 2011). Winston et al (2011) found seasonal differences in sediment load reductions with significantly lower reductions during turfgrass dormancy periods. A similar effect was not found for TN and TP. Bench-scale experiments in Scotland, however, suggest that the majority of sediment trapping is within the first few meters of the filter strip, with smaller particles (5.8 microns) passing through the filter (Deletic and Fletcher 2006). However, longer or larger filter strips that create longer hydraulic retention times may provide greater opportunity for the fine sediments to settle out along with dense vegetation preventing resuspension during subsequent storm events. Knight et al (2013) found significantly greater TS load reductions from longer filter strips (e.g.66.5ft [20m] vs 26.2 ft [8m]) with smaller median particle size fractions in the effluent compared to influent (i.e., 13 to 56 microns compared to 30 to 140 microns).

The runoff nutrient load reduction from UFS is more variable compared to sediment. Nutrient load reductions range from 38% to 69% for TN and -42% to 56% for TP (Table 3). Similar to runoff reduction, the nutrient load reduction from individual experiments ranged from negative to positive and varied by form of nutrient (e.g. organic, inorganic, dissolved, particulate). Monitoring studies suggest a greater number of factors affecting the removal of nitrogen and phosphorus (when compared to sediment), including the phase (dissolved or particulate) of the pollutant and soil media characteristics. Although, sedimentation of particulate forms of nutrients and infiltration are likely responsible for the observed surface runoff load reduction, biologically-mediated transformations of particulate organic nitrogen within the filter strip may occur. Dissolved nutrients may be stored in the surface soil layer or taken up by vegetation. However, this storage of nitrogen may be transient as dissolved forms of nitrogen may be released from mineralization and nitrification, or leached from decomposing organic matter. Line and Hunt (2009) also acknowledge that dissolved nutrients infiltrating in this BMP may reduce the load reduction efficiencies as they may contribute to groundwater flow. This represents a change in the fate of the pollutant rather than sequestration or reduction in the dissolved pollutant load.

The net effect of UFS as a net source or sink for nutrients depends on sources, factors and processes that affect the speciation of nutrients within a filter strip. Denitrification and removal of grass clippings from the filter strip are the two permanent loss mechanisms for nitrogen. Overall, surface runoff studies demonstrate that larger filter strips cause greater reduction in TP and TN loads, for all species (Figure 5) (Winston et al 2011). Similar to runoff reduction and sediment, the longer flow path length (i.e., length of filter strip) facilitates trapping of particles and provides greater opportunity for infiltration of dissolved nutrients as runoff velocities decrease through the length of the filter strip. The reductions for TKN, $NO_{2\text{-}3}$, NH_4, and Ortho-P in surface runoff were all significantly greater for the larger filter strips. Winston et al (2011) noted that the reconcentration of flow in the forested filter strip may have accounted for the lack of significantly lower organic-N and particulate-bound phosphorus loads.



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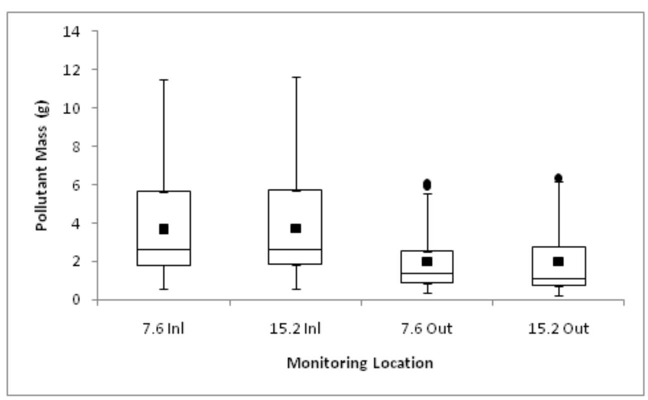

b)

Figure 5. A comparison of mass loading of a 7.6m grass and 15.2 grassed and wooded filter strips in Louisburg, NC for a) total nitrogen and b) total phosphorus. (from Winston et al 2011)

The sources of nutrients to, and within the filter strip will also affect the performance of UFS. Influent concentration of N and P that are below the 'irreducible concentration' (see Strecker et al 2002) may not be further reduced by the BMP and result in a negative or no load reduction. The TN concentrations in urban runoff are typically around the irreducible concentration of about 1.1 mg/L, with TKN comprising the majority of nitrogen in urban stormwater runoff (Maestre and Pitt 2006). These low influent concentrations of both TN and TP may cause reduced pollutant removal efficiencies in UFS (Winston et al 2011, Knight et al 2013, Line and Hunt 2009). Conversely, spikes in inlet concentrations of dissolved N and P in the catchment enhanced N and P removal by surface runoff by 70% (Winston et al 2011). The solubilization or release of P within the filter strip may be an additional source of nutrients and affect UFS performance. Knight et al (2013) found that increases in runoff TP concentration within the filter strip were likely due to solubilizing soil P. This was observed for soils with high soil P index values of 83 to 90 compared to filter strips with low index value (e.g., 19). The release of nutrients from decaying vegetation may also be an internal source of P. External sources of leaf litter from nearby trees may add detritus to the filter strip and become a potential new source of phosphorus leachate. Leaf litter may also provide an additional nitrogen source that is susceptible to microbial decomposition and transfer to other N-pools within the filter strip.

4.2.1 Nitrogen Loss to Groundwater

Research studies on UFS acknowledge the limited capacity of urban filter strips to treat nitrate compared to TP and TS. The load removal rates for TN shown in Table 2 are based on surface runoff measurements. However, the major removal process for TN is assumed to be infiltration, therefore the fate of nitrogen once infiltrated is uncertain. Resultantly, the expert panel explored turfgrass research and agricultural vegetative filter strip studies to better understand the fate of nitrogen, specifically infiltrated nitrate. These two research areas were explored for information purposes only, given the differences in the management and sources of nitrogen for turfgrass and agriculture vegetative filter strips.

Turfgrass

A study on the mass balance of turfgrass fertilizer (Raciti et al 2011) found, on average, that approximately 12-14% of the TN applied to a suburban-type lawn leaches below the rooting zone (Table 4). An increase in nitrate leachate is observed with increase in the amount of watering and fertilizer application rates to turfgrass. For example, Morton et al (1988) compared nitrate leaching from two fertilizer treatments and two watering treatments and found that nitrate leaching approaches 5% with high fertilizer application rates and increased to approximately 32% when the watering treatment increased by 50%. The amount of nitrate leaching remained under 3% when no fertilizer was applied and the watering treatment increase. This scenario of no fertilizer applications and water treatment correlates best to implementation of UFS; although is still only applicable in a broad sense.

Table 4. Nitrogen budget for a lawn in Baltimore, MD (from Raciti et al. 2011)

	Kg N ha^{-1} yr^{-1}	Lb N ac^{-1} yr^{-1}
N Inputs		
Atmospheric Deposition	11	10
Fertilizer	98	87
N Losses		
Nitrate Leaching	14	12
Denitrification to N_2	14	12
N Accumulation		
Soil	83	74

The review of the turfgrass science literature on nitrogen fate provided additional insight regarding nitrate leaching; however, differences in the site and management conditions within UFS limits a direct application of the turfgrass research. Table 5 highlights a few of the key differences between managed turfgrass and UFS. Further, it is unlikely the assumption of a constant percent removal (where the biological uptake rate of nitrogen from turfgrass increases in proportion to the load) applies to urban filter strips. This is probably due to urban stormwater runoff characteristics where the nitrate load to the urban filter strips increases with water volume while the average concentration remains nearly constant following first flush. However, if there was a disproportional nitrogen load in the upper slope of UFS, it would likely result in observation of differential quality in the turfgrass (e.g. poorer turfgrass health downslope) along with higher soil moisture near the upslope end of the filter strip or level spreader. This is not the case as observed in field studies in North Carolina where runoff flows through the length of the filter strip.

Table 5: Differences between managed turf and urban filter strips.

	Managed Turfgrass	Urban Filter Strips
Water Input	Precipitation plus watering during dry periods in growing season	Precipitation plus extra surface inflow during runoff events throughout the year in amounts proportional to runoff
N Input	Dry pellets commonly as urea applied during growing season	Organic N, NH_4^+, and NO_3^- mixed in water at about 2 mg N/L (CBWM) and input during runoff events throughout the year
Spatial distribution of inputs	Inputs evenly distributed	Inputs initially concentrated at the uphill edge of the strip but may disperse more evenly across the entire length of the filter strip as the runoff continues to enter the practice

Agricultural Vegetative Filter Strips and Buffers

There is limited research to quantify the fate of infiltrated nitrate in vegetative filter strips. Two studies by Verchot et al (1997) and Bedard-Haughan et al (2004) provide the most complete analysis of different forms of nitrogen within a vegetated filter strip. There are five potential pathways for dissolved nitrogen in surface runoff and include: denitrification; leaching to water table; microbial immobilization, plant uptake and removal of clippings from the filter strip. Dentrification and removal of clippings are the two permanent removal pathways for nitrogen. The storage of nitrogen in plant material and surface soils are considered transient, or temporary as they may be transformed to dissolved forms of nitrogen and exported from the filter strip later, similar to nitrogen reaching groundwater. Both Verchot et al (1997) and Behard-Haugh et al (2004) found the majority of dissolved nitrogen entering a vegetated filter strip or buffer is taken up by plants or stored in the surface soil layers. This nitrogen undergoes subsequent nitrification or ammonification within the filter strip. Less than one percent was denitrified (Verhcot et al 1997) given the aerobic conditions present in UFS. Neither study quantified the removal of nitrogen from clippings; although this may be estimated from nutrient content of turfgrass and other assumptions about the quantity of clippings generated per mowing period. Although the potential for denitrification is high in vegetated filter strips, the rate of denitrification is based on specific site conditions of oxygen or anaerobic conditions, available nitrate and organic matter. Groffman et al (1991) found that denitrification rates were low when oxygen is present and there is an absence of nitrate and carbon from organic matter. The dry-wet cycles experienced by filter strips between runoff events and the typically low concentrations of nitrate in urban stormwater runoff and aerobic conditions, may not provide the conditions needed for denitrification.

Section 5. Review of the Available Science: Urban Stream Buffers

Currently, the stream buffer upgrade BMP is not defined by any of the Bay jurisdictions nor the CBP. As such, the scientific literature review focused on research to provide a definition for this BMP that 1) may reduce the minimum required width for urban forest buffers and/ or 2) as a some type of combined practice with UFS.

The Expert Panel began with a review of the existing urban forest buffer BMP definition approved by the CBP. US EPA (2012) states an urban forest buffer is

> (a)n area of trees at least 35 feet wide on one side of a stream, usually accompanied by trees, shrubs and other vegetation that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals (p. 8-135).

The CBP definition assumes that sheetflow conditions must exist through the forest buffer to receive the TP, TN and TS reduction credits of 25%, 50% and 50%, respectively. The Chesapeake Bay Program (2006) documents the recommendations for removal efficiencies where buffer width varied in relation to buffer function; 12 m for sediment removal and 28 m for removal of soluble nutrients. Despite the variable removal efficiencies for grass and forest buffers in agricultural watersheds by physiographic region, the workgroup provided singular removal efficiencies for urban forest buffer.

The current definition of urban forest buffers guided the literature review by the Expert Panel to focus on research to support urban forest buffers that are less than 35 feet wide **and** in urban areas. It was important for the panel to limit the literature to urban areas given the impacts to urban streams that affect the performance of buffers. Land use land cover, storm drainage infrastructure and source loadings differ in urban watersheds compared to agricultural and forested watersheds.

The Expert Panel reviewed synthesis reports on riparian buffers as well as individual studies. Studies by Groffman et al. (2003), Stewart et al. (2005), Gift et al (2010) and Bettez and Groffman (2012) focused on urban riparian areas or buffers. A recent review by Sweeney and Newbold (2014) on streamside forest buffer width provided limited analysis of urban watersheds and defined narrow buffers as less than approximately 100-ft (30m). This research review concluded that adequate removal of sediment requires widths substantively wider than 33-ft (10m) and narrow buffers yield higher removal where water flux is low; however few studies documented water flux across buffers. The review by Wegner (1999) and Mayer et al. (2007), although comprehensive, did not address forest buffers in urban areas.

Central to the pollutant removal capacity of stream buffers is the settling and infiltration of surface runoff as it travels through the buffer where infiltrated nitrate is subject to plant uptake and denitrification along subsurface flowpaths. In urban areas, runoff from adjacent impervious surfaces may be directed to storm drain inlets that discharge directly to the stream circumventing surface runoff through the buffer, and thus reducing pollutant removal opportunities. Where surface runoff does occur within a forested buffer, the re-concentration of runoff is observed to create erosional channels (Helmers et al 2005, Winston et al 2011). These erosional channels may result in a net export of sediment to streams, while also minimizing opportunities for denitrification (Bettez and Groffman 2012).

The nitrogen removal capacity of forest buffers is well-documented in the literature and is largely a function of vegetative uptake or denitrification. Since Wenger (1999), research finds the subsurface removal of nitrate is related more to the hydrologic flowpaths rather than buffer width (Mayer et al 2007, Spieran 2012). The effect of urbanization on stream geomorphology with increases in bank erosion and streambed incision disconnects the stream channel flow from the floodplain, lowers the groundwater table affecting nutrient processing by the forest buffer. Groffman et al (2003) refer to the lowering of water tables as *hydrologic drought* which alters pollutant removal functions of the buffer to the degree that riparian areas may be a source rather than a sink for nitrate. The restoration of urban streams that reconnect the stream-riparian interface results in higher denitrification rates compared to unrestored streams as found by Kaushal et al (2008) and Mayer et al (2013) in Baltimore County, MD.

The only study the expert panel found to directly address the effectiveness of urban forest buffers was completed by Baltimore County (Stewart et al. 2005). The study compared two buffer classes defined as 100-feet wide buffers on either side of a headwater stream with 1) 75% or more forest cover, or 2) less than 40% forest cover. The study did not evaluate the change in pollutant loads from the inflow and outflow of the buffer themselves. The forest buffers were all located in drainage areas with some level of urban development (Table 6). Overall, the study found that greater amounts of forest cover increased the benefit provided by the buffer to include water quality, peak flow, temperature, biological and stream channel conditions. Pollutant loads for total solids, TKN, TP and ortho-P were all significant lower in the buffers with higher forest cover.

Table 6. Baltimore County Urban Forest Buffer Study Sites (selected characteristics)
Source: Stewart et al 2005

Study Area Characteristics	Low Buffer Study Areas			High Buffer Study Areas		
	DR2A	DR1A	LGF4	LGF3	RR4	UGF3
Size – acres (hectares)	414.2	277.6	213.6	201.7	187.8	147.7
Drainage density (mi./ sq. mi.)	0.8	1.1	2.3	2.3	2.6	1.4
% of buffer forested	27	35	36	79	75	67
% controlled by SWM[1]	36.7	60.2	48.3	23.3	77.1	89.2
% impervious	30.2	45.1	35.8	10.6	15.7	17.3
% piped with SWM to outfalls inside the buffer	37.4	38.3	6	17.7	0	58
% piped without SWM to outfalls inside the buffer	45	24.5	57.9	13.5	0	0

[1] SWM = stormwater management

Section 6. Protocols to Define Nutrient and Sediment Removal Rates

6.1 Volume Reduction and Pollutant Removal Rates for Runoff Reduction (RR) Urban Filter Strips for New Development, Redevelopment and Retrofit Projects

The *New State Stormwater Performance Standards* and *Urban Stormwwater Retrofit* expert panel reports define a new approach to estimate pollutant load reductions by stormwater BMPs (SPSEP 2012, SRPEP, 2012). The approach uses BMP pollutant removal rate adjustor curves (i.e., performance adjustor curves) for TN, TP and TS to define the percent pollutant removal based on the runoff depth captured. An example curve for TP is shown is Figure 1 for BMPs implemented at new or redevelopment projects. The runoff depth captured is the volume of runoff, in acre-feet, from the contributing drainage area that is used for sizing the stormwater BMP divided by the site or impervious area as defined in SPSEP (2012) and SRPEP (2012). The volume of runoff directed to a BMP is defined by each Bay State's stormwater compliance methods. The runoff depth captured is shown on the 'x-axis' in the nutrient and sediment performance adjustor curves (e.g., Figure 6). Although, urban filters strips are included in the list of runoff reduction (RR) BMPs in SPSEP (2012), they are not currently defined by Chesapeake Bay Program as an approved BMP.

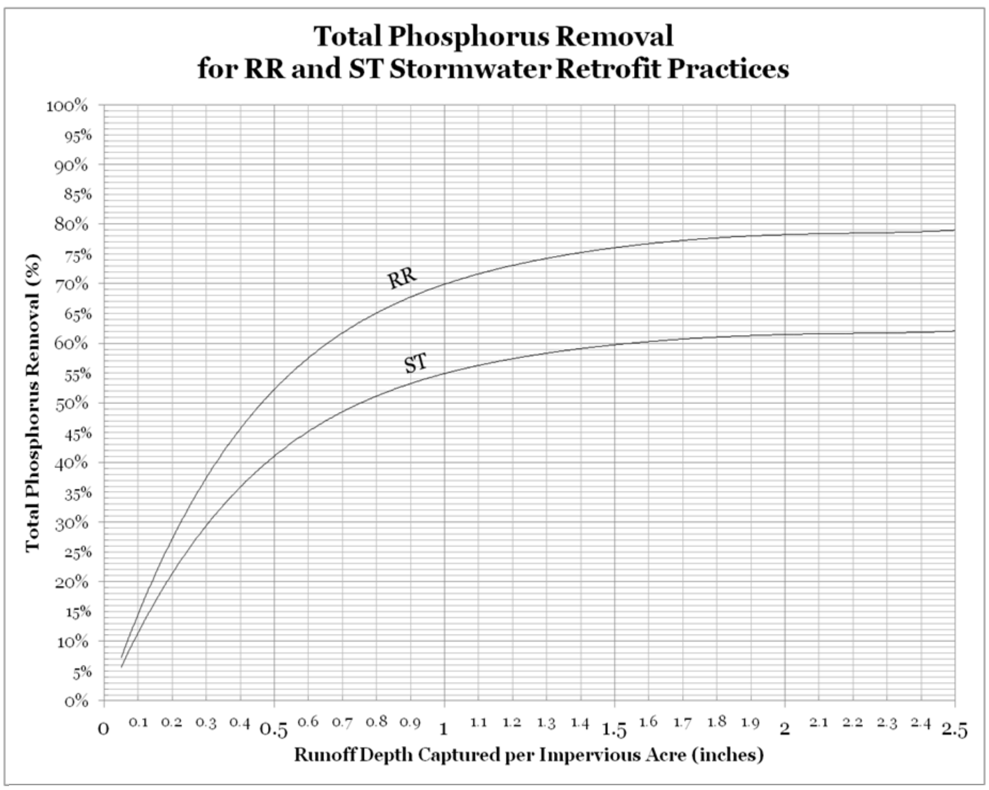

Figure 6. Percent phosphorus removal for runoff reduction and stormwater treatment (SPSEP 2012). Note: RR = runoff reduction BMPs and ST= stormwater treatment BMPs

An estimate of the pollutant removal that may be achieved for UFS was explored by the Expert Panel using the methods defined by SPSEP (2012). The Panel concluded the methods to standardize the runoff volume treated by an urban filter strip differed from other runoff reduction practices. The primary difference between UFS and other runoff reduction practices, such as bioretention, is that UFS are not designed to 'capture' or store runoff volumes. The primary pollutant removal processes for UFS are trapping particulates (sediment-bound pollutants) and infiltration as stormwater flows through the practice. Consequently the engineering design methods that use runoff volume or storage to size runoff reduction or infiltrating BMPs thereby allowing for a scaled performance credit as provided in the performance adjustor curves, do not apply to UFS and an alternative method to standardize the pollutant removal credit was needed.

Each Bay jurisdiction varies in its method to estimate the volume of runoff reduced by UFS. These methods assume the UFS reduces the runoff volume if the jurisdictional design criteria are met and vary from 10% to 100% runoff reduction, or are calculated based on UFS and drainage area characteristics. For example, the runoff reduction credit in DC and West Virginia is based on the vegetated area of the UFS. In Maryland, the runoff reduction credit is based on the ratio of the urban filter strip and impervious flow lengths that varies between 0.2 and 1. In Virginia, the runoff reduction credit is assumed to be 50% of the design runoff volume entering the practice. New York and Pennsylvania assume that 100% of the runoff entering the filter strips is reduced or retained. Following the procedures described in SPSEP (2012) and SRPEP (2012), these criteria formed the basis of the engineering parameter with which to estimate the runoff depth captured (or more appropriately described as treated) using the performance adjustor curves (e.g., Figure 6).

Table 7. Example methods to estimate runoff volume reduced by urban filter strips in each of the Bay jurisdictions.

DC	DE	MD	NY	PA	VA	WV
For compacted cover, reduce volume conveyed to grass area by 2.0 cu. ft. per 100 sq. ft. of pervious area.	Based on soils and vegetation ranging from 10% to 40%	Up to 1 inch credit provided based upon ratio of Disconnection (filter strip) and contributing (impervious cover) flow lengths varies between 0.2 and 1	100% runoff reduction volume (RRv) credit	100% runoff reduction volume credit	50% runoff volume reduction for treated area	Reduce volume conveyed to conservation area by 0.06 cu. ft per sq. ft. of conservation area. (6 cu.ft per 100 sq ft)

The Panel members applied a hypothetical project design in an attempt to standardize the size of the filter strip, and then estimate the resulting runoff depth treated. The design example is shown in Box 1 and provided the minimum site requirements needed to implement an urban filter strip (see also Appendix D). The stormwater design criteria from each of the seven Bay jurisdictions (Appendix B) were used to estimate the volume of stormwater runoff and corresponding depth of runoff generated from the hypothetical parking lot site. Each jurisdiction's method for estimating the volume of runoff reduced by UFS (Table 7) was then applied, with the reduced volume (or depth) of runoff equating to the engineering parameter or 'Runoff Depth Captured' on the performance adjustor curves.).

Box 1: Hypothetical Parking Lot Vegetated Filter Strip Design Example

An UFS is designed to treat runoff form a parking lot with the following characteristics:

- Parking lot configuration consists of a drive aisle (24 ft) with parking spaces on either side (18 ft) for a total flow length of 60 ft (< 75 ft);
- Long edge of parking lot is 180 ft, for a total of 10,800 ft^2 or 0.25 ac

A summary of the runoff depth estimates using the hypothetical design example is provided in Table 8. This example resulted in a range of calculated runoff depths from 0.19 to 0.96 inches to apply to the performance adjustor curves. The Bay jurisdictions' methods as specified in their respective stormwater guidance (see Appendix C) estimated TP pollutant load removals from 28% to 72%, TN pollutant removals from 22% to 60% and 28% to 75% for TS. While the performance adjustor curves estimate TN and TP removal within these ranges, research on UFS generally does not support the upper end of the estimated percent pollutant removal; on the other hand, UFS research supports a higher TS value.

Table 8: Runoff depth estimated using hypothetic design example for an urban filter strip.

	DC	DE	MD[1]	PA	NY	VA	WV
volume reduction (cu ft)[2]	288	450	171 - 855	1,653	855	428	378
Runoff depth captured (in) using New State Stormwater Performance Method	0.32	0.50	0.19 – 0.95	1.8	0.95	0.48	0.42
Runoff reduction (%)	28	20	8-38	100	99	50	44

[1] The values for MD represent the range in P_e available for urban filter strips and range from 0.2 , 0.4, 0.6 to 1.0.

[2] The volume reduction is based on the hypothetical design example provided in Appendix D with an impervious area of 10,800 ft^2

In summary, the following observations were made by the Expert Panel

- Monitoring studies support UFS Chesapeake Bay Program definition of a runoff reduction practice (e.g. reduces annual runoff reduction by at least 25%).
- A wide range of runoff volume reduction from UFS results from the State and DC defined methods; up to 100% by New York State (see Table 6). The volume of runoff reduced by an UFS varies with the characteristics of the contributing drainage area and site characteristics;

there is no volumetric stormwater capacity for UFS other than through infiltration into the soil. This suggests that UFS will perform better in sandy soil conditions

- The literature review (Table 3) suggest that UFS may reduce inflow runoff volume by 36% – 85%, and that larger filter strips relative to the contributing drainage area generally results in a higher percentage of runoff volume reduction
- There is a potential wide range in pollutant removal by UFS depending on the method used to estimate runoff depth captured

Based on these observations, the Expert Panel recommends the method developed by SPSEP (2012) and SRPEP (2012) be modified to estimate nutrient and sediment pollutant removal rates for UFS. Specifically, the Expert Panel recommends that the 'runoff depth captured per impervious acre' for the UFS entered into the performance adjustor curve be based on an average of the results presented in Table 8. The Expert Panel recommends this value be set at 0.5-inches and be constrained by a minimum UFS sizing ratio. A minimum sizing ratio of 0.4 is recommended and is based on the State and DC design specifications for a minimum UFS flow length and a maximum impervious flow length. The length of the filter strip is a major design feature affecting its runoff reduction capacity and associated pollutant removal. The UFS design criteria and sizing requirements by each of the Bay States and DC typically have a maximum impervious flow path length of 75ft (without the use of a level spreader) and a representative minimum UFS length of 25-35ft; and the required minimum length of the UFS may vary with the slope of the UFS (see Appendix C). These design criteria establish the basis for the qualifying conditions for the minimum sizing ratio for Bay jurisdictions to receive pollutant load reduction credits for UFS. This approach is consistent with methods described by SPSEP (2012), and reduces the variability demonstrated in the pollutant removal estimates using the states and DCs currently accepted methods for compliance.

Resultant percent pollutant removal for TN, TP and TS are summarized in Table 9. The pollutant removal TP and TS are based on a 0.5-inch runoff depth captured on the performance adjustor curves provided in Schuler and Land (2013a) and assumes the major pollutant removal process is trapping of sediment and associated pollutants. The research studies were limited to the evaluation of UFS performance through surface runoff monitoring and therefore the findings on the fate of infiltrating soluble nutrients, specifically nitrogen, is uncertain. The TS pollutant removal is lower compared to research studies, however the panel recommends this conservative value given the performance of BMPs in the field compared to those BMPs maintained during monitoring studies that are designed and maintained to maximize performance as part of the experimental study design. The Expert Panel assumed that the TP removed by the filter strip was largely associated with sediment, although TP may convert to dissolved forms and infiltrate to groundwater, reducing this mass reduction from surface runoff.

The TN credit was much deliberated amongst the Expert Panel members, with a general consensus to limit the TN reduction to 20%, despite the lack of research to document the reduction of nitrogen once infiltrated. The 20% TN reduction is based on a conservative estimate by the majority of the Expert Panel assuming that only the particulate-fraction of TN in runoff is removed, while the soluble fraction is infiltrated to groundwater. The Expert Panel acknowledged the potential for additional nitrate export or loss from the filter strip. One possible source is organic N that settles out with sediment within an UFS can breakdown to ammonia or ammonium that is then available to undergo nitrification in the soil and export as nitrate in surface runoff or in groundwater. Thus it is possible that any form of nitrogen removed from runoff entering an UFS could eventually be released to groundwater as nitrate. Nitrate leaching to the groundwater could offset the removal of nitrogen from runoff resulting in no net reduction in nitrogen discharge from the watershed. Given that nitrate leaching under UFS has not been studied and that UFS are designed to facilitate infiltration of runoff to groundwater, one of the panelists (Jordan) felt that UFS should not be given credit for nitrogen removal. An explanation of the method to calculate the 20% TN reduction is provided in Appendix E.

Table 9: Recommended pollutant removal rates for urban filter strips as a RR BMP.

	TN[1]	TP[2]	TS[2]
0.5" Runoff depth captured	20%	54%	56%

[1] TN removal is based on particulate-N only and assumes that particulate N removed is not converted to nitrate and leached to groundwater. No credit is provided for dissolved N.
[2] The percent pollutant removal is estimated using the 0.5" rainfall depth capture for the TP and TS performance adjustor curves provided in SPSEP (2012).

6.2 Pollutant Removal Rate for Stormwater Treatment (ST) Urban Filter Strips

The early design and pollutant removal function of urban filters strips was focused on particulate matter, or coarse sediment in urban runoff. However, there is limited research to define pollutant removal rates for filter strips designed for sediment trapping. Typically, the design of these older filter strips are 10-15 ft in length (Greer, pers. comm) and pre-dated Bay State and the Districts current stormwater design specifications for UFS. Given their use throughout the Bay jurisdictions, the Expert Panel used best professional judgment, combined with the credit development process for new filter strips to recommend a pollutant removal rate for urban filter strips that were designed to trap **sediment only** and were considered a **stormwater treatment (ST)** BMP.

The TS pollutant removal rate for new urban filter strips for stormwater treatment with a 0.5" runoff depth captured is equivalent to approximately 56%. This pollutant removal rate is used as the basis to define the pollutant removal rate for an older, stormwater treatment UFS and is discounted with the following factors and implemented with the given qualifying conditions:

- Reduce minimum 0.4 sizing ratio to 0.2, or by 50 %. The minimum 0.4 ratio assumes a UFS minimum flow path length of approximately 25- 35ft and a maximum runoff source flow path length of 75ft. A 0.2 ratio assumes a minimum filter strip width of 15ft

- Apply an 80% reduction based on the percentage of coarse sediment typically associated with urban runoff based on research by Law et al. (2006) (Appendix F).
- Designed and installed consistent with state BMP criteria at time of implementation.
- Treatment limited to coarse sediment
- Recorded as BMP by the reporting jurisdiction
- Runoff enters and continues as sheetflow through the filter strip. Level spreader is not required
- BMP is well-established and maintained to ensure performance
- Subject to tracking and verification requirements

Resultant TS pollutant removal rate for older, stormwater treatment filter strips is summarized in Table 10.

Table 10. Recommended pollutant removal rate for UFS as a ST BMP.

	TN	TP	TS
0.5" Runoff Reduction depth	n/a	n/a	22%[1]
[1] 56% x 0.5 discount sizing factor x 0.8 particle-size discount factor			

6.3 Pollutant Removal Rate for Stream Buffer Upgrade for New Development, Redevelopment and Retrofit Projects

The Expert Panel currently does not provide a recommendation for stream buffer upgrades as an urban BMP because there are insufficient data to evaluate the function of stream buffers within an urban area and the inability to differentiate this BMP from existing urban BMPs approved by the Chesapeake Bay Program. The following definitions for stream buffer upgrade BMPs were explored by the Expert Panel.

1. Define as a stream buffer with less stringent width requirements compared to existing urban forest buffer.

   Narrow buffers often provide multiple benefits, including some benefit to water quality, however there is insufficient research 1) specifically on the water quality benefits of narrower buffers (less than 35 ft minimum, CBP definition) and 2) urban buffers, in general. Although, Mayer et al (2007) identified studies with pollutant removal in buffers less than 15 ft (5m) in width, the reported efficiencies were variable and were not in urban areas. Further, nitrogen removal occurs largely via shallow groundwater flowpaths compared to surface runoff and subsurface removal may not be related to buffer width. As such, it would be expected that narrower buffers would not have a significant impact on the reduction of nitrogen.

2. Define stream buffer upgrade on an area basis whereby the minimum width issue is avoided.

   The Chesapeake Bay Watershed Model currently uses acres of buffer to quantify the load reduction from the BMP. The smaller acreage practice, such as those urban buffers with a narrow width, automatically get apportioned less water quality benefit. However, this assumes or uses an average width provided by the jurisdictions. Although the area approach may be an option, this practice could alternatively be counted as urban tree planting (Expanded Urban Canopy BMP) currently credited by the CBP.

3. Define this practice as a treatment train with a vegetated filter strip located upslope of the buffer.

   A review of the CBP definition of urban forest buffer in US EPA (2012) provides minimal requirements or qualifying conditions for this BMP. However, the recommended 3-zone design approach to implement urban forest buffers includes an outer zone to manage runoff from adjacent surfaces that is typically herbaceous in nature. The Expert Panel agreed that this outer zone would be similar in function and design as an urban filter strip and would result in double-counting load reductions that may be credited to urban forest buffers. The function of this outer zone, is in part to create sheetflow conditions to the forested buffer.

4. Upgrade a grass buffer to a woody vegetated, forest buffer.

   This BMP is currently defined as an urban grass buffer in the CBWM.

5. Upgrade stream buffer to provide hydrologic connection with the stream channel during baseflow and storm events.

   The expert panel considered the stream buffer as an upland BMP that has a hydrologic connection to the stream channel. As such, pollutant removal through a stream buffer should consider the pollutant removal mechanisms and processes throughout the buffer, from the upland edge to the stream edge, both surface runoff and shallow groundwater flowpaths. Bank erosion and stream incision in headwater streams limits the deposition of sediment in adjacent floodplains and lowers the groundwater table limiting denitrification. The Urban Stream Restoration Expert Panel report (Stream Restoration Expert Panel, 2013) recommends a credit for nitrogen removal during baseflow conditions (Protocol 2) and a credit for floodplain reconnection (Protocol 3).

Section 7. Accountability Mechanisms

The verification of individual BMPs is a critical element to ensure that BMPs continue to reduce pollutants as designed following implementation and for the expected life of that BMP. The guidance for verification is based on SPSEP (2012) and SRP (2012) for new development, redevelopment and retrofits, USWG (2014) with additional information specific to design elements that may affect UFS performance.

Basic Reporting Unit. Reporting entities will track the number of treated acres each year that fully meet the expert panel qualifying UFS BMP definition. The typical duration for the UFS removal rate for new development will be twice the prescribed MS4 inspection cycle, which ranges from 6 to 10 years. The removal rate can be extended if a field inspection verifies the BMP(s) are still performing.

State BMP Reporting Systems. Each state has a unique system to report BMPs. In some cases states have incorporated these reporting requirements into their MS4 Permit annual reporting, while the reporting process for non-MS4 jurisdictions and other entities are still being developed. To get credit for load reductions in the context of CBWM progress runs, states will need to report BMP implementation data using CBP-approved rates or methods, reporting units and geographic location (consistent with the National Environmental Information Exchange Network, NEIEN standards), and periodically update data based on the local field verification of BMPs.

Reporting to the State. The reporting entities will need to submit documentation to the state on the acres that were treated by urban filter strips in the preceding year. To be eligible for the removal rates in the model, localities, or other data providers, need to check with their state stormwater agency on the specific BMP data to report, and follow the BMP reporting and tracking procedures established by their state. The Panel recommends that the following information be reported for UFS:

- Whether the project is classified as new development or redevelopment
- Total drainage area treated (acres)
- Post development site land cover (e.g., % forest, % turf, % impervious cover)
- Pre-development land cover (e.g., % forest, % turf, % impervious cover)
- Year installed
- GPS coordinates (lat/long) and the 12 digit watershed in which it is located (optional)

Initial Verification of BMP Installation. Localities, or other data providers, will need to verify that urban BMPs are installed properly, meet or exceed the design standards for its BMP classification, and are functioning hydrologically as designed prior to submitting the BMP for load reduction credit in the state tracking database. This initial verification is provided either by the BMP designer or the local inspector as a condition of project acceptance, as part of the normal local stormwater BMP plan review process. From a reporting standpoint, the data provider would simply indicate in its annual report whether or not it has BMP review and inspection procedures in place and adequate staff to implement them.

New BMP Record-Keeping. Localities, or other data providers, should maintain a project file for each new or redevelopment project. This may include a low impact development (LID) locator map showing all LID and site design practices employed, construction drawings, as-built survey (for larger practices), digital photos, inspection records, and maintenance agreement. The file should be maintained for the lifetime for which the BMP removal rate will be claimed. Localities are encouraged to develop a GIS-based BMP tracking system in order to schedule routine inspections and maintenance activities over time.

Non-Conforming Projects. Jurisdictions should also keep track of any future development projects that are designed under the old standard, or cannot fully comply with the new standards. No credit is available for urban filter strips that do not conform to the expert panel recommendations. The pollutant load reduction is available for RR UFS and ST UFS.

Verification for Older UFS. The UFS should be reported in the State or DC BMP database and may be downgraded based on BMP inspections.

Periodic BMP Inspections. Simple visual indicators are used during routine maintenance inspections to verify that the system of practices still exists, is adequately maintained and is operating as designed. Inspections for UFS should specifically ensure: 1) the absence of any erosional channels, 2) the vegetative cover is in condition according to the qualifying conditions for this BMP and 3) structural integrity of the level spreader is intact. A record of a soil test to determine the amount of nitrogen and phosphorus applied from fertilizer application is recommended and should be noted on the inspection form, or as a separate follow-up action according to State or District guidance. It is recommended that these rapid investigations be conducted as part of every other routine stormwater BMP inspection (e.g. 6 to 10 years), or as mandated in their MS4 permit, to assure that individual LID and site design practices are still capable of removing nutrients/sediments.

Suggested Process for BMP Downgrades. If the field inspection indicates that a BMP system is not performing to its original design, the responsible party would have up to one year to take corrective maintenance or rehabilitation actions to bring it back into compliance. If the facility is not fixed after one year, this would be reported to the state BMP tracking entity and the BMP would be eliminated. If corrective maintenance actions were verified for the BMP system at a later date, the reporting entity could take credit for the load reduction at that time.

Special Procedures for BMPs Installed in Non-Regulated Areas. Development is expected to occur in non-regulated communities, which tend to be very small in size and fairly new to stormwater BMP review. It is acknowledged that these non- regulated communities may not currently have the budget and/or regulatory authority to fully meet the new BMP verification protocol. The Urban Stormwater Work Group has recommended alternative verification procedures (USWG, 2014) for these communities. Data providers are encouraged to check with their state stormwater agency on the specific BMP data to report, and follow the BMP reporting and tracking procedures established by their state.

7.1 Un-Intended Consequences and Double-Counting

The Expert Panel does not foresee any unintended consequences of the implementation of the recommendations for UFS. The specific qualifying conditions for ST UFS and RR UFS provide the States and DC clear guidance for their application and pollutant removal.

Given the sequential implementation of BMPs in the CBWM, the Expert Panel does not foresee any double counting related to UFS. UFS may be used as part of a treatment train approach to urban stormwater management and as such is discounted accordingly in the CBWM. Given the qualifying conditions for fertilizer management for UFS, pollutant load reductions for Urban Nutrient Management (UNM) may not be applied to the area of an UFS, however, any pervious areas draining to the UFS may be eligible for UNM. A UFS may be credited as pretreatment to an urban forest buffer where the purpose of the UFS is to create the sheetflow conditions that are required for urban forest buffers. In this circumstance, the area of the UFS may not be included as buffer area but must meet the qualifying conditions outlined in Section 2.2 to be eligible for credit.

Section 8. Future Research and Management Needs

1. The Urban Stormwater Work Group review and update the New State stormwater performance standards and retrofits expert panel reports to reference the recommendations in this report as the method to credit TN, TP and TS load reductions for UFS.
2. Monitoring studies to evaluate the fate of nitrogen and phosphorus treated by urban filter strips. Such studies need to measure leaching of N and P into the groundwater beneath the UFS at different distances along the flow path from the level spreader. The accumulation of N and P over time in the surface soils of the UFS at different distances along the flow path from the level spreader would also help to inform the fate of nutrients within an URFS. Observations of different UFS's of different ages could substitute for repeated observations of particular UFS's at different times.
3. Monitoring studies to further evaluate the impact of concentrated flow through forested buffers. As part of this review, it is important to evaluate the function throughout the buffer. The areas with no flow might significantly reduce the load while concentrated flow areas may have slightly higher concentrated loading. Studies that review event mean concentration through various types of vegetated buffer may be helpful.
4. Research to evaluate the function and pollutant removal capabilities of urban forested buffers less than 35ft along the flow path.

5. In forested stream buffers, investigate the effect of hydric soils or groundwater flow close to the soil surface on the nitrate removal capacity. Hydric soils of near-surface groundwater may decrease the flow path distance required for nitrate removal.

References

Bedard-Haughn, A., K.W. Tate and C. van Kessel. 2004. Using Nitrogen-15 to quantify vegetative buffer effectiveness for sequestering nitrogen in runoff. *J. Environ. Qual.*, 33: 2252-2262.

Bettez, N. D. and P. M. Groffman. 2012. Denitrification potential in stormwater control structures and natural riparian zones in an urban landscape. *Environ Sci. Technol.*, 46, 10909−10917, dx.doi.org/10.1021/es301409z

Brater, E. F. and H.W. King, 1976. *Handbook of Hydraulics for the Solution of Hydraulic Engineering Problems*, Sixth Edition. McGraw-Hill Book Company, New York, NY, USA
Chesapeake Bay Program (CBP). 2006. *Best Management Practices for Sediment Control and Water Clarity Enhancement.* CBP/TRS-282-06

Chin, D.A. 2006. *Water-Resources Engineering.* 2nd edition. Pearson Education, Inc. Upper Saddle River, NJ, USA.

Claytor, R. A. and T.R. Schueler. 1996. *Design of Stormwater Filtering Systems.* Center for Watershed Protection, Ellicott City, MD

Deletic, A. and T. D. Fletcher. 200. Performance of grass filters used for stormwater treatment – a field and modelling study. *Journal of Hydrology*, 317: 261-275. DOI:10.1016/j.jhydrol.2005.05.021

Gift, D. M., P. M. Groffman, S. S. Kaushal and P. M. Mayer. 2010. Dentrification potential, root biomass, and organic matter in degraded and restored urban riparian zones. *Restoration Ecology*, 18(1): 113-120.

Groffman, P., E. A. Axelrod, J. L. Lemunyon and W. M. Sullivan. 1991. Denitrification in grass and forest vegetated filter strips. *J. Environ. Qual.*, 20: 671-674.

Groffman, P. M. , D. J. Bain, L. E. Band, K, T. Belt, G. S. Brush, J. M. Grove, R. V. Pouyat, I. C. Yesilonis, W. C. Zipperer. 2003. Down by the Riverside: Urban Riparian Ecology. *Frontiers in Ecology and the Environment*, 1(6): 315-321. http://www.jstor.org/stable/3868092

Han, J., Wu, J.S, and C. Allan. 2005. Suspended sediment removal by vegetative filter strip treating highway runoff. *Journal of Environmental Science and Health.* 40: 1637-1649. DOI: 10.1081/ESE-200060683

Helmers, M. J., D. E. Eisenhauer, M. G. Dosskey, T. G. Franti, J. M. Brothers and M. C. McCullough. 2005. Flow Pathways and Sediment Trapping in a Field-Scale Vegetative Filter. *Transactions of the ASAE*, 48(3): 955-968.

Hunt, W. F., J. M Hathaway, R. J. Winston, and S. J. Jadlocki. 2010. Runoff volume reduction by a level spreader-vegetated filter strip system in suburban Charlotte, N.C. *Journal of Hydrologic Engineering*, 15(6): 499-503.

Kaushal, S. S., P. M. Groffman, P. M. Mayer, E. Striz, and A. J. Gold. Effects of stream restoration on dentrification in an urbanizing watershed. *Ecological Applications*, 18(3):789-804.

Knight, E.M.P., W.F. Hunt and R. J. Winston. 2013. Side-by-side evaluation of four level spreader-vegetated filter strips and a swale in eastern North Caroline. *Journal of Soil and Water Conservation,* 68 (1): 60-72. DOI:10.2489/jswc.68.1.60

Line, D. E. and W. F. Hunt. 2009. Performance of a bioretention area and a level spreader-grass filters strip at two highway sites in North Carolina. Journal of Irrigation and Drainage Engineering, Field evaluation of four level spreader-vegetated filter strips to improve urban storm-water quality. DOI: 10.1061/_ASCE_0733-9437_2009_135:2_217

Maestre, A., and R. Pitt. 2006. Identification of significant factors affecting stormwater quality using the NSQD. In: W. James, K.N. Irvine, E.A. McBean, and R.E. Pitt *(eds). Stormwater and Urban Water Systems Modeling Proceedings*, Monograph 14. pp. 287 –326. CHI. Guelph, Ontario.

Magette, W. L., R. B. Brinsfield, R. E. Palmer, and J. D. Wood. 1989. Nutrient and sediment removal by vegetated filter strips. *Transactions of the ASAE*, 32 (2): 663-667. American Society of Agricultural and Biological Engineers.

Malcolm, H.R. 1993. *Elements of Urban Stormwater Design*. North Carolina State University Industrial Extension Service. Raleigh, NC, USA.

Mayer, P. M., S. K. Reynolds Jr., M. D. McCutchen, and T. J. Canfield. 2007. Meta-analysis of nitrogen removal in riparian buffers. *J. Environ. Qual.*, 36:1172–1180. doi:10.2134/jeq2006.0462

Mayer, P. M., S. P. Schechter, S. S. Kaushal and P. M. Groffman. 2013. Effects of stream restoration on nitrogen removal and transformation in urban watersheds: lessons from Minebank Run, Baltimore Maryland. *Watershed Science Bulletin*, 4(1).

Morton, T. G., A. J. Gold and W. M. Sullivan. 1988. Influence of overwatering and fertilization on nitrogen loss from home lawns. *Journal of Environmental Quality*, 17(1):124-130.

Raciti, S., A. Burgin, P., Man, D. Lewis, and T. Fahey. 2011. Denitrification in suburban lawn soils. *Journal of Environmental Quality*, 40(6): 1932-1940.

SPS EP (New State Stormwater Performance Standards Expert Panel). 2012. *Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards.*

SRP EP (Urban Stormwater Retrofit Projects Expert Panel). 2012. *Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects.*

Stream Restoration Expert Panel. 2013. *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects: Final Draft (April 2013).*

Spieran, G. 2012. *Several Characteristics to Consider for Mapping to Target Placement of Effective Riparian Forest Buffers for Water-Quality Improvement.* Presentation to the Chesapeake Bay Program Forestry Workgroup. November 7, 2012. US Geological Survey, Reston, VA.

Stewart, S. E. Gemmill and N. Pentz. 2005. *An Evaluation of the Functions and Effectiveness of Urban Riparian Forest Buffers.* Project.99-WSM-4. Water Environment Research Foundation. Alexander, VA.

Strecker, E., B. Urbonas, M. Quigley, J. Howell and T. Hesse. 2002. *Urban Stormwater BMP Performance Monitoring: A guidance manual of meeting the National Stormwater BMP database requirements*. U.S. EPA and ASCE. EPA-821-B-02-001,

Sweeney, B.W. and J. D. Newbold. 2014. Streamside forest buffer width needed to protect stream water quality, habitat and organisms. A literature review. JAWRA(accepted for publication)

USDA SCS. 2003. *Technical Note: Revised Hydrology Technical No. N4. Time of Concentration.*

USEPA (U.S. Environmental Protection Agency). 2010. Chesapeake Bay Phase 5.3 Community Watershed Model. EPA 903S10002 - CBP/TRS-303-10. U.S. Environmental Protection Agency, Chesapeake Bay Program Office, Annapolis MD. December 2010.

US EPA. 2012. Estimates of County-Level Nitrogen and Phosphorus Data for Use in Modeling Pollutant Reduction. Documentation for Scenario Builder Version 2.4.

Urban Nutrient Management Expert Panel. 2013. *Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management.*

Urban Stormwater Workgroup. 2014. *Recommended Guidance for Verification of Urban Stormwater BMPs.* Prepared in support of the Water Quality Goal Implementation Team's BMP Verification Committee.

Verchot, L. V., E. C. Franklin and J. Wendall Gilliam. 1997. Nitrogen cycling in Piedmont vegetated filter zones: 1. surface soil processes. *J. Environ. Qual.*, 26: 327-336.

Wenger, S. 1999. *A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation.* Institutue of Ecology, University of Georgia. 59 pp.

Winston, R. J., W. F. Hunt, W. G. Lord and A. C. Lucas. 2010. Level Spreader Update: Design, Construction, and Maintenance. *Urban Waterways.* North Carolina Cooperative Extension, College of Agriculture and Life Sciences.

Winston, R. J., W. F. Hunt III, D. L. Osmond, W.G. Lord and M. D. Woodward. 2011. Field evaluation of four level spreader-vegetated filter strips to improve urban storm-water quality. *Journal of Irrigation and Drainage Engineering*, 137: 170-182. DOI: 10.1061/(ASCE)IR.1943-4774.0000173.

Yu, S. L., Kaswick, M. A. and M. R. Byrne. 1993. A level spreader/vegetative buffer strip system for urban stormwater management. In: R. Field, M. L. O'Shea and K K. Chin (eds), *Integrated Stormwater Management*, pp. 93-103. Lewis Publishers.

Appendix A: Expert Panel Meeting Minutes

Urban Filter Strip/Stream Buffer Upgrade Expert Panel
Meeting 1 Notes
Tuesday, February 19, 2013
2 – 4PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	x
Ken Belt	USFS, Baltimore Ecosystem Study	
Joe Battiata	Center for Watershed Protection	x
Jennifer Zielinski	Biohabitats	x
Ryan Winston	North Carolina Extension, NCSU	x
Curtis Hardman	WV DEP	x
Scott Crafton	VA DCR	
Dan Frisbee	Charlottesville, VA	x
Tom Jordan, PhD	SERC	x
John McLeod	Star Homes Program Manager, Elizabeth River Project	
David Gasper	NY DEC	x
Randy Greer	DNREC	x
Steve Stewart	Baltimore County DEPRM	x
Jeff Sweeney	CBPO	x
Neely Law	CWP, Facilitator	
Non-panelists: Bill Stack, CWP; Laura Gardner, CWP panel support; Jeff Sweeney CBPO, Matt Johnston, CBPO		

- Neely called the meeting to order at 2:00 PM and thanked the participants for their participation

<u>WQGIT BMP Review Protocol Review and Panel Charge</u>

- Neely went through the Protocol Review and the Panel Charge
- Workplan includes:
    - Meetings 1, 2 will be to introduce how BMPs are modeled in the Chesapeake Bay modeling framework (watershed model, scenario builder, how similar BMPs to vegetative filter strips (e.g. grass buffers) are currently modeled and credited, recently adopted BMP performance standards
    - Meetings 3, 4: Review and discuss literature and define BMP
    - Meetings 5+ : reach general consensus on research for this BMP and then develop recommendations Bay Program, write report
    - Report submitted to Urban Stormwater Work Group (USWG) for approval as per protocol
- Proposed Panel Charge
    - Panel reviewed the proposed charge and proposed the following changes (but not approved):
        - Add runoff reduction credit (David Gasper)

        - Add urban to model simulations (Steve Stewart)
        - Define ‘disconnection” as part of this practice; applied in MD, VA
        - Add switch grass as a vegetation cover type. Bill Stack talked about the communities on Eastern shore who want to use switch grass as cover on urban institutional land – like a cover crop in agricultural land. How could this be defined? Land cover change? But if runoff is directed to it, how is it classified?
    - Neely provided background on how this BMP is currently defined based on State stormwater manuals reviewed to date .
    - Panel requested to provide a specific definition of this BMP as a separate or combined practice
    - How could jurisdictions take advantage of this BMP to get credit?
    - 2 expert panel reports for panel to review and its potential use for VFS/SBU
- Panel to further discuss merits of adding conservation landscaping to the scope of the expert panel as per request by Tom Schueler.
    - Joe B asked if conservation landscaping is being included for credit and if the program was looking for a panel to assign to it.
    - Randy G asked if this was meant to be an active or passive conservation area (higher or lower curve number)? If SW could be directed to this landscaping, then yes we should add it to this group.
    - Sally C thinks that conservation landscaping has a wide range of definitions for implementation and use – and may be too broad for this group.
    - Bill Stack thought that urban pervious (in next stage of model) could take conservation landscaping.

<u>Panel Member Feedback</u>

- Randy G – filter strips a mixed bag – started in early 2000s – expanded from TSS reduction to runoff reduction. TSS filter has been mixed. DE has shallow slopes and works better if thick stand of grass. Without thick stand then subject to scouring and erosion. Hard to achieve a good level spreader. Maintain a good vegetative condition between impervious area and filter strip
- Ryan W – used turf grass, urban forest strip evidence of scour from parking lot runoff. Grass buffer next to riparian buffer had erosion issues where grass meets the stream itself.
- Dave Gasper – added vegetative buffers and filter strips to NY manual in 2010 as runoff reduction technique for water quality. We haven’t seen a lot of people try green infrastructure techniques – using end of pipe practices – hard to change thinking.
- Jeff Sweeney noted that jurisdictions likely taking credit for VFS as defined by another similar BMP, or as part of a treatment train and it would be useful to apply approved protocols (e.g. performance standard, retrofit) or it may be recommendation of panel to define this as a separate BMP
- Steve S suggest increased use of this BMP with environmental site design becoming more prevalent
- Matt J may provide another presentation on infiltrating BMPs

<u>Chesapeake Bay Watershed Model 101</u>

- Presentation provided by Matt Johnston. Neely will upload copy to Sharepoint site.
- Watershed model broken into land/river segments into 100 cfs stream ; Model does not simulate small order stream
- Start with representative acre and have source inputs , submodels to simulate soil layers – runoff to management filter (e.g. BMPs) and then to stream segment
- Edge-of-Field load only applies to sediment;

- "Simple model" P-Qual model used to simulate nutrients in urban areas ; more complex N cycling model in ag and forested lands
- Modeling team want to know from this group what the reductions should be to go into the model – they can make the model work ; not limited to current model structure (ver. 5.3.2). Phase 6 under development
- Example provided using agricultural grass buffers – both a land use change and a management filter
- Urban grass buffers – grass buffers are converted from pervious urban to pervious urban – there is no benefit
    - How difficult to add upland benefit to urban grass buffers? Easy to add to model but need some defensible data from the expert panel
    - Need minimum criteria as what is a filter strip – how much urban is filtering to what size of filter strip?
    - Urban forest buffer – is there an upland benefit? Joe B stated a 2:1 benefit ratio
    - If have trees on urban to pervious urban – will get the land use change

<u>Urban Filter Strips/Stream Buffer Upgrade Definition</u>

- Comparison document – filter strips definitions by state
    - DE is updating their standards for BMPs for the next year
    - **Randy G send Neely the updated standards for filter and she will share with panel**
- Commonality – runoff must be sheetflow
    - Slopes have a wide range of acceptable slope
        - Higher slope – need wider strip
    - Applies to all soil types – if C or D, then need amended soils
    - Application area – treat small areas (500 – 5000 sf)
    - Need dense turf grass/vegetation
    - Disconnection length – 50 ft pervious, 150 ft impervious
- Who uses the BMP?
    - DE DOT – to meet TSS requirements, some small commercial and residential – post construction requirements
    - MD – to meet water quality and channel protection requirements, applied in new developments for example where backyards adjacent to stream buffer
- **State reps – please look at your state and make sure that the requirements are adequately represented**

<u>Other thoughts?</u>

- Upslope treatment to prevent concentrated flow?
- Width instead of area for practice?
- Fertilizer used in these practices? Some jurisdictions to establish cover
- Seeded area vs. sod? NC specify use of sod due to time to establish desired vegetative cover; DE need blanket with seeding
- How to scale filter to size of area received? Maybe look at peak flow? How much water comes through filter area? Limit size of drainage area?
- Sheet flow is "unnatural". How to maintain sheet flow, especially in a hilly environment? Has to be on a level – follow the topography.
- How to define all the different types of filtering/buffering?

<u>Next Steps</u>

- **Neely to send out revised charge with tracked changes**
- **Neely to send an email with a user name and log in for SharePoint site**
- *Next Meeting: Chesapeake Bay BMP Protocols, Research/Literature Review Summaries*

Urban Filter Strip/Stream Buffer Upgrade Expert Panel
Meeting 2 Notes
Tuesday, March 19, 2013
1:00-3:00PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Ken Belt	USFS, Baltimore Ecosystem Study	
Joe Battiata	Center for Watershed Protection	
Jennifer Zielinski	Biohabitats	Y
Ryan Winston	North Carolina Extension, NCSU	Y
Curtis Hardman	WV DEP	Y
Scott Crafton	VA DCR	Y
Dan Frisbee	Charlottesville, VA	
Tom Jordan	SERC	
John McLeod	Star Homes Program Manager, Elizabeth River Project	
David Gasper	NY DEC	Y
Randy Greer	DNREC	Y
Steve Stewart	Baltimore County DEPRM	Y
Jeff Sweeney	CBPO	
Neely Law	CWP, Facilitator	Y
Non-panelists: Hannah Martin, CRC Panel Support		

- Neely called the meeting to order at 1:00 PM and thanked the participants for their participation

1. Meeting #1 Minutes

- February Meeting minutes approved by panel

2. Panel Charge

- Neely went over the revisions made to the panel charge based on input from panel members during Meeting #1. Panel members accepted the revised panel charge
  Discussion
    - Nutrient and runoff reduction credits are separate within the charge as some pollutant removal is attributed to volume of stormwater runoff reduced by a practice while others are based on treatment alone

- State regulations will be reviewed before making recommendations. State regulations recently updated or currently being revised to incorporate the new science into guidance.
- Panel to specify criteria for individual and combined practices (VFS, buffer). Modeling and credit issue if used in combination as a treatment train
  - Explore if there is enough science to break up first bullet “Provide a specific definition of what constitutes effective urban filter strips and stream buffer upgrades as separate or combined practice(s) in the context of any nutrient, or sediment or runoff reduction credit, and define the qualifying conditions under which such practices may be eligible to receive the credit, to include rooftop disconnection.”

3. <u>Ryan Winston: “Filter Strips: Pollutant Removal Performance (and Other Topics)</u>

- Ryan Winston, M.S., P.E., Extension Associate, Biology and Agriculture Engineering, North Carolina State University
- Presentation highlights research on the performance of vegetated filter strips; attempt to reduce erosive effects of runoff entering riparian buffers; use of engineered level spreader and other reasons for improved and poor VFS performance provided. Research strongly suggests the use of a vegetated filter strip is effective in reducing pollutant runoff. Flow rates critical for VFS performance.

  <u>Discussion</u>
  - Soils underneath the vegetated filter strips were not accounted for in the studies by NC State hilighted in the presentation. Flow rates defined for NC focused on ‘erosive velocities’ rather than defining flow rates based on HSG
  - NC does not recommend use of soil (organic) amendments due to N and P outputs associated with them. Recognized trade-off with potential runoff reduction gained.
  - What’s the implication for earlier understanding of forest buffers along streams? The key thing to understand, if you pair a riparian buffer with a vegetated filter strip, you will get the best results. Lots of benefits provided to use the two together, directing the water straight into riparian buffer is not ideal.
  - NC filter strip study suggests that sediment is actually trapped in the filter and does not dislodge after a certain number of storm events. The study observed a pretty consistent sediment concentration over the course of the study.
  - Research in NC is based on TSS rather than SSC. Might move to SSC in future.
  - Moving from research to credit—Filter is used for runoff reduction and some research suggested potential clogging of soil pores with fines. **Technical issue that panel address under maintenance of vfs (future issue topic to address).**
  - Grass was more successful than a wooded filter because it maximizes the potential for infiltration and reduces velocity of water outflow.

4. <u>Randy Greer: “Performance Standards Expert Panel”</u>

- Randy Greer, Delaware DNREC
- Presentation of overview of the approved ‘Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards’. This describes the rationale and method to calculate credit for runoff reduction and stormwater treatment BMPs. It also discussed how the panel approached the charge as well as plans on outreach.
- Notion of “Don’t Invent the wheel.” Successful methods of one panel can be adopted and revised by new panels. Accountability Procedures are entrusted to the panels and are very important components to CBP.

  <u>Discussion</u>

- Adapt this method for filter strips and set specific width to hit numbers on the ruff curve. Depending on states criteria, make sure the filter strip width can perform at that level of runoff.
- **Issue of applying this method – performance of VFS based on flow rate achieved for runoff across filter strip to achieve reductions in runoff volume and quality – rather than volume capture or reduced as shown on x-axis of performance adjustor curves.**
- Need to define information / method to report info to model but at same time assured states get credit.
- Vegetated filter strips are currently not an accepted/defined CBP practice; although included in the list of "runoff reduction' practices in the report. Purpose of the panel is to put boundaries on definition in order for credit.
- Acceptable widths? NC minimum is at least 30 ft, however this is relatively conservative, also must be outside of riparian buffer and turf grass.
- Future discussions-sediment and level spreader requirements. Should the credit only go to engineered areas with spreader?
- Action Item-Neely will send out report of approved BMPs
- Action Item – Neely request Matt Johnson provide presentation on implementation of the performance standards and retrofit protocols at next meeting

5. Sharepoint website

- If people could volunteer to review some papers and provide quick summary
- Need more papers on riparian buggers and buffer widths
    - Action Item-Neely will send out guidance with signup sheet
    - Action Item-Everyone, alert Neely if you cannot access sharepoint site

6. Next Meeting

- 4th Tuesdays of every month, 1:00-3:00PM
- April 23-VFS research summaries
- May 28-Conservation landscaping, buffers research summaries
- June 25-State regulations
- Action Item-Neely will send out doodle poll to ensure we maximize participation

Urban Filter Strip/Stream Buffer Upgrade Expert Panel
Meeting 3 Minutes

Tuesday, April 23, 2013
1:00-3:00PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Ken Belt	USFS, Baltimore Ecosystem Study	Resigned
Joe Battiata	Center for Watershed Protection	Y
Jennifer Zielinski	Biohabitats	Y
Ryan Winston	North Carolina Extension, NCSU	Y
Curtis Hardman	WV DEP	Y

Scott Crafton	VA DCR	Y
Dan Frisbee	Charlottesville, VA	Resigned
Tom Jordan, PhD	SERC	Y
John McLeod	Star Homes Program Manager, Elizabeth River Project	
David Gasper & David Follansbee, PhD	NY DEC	Y
Randy Greer	DNREC	Y
Steve Stewart	Baltimore County DEPRM	Y
Al Todd	Alliance for the Chesapeake Bay	New-Y
Jeff Sweeney	CBPO	
Neely Law	CWP, Facilitator	Y
Non-panelists: Hannah Martin, CRC Panel Support, Matt Johnston (CBPO)		

Meeting#3 Objective: Report on literature summaries

7. Meeting #2 Minutes

- February Meeting minutes approved by panel

8. Panel Updates

- Ken Belt (USFS) and Dan Frisbee (VA) had to resign from the panel due to agency commitments. Al Todd has joined as a replacement. He is the director for the Alliance of the Chesapeake Bay and has previously spent 32 years as a hydrologist with USFS.
- Neely relayed Tom Schueler's findings re the limited research on conservation landscaping. Panel may drop this as part of the expert panel scope
- Panel may develop an interim rate to be available for jurisdictions want BMP credits before panel recommendations are finalized
- Panel request additional information on Chesapeake Bay Watershed Model and how N and P are modeling

9. Literature Reviews
    - A total of 12 papers were reviewed and results presented to panel. The following papers were reviewed. Copies of the review available from Sharepoint site.
    - Curtis H (Barrett et al, nd; Han et al 2005)
    - Ryan W (Deletic and Fletcher 2006; Barrett et al. 1998b) (Neely provided update)
    - David G (Knight et al 2013; Lantin and Barrett 2005)
    - Steve S (Helmers et al. 2005)
    - Neely L (Winston et al 2011)
    - Randy G (Hunt et al 2010; Line and Hunt 2009)
    - Scott C (Winston and Hunt, nd; Winston et al nd)

Note: Ryan Winston presentation from March 19 meeting on sharepoint site summarizes additional research

Discussion points and issues identified for further discussion

- Terminology for urban filter strip include to length and width. These dimensions used interchangeably in the literature
- Implementation and maintenance of grassed filter strips needs to prevent grass build-up at grass/pavement interface; trap sediment and prevent flow into the practice
- Identify factors that affect, or result in soluble P export from some experiments from filter strips but overall performance was positive
- Suggestion to vary credit by filter strip design and age
    - e.g. with / without level spreader, use of sediment forebay among others to consider).
    - Installation is key to proper function of vegetated filter strip – level the level spreader to achieve desired sheet flow
    - Fertilizer application to establish turf may consider reduced credit for 1st year of establishment. Enhanced Erosion & Sediment Control expert panel reported N and P fertilizer used to establish turf has greater application rate than crops
- Address groundwater as well as surface water

Summary of load reduction and sediment, nitrogen and phosphorus load reduction observed in studies

- **"Stormwater Pollutant Removal in Roadside Vegetated Buffer Strips" -Barrett, M.; Lantin, A.; and S. Austrheim-Smith**
    - Highway roadside filter strip, 8 sites, California
    - Performance affected by vegetative coverag. Less than 80% require longer distances to achieved minimum concentrations
    - Infiltration responsible for greater proportion of load reduction than the change in concentration
        - TSS load reduction for "minimum effective width" 77-97%, with one site -450% (<25% vegetative cover?)
    - TSS, nutrient and metals removed were provided as a function of filter strip width
        - Concentration reductions TSS and metals
        - Nutrient concentrations generally unchanged
    - Steady state pollutant concentration achieved within 5ft of edge of pavement
    - <u>Discussion points:</u> Focused on highway stormwater runoff using roadway medians rather than shoulder. Larger particles settle out in the first few feet of the practice rather than the whole strip with a high sediment removal concentration. The vegetation was the natural grass found in California with a range in soil types.
- **"Suspended Sediment Removal by Vegetative Filter Strip Treating Highway Runoff"-Han, J.; Wu, J.S.; and C. Allan**
    - <u>Summary:</u> Study funded by NC Department of Transportation. An experimental filter strip (24 ft wide x 53 ft long) was installed adjacent to a state highway in central North Carolina. Runoff entered the filter strip through a trapezoidal channel, catch basin, and level spreader.
    - A gravel infiltration layer was also installed under the level spreader and the initial portion of the filter strip.
    - TSS was sampled for 2 storm events and TSS removal efficiencies (load reductions) were calculated for by comparing inflow and outflow samples.

- EMC reduction efficiencies 89.0-90.3%
- Mass load reduction 90.6 – 93.1%
- Discussion points: Most of the conclusions drawn appear to be consistent with existing knowledge on the functioning of filter strips. The study could perhaps have been improved by collecting more field data and significance testing of those results. I would rank overall as medium quality on the review guidance criteria.

- **"Performance of grass filters used for stormwater treatment – a field and modeling study" Deletic, A. and T. D. Fletcher. 2006. Journal of Hydrology, 317:261-275**
  - Summary: Experimental setup in Aberdeen Scotland (Filter), Brisbane AUS (swale) with controlled field studies looking at TSS, TN, TP, % efficiency (both EMCs & loads), varied inflow rate and sediment concentrations
  - Site characteristics included grass height 2-5cm; uniform and good density (3.6 blades/cm^2), 0.3 m wide x 6.2 m length construction channel; effective length for experiment was 5m, and longitudinal slope 7.8%. The study sampled along length at 5 places.
  - Key findings of the study were greater reduction in outflow rate with slower inflow rates; diminished infiltration capacity attributed to clogging soil pores with subsequent experiments and 'washing' grass after experiment, TSS (& particulate bound P) removal due to physical processes, flow rate, grass density, particle size, biochemical processes for nitrogen removal, hydraulic characteristics and soil
  - 61-86% TSS removal (EMC) exponential decay (did not include load or mass removal). The rate of the decay was a function of flow; the lower the flow rate, the more sediment is deposited. The majority of sediment trapping within first part of strip; smallest particles (5.8 microns) for the most part past through filter => particle size important to assess vfs performance and the higher the flow rate, the longer the distance to trap particles.
  - Discussion topics: This study pumped water in and across the top of the filter strip and found that reduction rate was reduced over time due to an unsteady input rate of pollutants and finer sediments clogging the filter pores and reduced infiltration. The study tried to fix this issue by washing the grass with high pressure but that did not work. The concentrated flows likely will cause erosion and sediment transport. Infiltration is independent of the inflow, it should depend on soil permeability since width is constant and depths of overland flow too shallow to cause sufficient pressure to induce infiltration.
- **Side-by-side evaluation of four level spreader-vegetated filter strip and a swale in eastern North Carolina- E.M.P. Knight, W.F. Hunt, III, and R.J. Winston *Journal of Soil and Water Conservation, 2013***
  - Summary: The purpose of this study was to determine volume reduction and pollutant removal efficiency for four vegetated filter strips located in eastern North Carolina. These filter strips are summarized below.
    - Small filter strip (8x6 m) with unamended soils
    - Small filter strip (8x6 m) with phosphorus sorptive amended soils
    - Large filter strip (20x6 m) with unamended soils
    - Large filter strip (20x6 m) with phosphorus sorptive amended soils
- The drainage area to these filter strips was 3.03 ac with 56% impervious cover (mostly parking lot). The seasonal high water was approximately 2 ft below grade. The rainfall depths for this study ranged from 0.04 to 1.67 in with a medium rainfall event of 0.36 in. Hydraulic conductivity of the native (unamended) soil was 0.04 in/hr.
- Overall average volume reduction ranged from 39% to 59% for all filter strips. Specific average volume reductions were as follows, 36, 42, 59, and 57 for small unamended, small amended, large unamended, and large amended respectively.

Average EMC pollutant removal efficiency:

- Small unamended filter strip
  - TSS: 81%
  - Particle bound Phosphorus: 46%
  - Dissolved Phosphorus: -345%
  - Total Nitrogen: 13%
- Small amended filter strip
  - TSS: 89%
  - Particle bound Phosphorus: 53%
  - Dissolved Phosphorus: -45%
  - Total Nitrogen: 40%
- Large unamended filter strip
  - TSS: 84%
  - Particle bound Phosphorus: 46%
  - Dissolved Phosphorus: -304%
  - Total Nitrogen: 15%
- Large amended filter strip
  - TSS: 91%
  - Particle bound Phosphorus: 55%
  - Dissolved Phosphorus: -161%
  - Total Nitrogen: 27%

- The increase in dissolved phosphorus concentration was attributed to the phosphorous in the soil.
- All of these results correlated well with other studies performed in similar areas.
  Discussion Points: The variables of this study were size and soil media to see the difference between width and amended soils. All four filter strips were above 81% for TSS (EMC, not mass/load reduction). The study looked at total, dissolved, and particulate phosphorous and was interesting to see that dissolved was increasing because of exfiltration from the soil. The study used natural rainfall events. New York particularly found this study to be interesting and useful for state management. The amended soils are becoming more common and used more in bioretention type facilities. A lot of the states (and counties like Montgomery in MD) are allowing amended soils to be used as runoff reduction credit. Montgomery County is looking to require it for private development. A lot of discussion focused on how widely amended soils are used and if it is becoming a more common practice.

- **"Design and Pollutant Reduction of Vegetated Strips and Swales"-Anna Lantin, P.E. and Michael Barrett, Ph.D, PE**
  - Summary: The studies were conducted on behalf of Caltrans and Texas DOT. The study areas consisted of existing vegetated areas adjacent to some of their highways. The areas were not intended for stormwater treatment.
  - Key findings of the study:
    - Filter strips consistently resulted in reductions in concentration of TSS and total metals
    - Nutrient concentrations were generally unchanged by the vegetated filter strips.

        - Water quality performance declines rapidly when vegetative cover falls below 80%.
        - There was a substantial load reduction for most constituents because of large amount of infiltration that occurred at most of the sites.
        - Median TSS concentrations removal by vegetated filter strips was 25 mg/l, excluding sites in Moreno Valley.
        - Study sites with sufficient vegetation produced an effluent quality that was equal to or better than that observed from engineered vegetated strips designed and operated for water quality improvement.
        - Existing routine maintenance activities for the vegetated shoulders was sufficient to establish conditions favorable for substantial pollutant removal.
    - <u>Discussion Points:</u> The slopes of the study ranged from 10-35% with widths ranging from 14-30ft. This study did not look at nutrient removal, only TSS. The study emphasized better rates were observed in areas with more than 80% vegetated cover and attributed load reduction in infiltration in soils. Areas were more sandy type soil and routine maintenance of vegetated shoulders was sufficient to maintain these efficiencies. It was noted that it was interesting point that natural sites are better than engineered sites for sediment removal for water quality. Could be because of soils and levels of disturbance and maintenance disturbance of soils. The consistent point was that the vegetation needed to be continual, not patchy. It would be good to look at area of impervious surface relative to filter strip size.
        - <u>Action Item:</u> Come up with standardized terminology, length vs. width
- **"Flow Pathways and Sediment Trapping in a Field-Scale Vegetative Filter" – Helmers, et.al. 2005**
    - <u>Summary</u>: This study focused on an agricultural vegetative filter study in Nebraska. The purpose of the study was to quantify the performance of a vegetated filter where flow path is not confined and to develop methods to detect and quantify overland flow convergence and divergence. The study site was a vegetated filter below row crop (corn) (spacing 0.762 meters), furrows irrigated, slope of field and vegetated filter 1%, vegetative cover classified as poor to fair cover, and little cross slope.

      Study design:
        - Topography determined at two scales, low resolution (6 cm contour) and high resolution (3 cm)
        - Flow and sediment monitored at beginning of vegetative filter and at exit of vegetative filter.
        - Five controlled runoff experiments (using irrigation to supply water and sediment added to water) and one natural rain event (1.4 inches, 6.5 hour duration). Irrigation studies were typical irrigation events with one higher irrigation rate to simulate a 1 hour, 10 year event.
        - Dye used to determine direction of flow.
        - Grid system used to measure depth of flow during each experiment.

      Results:
      - Greater average outflow for 4 of 6 events – indicates convergence of flow
      - Higher resolution topography predicted flow paths determined by dye test with greater accuracy.
      - Flow depth varies across the vegetative filter indicating flow is not uniformly distributed across the filter
      - **Sediment reduction efficiency not affected by flow convergence**
      - Used data to develop a method for calculation of convergence and divergence (not really applicable to us)

- Discussion Points: Considerations based on this study—Source area to buffer area ratio – the lower the ratio to higher the sediment trapping efficiency, confined flow studies disrupt natural flow paths and may not reflect field installations, and convergence of flow does not affect sediment reduction efficiency – 80% in this study which is about the efficiency from other studies. It appears from this study that there doesn't seem to be good correlation between reduction and area slope. When this panel is looking at what ratio to use, it should be consistent between BMPs or physiographic regions. Need to look at flow input per linear foot of vegetated flora. The width of the buffer really matters when measuring the trapping of fine sediments.

- **"Runoff Volume Reduction by a Level Spreader-Vegetated Filter Strip System in Suburban Charlotte, NC" (*2010*)-Hunt, W. F., J. M. Hathaway, R. J. Winston, and S.J. Jadlocki**
  - Summary: This study looked at runoff volume reductions for combination level spreader with a filter strip in Charlotte, NC. The design of this study was based on level spreader + vegetated filter strip (LS-VFS) with clover/turf with a sediment forebay installed before level spreader.
  - The study monitored 23 natural storm events. Of 23 storms reliably monitored, outflow from the LS-VFS was only measured for 3 storm events. The smallest of these events was 1.64 in., and the largest was 3.72 in.
  - The median size of measured storm events that did *not* produce outflow was 0.53 in. The largest event that was completely captured by the LS-VFS system was 2.30 in. For the 23 events that were monitored at this LS-VFS system, cumulative runoff volume reduction was 85%
  - Comparable to bioretention runoff volume reduction
  - Discussion Points: Evaluation of an amended soil as part of filter strip. Wish they had half events with native soil and other with amended. The 85% reduction is probably because of the filter strip; the forebay captured sediments, but didn't have nutrient removals (not focus of study). Nitrogen may be transferred from stormwater to base groundwater because of the infiltration in this study unless it is being taken up by vegetation.
- **"Performance of a Bioretention Area and a Level Spreader-Grass Filter Strip at Two Highway Sites in North Carolina" (*2009*)-Line, D.E. and W. F. Hunt**
  - Summary: Study was designed to compare pollutant removal efficiencies between bioretention facility and grass filter strip. Both BMPs treated highway runoff, but at 2 different locations. Sediment forebay installed before level spreader. LS-VFS drainage area: 0.86 ac. asphalt highway; 49% imperv. VFS planted with Bermuda grass sod on native fine sand soil + topsoil layer. LS length = 24'. VFS dimensions: L = 56'; W = 24'
  - Runoff reduction 49%, peak flow rate reduced by 23%
  - Average concentration NH4-N reduction 45% during growing season; 23% when dormant
  - Other N-species ranged from 11-17% concentration reductions
  - Load reductions 49-66%
  - Dissolved P concentrations increased; overall reduction in TP load occurring mostly through growing season
  - Influent P concentration low (median = 0.2 mg/L)
  - TSS load reduction 52-100%; avg 83%
  - Buildup of sediment contribute to deterioration of practice efficiency - sediment forebay preventing this build-up in this study
  - Discussion Points: Two purposes of this study, to compare bioretention area to a level spread and to use native soil without amendments but did use top soil with the sod. There was an increase with soluble N concentrations with sediment reductions at about 70%.

There was a total increase in phosphorous for all storms. TSS loads reduced after going through forebay and the study used a gravel diaphragm.

- **"Level Spreader Update: Design, Construction and Maintenance"- Winston, R.J., W.F. Hunt, W. G. Lord and A. C. Lucas**
    - <u>Summary:</u> This document provides guidance regarding design, construction and maintenance of Level Spreaders, based on earlier research and guidance performed or produced by N. C. State.
    - High Quality -- supported by statistical analyses. This document is a useful reference for developing or updating a BMP design specification for level spreaders, including sizing, construction sequencing and techniques, and long-term maintenance considerations.
- **"Level Spreader Update: Performance and Research"- Winston, R.J. and W.F. Hunt**
    - <u>Summary:</u> This document discusses the anticipated performance of forested and turfgrass filter strips used with level spreaders, based on a small number of studies in North Carolina and Virginia. The document discusses various benefits of these practices based on these research sites, including runoff volume reduction (28-92%), TSS reduction (51-84%), TP reduction (-27 - 40%, but typically not including soluble forms), TN reductions (-17 - 32%, but typically not the dissolved forms), and thermal load reduction. Pollutant mass load reductions, based on both the treatment mechanisms and volume reduction, varied as follows: TSS (47-89%); TP (32-48%); and TN (49-62%). Design improvements involve the use of a flow splitter to a (1) a reinforced swale for overflows and (2) a small forebay discharging to a "blind" swale with an underdrain and fronted by a concrete level spreader (not to exceed 100 feet of length) overflowing in sheet flow onto a vegetated filter strip 30-50 feet wide and, potentially, then into a forest buffer 30-50 feet wide.
    - High Quality -- supported by statistical analyses. This document provides some scientific basis for recent updates of design criteria for level spreaders, vegetated filter strips and stream buffers in North Carolina. The results have application for other Chesapeake Bay region states as well. However, the authors note that additional research is needed to pin down improvements to the designs and better predict the effectiveness of these practices.
    - <u>Discussion Points:</u> Filter strips may not be good as good for nitrogen reduction compared to P and TSS – physical processes – settling of particles. Took into account mass load reductions—volume and treatment mechanisms which equal the pollutant mass load reductions. It's very important to keep the level spreader level and even. The longer the spreader, the harder it is to keep it level and even therefore advises for no more than 100ft. Both papers are useful and applicable to our uses in CB basin, especially for construction. We want to make sure whatever efficiencies we use include groundwater, important to remember to think about both surface runoff and groundwater.

10. <u>"New State Performance Standards" Matt Johnston, CBP Non-Point Source Data Analyst</u>
    a. Matt noted before his presentation that it was just brought to attention that there is an incentive to grow grass as a result of these panels and fertilizer is needed to grow the grass. Are they fertilizing these filter strips?
    b. Matt presented on how different BMPs are reported and used in the model. Most likely Urban filter strips will not show up as predominant practice in reporting, however the urban filter strips will fit into the model.
        i. Possible we may come up with more than one removal efficiency considering we may not get optimal dimension for filter strip? Yes, but it makes it a bit complicated the more we make. Level Spreader, forebay, forested buffer, stand alone practice, etc. Lots of variables.

ii. Include practice duration—the longevity of the practice that should hold up without extra maintenance.

c. Matt will return to continue the presentation and answer questions.
d. ACTION-Forward any modeling questions to Neely in order to bring the modeling people into the meetings.

11. May Meeting
    a. Panelists reporting out on stream buffer literature
    b. May 28th from 1:00-4:00PM

Urban Filter Strip/Stream Buffer Upgrade Expert Panel
Meeting 5 Notes
Tuesday, May 28, 2013
1:00-4:00PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Joe Battiata	Center for Watershed Protection	Y
Jennifer Zielinski	Biohabitats	Y
Ryan Winston	North Carolina Extension, NCSU	Y
Curtis Hardman	WV DEP	N
Scott Crafton	VA DCR	Y
Tom Jordan, PhD	SERC	Y
John McLeod	Star Homes Program Manager, Elizabeth River Project	N
David Follansbee	NY DEC	N
David Gasper	NY DEC	Y
Randy Greer	DNREC	Y
Steve Stewart	Baltimore County DEPRM	Y
Al Todd	Alliance for the Chesapeake Bay	Y
Jeff Sweeney	CBPO	N
Neely Law	CWP, Facilitator	Y
Non-panelists: Hannah Martin, CRC Panel Support, Matt Johnston (CBPO)		Y, Y

12. <u>Meeting #4 Minutes</u>

- April Meeting minutes approved by panel

13. Panel Updates

- Panel will not develop default rates prior to final report. Default rates to be used for 2013 Progress Run and needed by Sept 2013.
- Bay Program request (Olivia Dereveaux, Norm Goulet) for panel to report a range of acceptable values for numerical reporting. For example, the states will be asked to provide engineering parameters for the stormwater performance BMPs when reporting to the Bay program. The Chesapeake Bay Program models will calculate the actual reduction using the curves in the report (i.e., New Stormwater Performance, Retrofit). Evaluating the data reported by the states will need some guidelines for what is a typical value, or a range of typical values.
    - Acceptable to panel. Recently updated State manuals typically provide a range of values depending on site conditions and filter strip design. **Neely to provide summary of values reports in literature reviewed to date.**

14. Neely's List of Issues to discuss

- **Physical Features**
    - Width vs. Length: Width is perpendicular to the flow and length is the flowpath length. This is consistent with State's definitions in stormwater manuals. Differs from research and riparian buffer (reversed). **Important to be clear in the report with diagrams**.
    - Sizing of BMP drainage area: Studies reviewed to date address impervious cover with exception of Helmers paper that focused on ag land. Panel to focus on impervious cover
        - Steve- Look at ratio of source/drainage area to vfs area; *Is there an upper ratio for this practice?* Could result in some curve, where ratio related to removal efficiency/runoff reduction. Higher ratio = improve treatment but need to define an upper limit. *Helmers et al. 2005 in ag setting set max ratio between 70:1 and 50:1. NRCS uses 30:1 for their designs*
        - Matt- Stormwater performance BMP is requiring impervious acres and acres treated to be reported. No reason why this BMP couldn't do the same if it's treating pervious land too. 0 pervious, 10 treatment. This would tell us it is pervious.
- **Performance Factors**
    3. Factors**:** Include soil type/permeability/compaction. Avoid D soils unless you amend the soil. **Add slope and hydraulic loading as factors**
        - What do you do to amend? Compost amendment. Few values in terms of depth and incorporation and type of compost. North Carolina does not recommend compost amendment to avoid nutrient issues. Delaware found through literature and data that it indicated high nutrient loading but gain in infiltration. Certifications requirements for compost to reduce or minimize nutrient leaching issue
    4. Soluble P Export: P concentration increases because of high soil P index. Filter strips and bioretention sites have high relic soil content because of decades of fertilizer for ag cropping. Over time P chemically binds to the soil and acts like tea bag where it will leach out P and increase groundwater concentrations. Consider loss from surface and export via groundwater. Addressed by other panels by reducing effectiveness of practice (e.g. 20%).
        - Panel recognize (Scott C) that urban BMPs generally not very effective reducing ortho-P
        - VTech research on denitrification using compost put in "trench" at the end of a farm field and water collected in the compost trench. The study had good reduction of dissolved N and P in this practice. Idea that down the road, combine this with filter strip and get some enhanced removal beyond what we can capture now. USDA

developed this in Iowa, not a new idea (ag application). The dissolved P is the problem with the urban BMP. Extensive research on this in Australia. Also studies with wood chips and compost.

    - Effect of "irreducible concentrations" affecting removal efficiency.
    - 4 different soil layers in Ches Bay watershed model for urban lands. Panel review and recommend approach to model reduction of P in all layers (different or same value for all 4 layers?); current research doesn't support differentiation amongst different soil layers. **Gary Shenk to present model to panel at June meeting**.
    - Are we looking at filter strips as runoff reduction practice and physical removal efficiency? We could look at it both ways with two curves. Probably report runoff reduction practice.
    - Tom J: How does the intensity of rain affect treatment/performance? Assume no storage in this BMP. How does rainfall intensity translate into the design? The width of the filter strip, one inch per hour and calculate peak flow rate and then the length of level spreader is dependent on that rate. E.g., 13 ft level spreader for every 1cfs of inflow; Incremental change in inflow rate influences level spreader size and if discharging to turf or forested area.
  - <u>Matt Johnston Comments:</u>
    - Panel needs to develop an efficiency no matter which way the panel goes with recommendations. Default rate for state or locals that cannot report all elements to get curve number. The default would be typically a single number that is not a point on the curve (see also Olivia Dereveux and range of values)
    - Sally—How many practices are we going to be defining? Forest buffers with VFS?
    - Neely - Forest buffers are not focus of this panel. It is a standalone BMP with current efficiency + land use change defined by Bay Program.
    - Sally - No studies have looked at combination of VFS and forest buffer but there is unwritten assumption that flow from VFS to forest buffer would be sheet flow
    - Neely - This panel will need to address surface flow and groundwater (since infiltration is the major process for soluble N removal) to extent that we are able to.
      - Panel agreed that report needs to have 'checks and balances' to prevent misapplication of filter strips; such that forest buffers are not replaced with planting grass for credit.
        - VA practice has grass filter component and if you preserve or restore native vegetation and standing forest you get a higher credit.
        - DE similar: left spec open for ag forestation.

15. <u>Presentations</u>
  - **Sally Claggett**
    - **Wenger Paper.**—Study based in Georgia, 1999.
      - This is a dated study but follows the next paper that is more recent. No focus on urban land in this investigation. Mixes grass and forest in this review. Forest higher efficiency than grass.
      - Most effective way to get P out of system was to harvest the vegetation.
      - Wider buffers are better—accounts for channelization and natural system function. In most cases 30 m buffer provided good control and 15 m buffers were sufficient.
      - Similar issue with riparian expert panel—how can you credit 35 ft buffer and 100 ft buffer that both treat 4 acres. Ratio dilemma.

- Sweeney paper-Draft, advanced copy. Under review. Panel use only.
  - Synthesis paper focuses on width issue of forest buffer. It does not consider grass or as a BMP. Looked at whole watershed and complete treatment (precipitation, outflow, etc)
  - This paper goes into water quality, habitat and benthics. Wide range of things provided by forests.
  - Only looked at TN and SS for water quality.
  - Buffers-wide buffers greater than 40 m for over 65% TN efficiency removal.
  - Hard time finding studies including water flux.
  - Realistic field conditions. Adequate sediment removal requires bigger than 10 m buffer.

- **Tom Jordan**
  - Weller et al paper
    - This study focused on the removal of nitrate from groundwater through an investigation of a corn field with a grass strip. Leaching of nitrate down into the sandy layer and carried through the stream or pick up as soil N, Plant N, denitrification.
    - Nitrate decreases as distance from corn field increases. Nitrate seems to disappear where water is closer to soil surface. Critical to have groundwater with nitrate brought close to soil surface where organic matter and roots of vegetation can reach it.
    - Developed land, cropland and forestland can be distributed in different arrangements with the same land use proportions. Important to look at flow path and impact on N removal. Riparian buffer model predictions - if we had no buffers at all there would be more discharge. If we restore the buffers there will be much lower stream nitrate. Results of model varied by physiographic province (ie.., Buffered croplands in Piedmont watersheds supply significantly more nitrate per unit watershed proportion (21.2 mg N/L; 95% CI:16.1, 26.3) than do unbuffered croplands in the Coastal Plain (10.7 mg N/L; 95% CI: 8.6, 12.8).
    - Discussion: This study focused on cropland, however it could be transferable. Where riparian forests don't work, a grass buffer may be the next effective option.
  - Groffman et al paper
    - Urban Areas. Impact of groundwater table elevation and denitrification potential in buffers.
    - Natural channel vs. incision due to runoff. If there is something that slow surface water flow (like VFS) or stormwater detention ponds, which would prevent incision. Protect the functionality of riparian forest buffers downstream.
- **Steve Stewart**
  - BMPS for Sediment Control and Water Clarity Enhancement
    - Workshop findings looking at sediment issues and BMPs that reduce sediment and enhance water clarity. Graphs show differing buffer width for various functions.
    - Nutrient removal efficiencies: Grass buffers had lower percentage removal for N
    - Discussion: CBP model has been changed since this workshop was held. Further reduced from this paper. There aren't a lot of papers dealing with naturally present grass buffers. Always will be coming at it from experimental perspectives. Hard time getting independent grass buffer info for the model.

- <u>Function and Effectiveness Urban Riparian, Baltimore County</u>
    - Baltimore County contracted to perform study during early 2000s. Looked at concentrations and loads for water quality at six sites with buffers.
    - High buffer-higher than 75% forest
    - Low buffer-25%
    - Storm event-lower concentrations than base flow. Typical of all sampling regime.
    - Load—Nitrogen-Loads in high buffer are lower than in low buffer. Phosphorous-not as much differentiation between low and high buffer.
    - Total N pollution reduction from high buffer was 42% in relation to low buffer. Total P was 46% in high buffer site compared to low buffer site.
    - Discussion: Didn't have to be contiguous buffer.

16. **Discussion: comments what you got out of this research related to our scope and what additional questions still need to be addressed to focus future paper searches.**
    - **a.** Discussion on riparian grass strips;
        - **i.** riparian grass strip could enhance nutrient removal by preventing stream from becoming incised, but not remove nutrients within themselves but rather preserving functionality of riparian forest downstream.
    - **b.** Limited to extrapolate ag buffer research to urban environment (e.g. TSS removal in ag, limited upland sediment source post construction urban areas).
    - **c.** By slowing down water flow, grass strips reduce erosion downstream and that erosion may be sources of TSS. Hydrologic benefits outweigh removals.
    - **d.** By our July meeting—Concerted effort between now and then to complete literature research.
        - **i.** Ryan to help search to identify filter strip papers that exist specific to Bay watershed
        - **ii.** Neely review turfgrass papers (Steve Raciti) and contact Peter Groffman re urban riparian function
17. July Meeting
    - a. July 30th, from 1:00-4:00PM

Urban Filter Strip/Stream Buffer Upgrade Expert Panel
Meeting 5 Notes

Tuesday, June 25, 2013

1:00-4:00PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Joe Battiata	Center for Watershed Protection	Y
Jennifer Zielinski	Biohabitats	N
Ryan Winston	North Carolina Extension, NCSU	Y
Curtis Hardman	WV DEP	Y

Scott Crafton	VA DCR	N
Tom Jordan	SERC	Y
John McLeod	Star Homes Program Manager, Elizabeth River Project	N
David Follansbee, PhD	NY DEC	Y
David Gasper	NY DEC	N
Randy Greer	DNREC	Y
Steve Stewart	Baltimore County DEPRM	N
Al Todd	Alliance for the Chesapeake Bay	N
Jeff Sweeney	CBPO	N
Neely Law	CWP, Facilitator	Y
Non-panelists: Laura Gardner (CWP), Gary Shenk (CBPO)		Y, Y

- Neely welcomed panelists and stated purpose of meeting is to review State design criteria and application of nutrient efficiency curves to State design criteria and methods to estimate pollutant load reduction from vegetated filter strips. Ask panelists for input on draft working definition(s) for this BMP.
- Meeting Minutes #4 revised to only reflect summary from Weller et al 2013
- Neely uploaded additional riparian buffer papers provided by Peter Groffman; limited research on urban riparian buffers. Adds to Ches Bay specific studies within Baltimore County but no new findings

<u>State Design Criteria</u>

- Summaries of the State design criteria and examples on Sharepoint site
- Results showed clustering amongst States and DC where MD load reduction varied based on size of designed filter strip and variable "Ratio of Disconnection Length to Contributing Length"
- DE's reduction credit was close to VA's (450 cu. Ft.) given two different storms and two different reduction methods
    - **ACTION: NLaw, JBattiata review interpretation with NY DEC;** 100% runoff reduction credit, No pollutant removal credit given at State level
- **ACTION: NLaw to request N and P concentrations for urban impervious and pervious runoff concentrations used in CBWM**
- Applicability of performance adjustor curves for urban filter strips
    - Suggested a different phrase for "runoff depth captured"; filter strips not designed for storage/capture of runoff. Infiltration is major runoff reduction pathway
    - Panelist to review curve documentation available in Appendix A of the "New Stormwater Performance Standard" panel report. Download from the SharePoint site

- Presented table summarizing the loading ratios and load reduction from vegetated filter strip literature reviewed.
    - TN load reductions: 38 – 69%
    - TP load reductions: 22 to 56% (negative value of -42, not statistically sig represents increase in load, attributed to high soil P index or internal production,)
    - TS load reductions: 82-94%

2:15 – 3:15 BMP definition (Law/Winston/ Battiata, ALL)

- Neely shared working definitions prepared by J. Winston, J Battiata for panel input
    - **Urban filter strip**
        - Qualifying conditions but refer to state specific definition for design criteria
        - Limiting BMP to only volume reduction? Or some nutrient reduction?
    - Suggestions
        - BMP not to be treated for hotspots
        - Could add guidance on which curve to use – would be in definition of the BMP
        - Expand definition for credit for filter strips that were designed for TSS reduction
        - Most of the practices use only one curve – either RR or ST – filter strips could be an exception;
        - Does the literature support using both curves? **Review earlier filter strip paper (S. Yu)**
        - RGreer request application of curves for older filter strips designed for TSS removal. **Review literature, design criteria to support?**
        - May define BMP as part of an acceptable treatment train to be used in the model (e.g. combined filter strip stream buffer upgrade)
    - **Stream buffer upgrade & Combination Practice**
        - **ACTION: Request panelist to provide input prior to July meeting**

3:15 –3:55 Chesapeake Bay Watershed Model (Gary Shenk)

- Q&A following presentation on model framework
- Panel to determine how account for loss of soluble nutrients to groundwater and its impact on the overall load reduction
    - Models surface (flow, nutrients, sediment), interflow (flow, nutrients), groundwater (flow, nutrients)
- How does model handle infiltration?
    - Nutrients will move from surface flow down to groundwater – there is some reduction in nutrients
    - Not a spatial model – no age of groundwater
    - Simulates nutrients that reach stream/Bay
    - Mass balance approach to estimate losses
- How does urban filter strip differ from ag grass filters?
- Load to groundwater –Soil could contribute to adding nutrients to the groundwater (soils have amended soils or high P-index)
    - Avoid transient effects of practice, focus on long-term performance
    - Would be up to us to decide if this is an issue depending on soil types
- Are we going to credit for surface flow and groundwater flow?

- Yes – model has always counted the total load to the Bay
- Would need to specify that credit would apply only to surface or all water

- **ACTION: Neely and T.Jordan discuss nutrient fate of turfgrass systems**
    - But not in the surface flow? Something to consider . . .
    - Designs for filter strips are for flow rate reduction
- What nutrients are coming off of impervious surface? Urban vs. non-urban? Other sources of N from leaking sewage infrastructure – does the model segment the N sources from pipes vs groundwater?
    - Yes, there is an estimate in the model
    - Point sources are about 20% of total load
    - Urban is a little less
    - Model assumes there are leaky pipes and accounts for them
    - There is IDDE panel – looking at leaky pipes issue

Where are EMC values in the models for urban developed land (The documentation is here: ftp://ftp.chesapeakebay.net/Modeling/P5Documentation/SECTION_10.pdf)
Starting on page 15

- 2.0 mg/L TN
- 0.27 mg/L TP

Next steps

- July meeting – send out poll for extended meeting time
- No meeting in August.

Urban Filter Strip/Stream Buffer Upgrade Expert Panel
Meeting 6 Notes

Tuesday, July, 24,2013

1:00-4:00PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Joe Battiata	Center for Watershed Protection	Y
Jennifer Zielinski	Biohabitats	Y
Ryan Winston	North Carolina Extension, NCSU	N
Curtis Hardman	WV DEP	N
Scott Crafton	VA DCR	N
Tom Jordan, PhD	SERC	Y
John McLeod	Star Homes Program Manager, Elizabeth River Project	N
David Gasper	NYDEC	Y
David Follansbee,	NY DEC	Y

PhD		
Randy Greer	DNREC	Y
Steve Stewart	Baltimore County DEPRM	Y
Al Todd	Alliance for the Chesapeake Bay	N
Neely Law	CWP, Facilitator	Y
Non-panelists: Hannah Martin		Y

Introduction:
-All Action Items addressed from Meeting #5

Nitrogen Loss to Groundwater
-Tom Jordan presented a summary of research findings from urban nutrient management (fertilizer studies) to evaluate the nutrient loads that are reduced from runoff and what is infiltrated to groundwater

Conclusions: Turfgrass may not be good analog for vegetated filter strips for the following reasons:

- Increased water infiltration rates may stimulate nitrate leaching from VFS,
- Assumption of constant percentage of uptake may not hold,
- VFS may not be able to increase N accumulation in response to increased N load,
- Currently there are no direct measurements of the fate of N in infiltrating water
- Monitoring studies are needed to assess N removal efficiency to VFS. The load reduction is largely attributable to infiltration, however understanding the fate of nitrogen once infiltrated requires further research
- Reasonable to assume that 100% of TSS in infiltrated is removed due to the physical filtration effect
- Reasonable to assume nearly all the P in infiltrated water is removed to due physical-chemical binding in soil of most forms of P.

Discussion

- The research on other BMPs is often incomplete for newer practices, or to apply to a specific region. Professional judgment is needed 'fill in the gaps'. This is the case for VFS given the uncertainty about nitrate loss to groundwater.
- Tom is curious if grass grows more at leading edge, upper edge? Responding to increased loading up there?
    a. VFS would have to retain some in order to survive.
    b. As you add more and more water, you will get more leaching.
        i. Force water into soil, force past root zone rapidly no time for uptake
        ii. Uptake limited by concentration by vicinity of roots. Extra water you get from impervious the nitrate may pass through and not taken up by turfgrass. Some organic N and ammonium trapped by load will get converted to nitrate then when will get washed out with a storm event. The temporal dynamics of these transformations need to be addressed by further research of VFS
- ACTION: Forward questions to Tom or Neely.

- Panel decided to move forward with professional judgment as the research and its analysis has been comprehensively addressed.

BMP Definitions (edits indicated by blue highlight)

- Definition
  - Change second sentence to include "Provide both load reduction function through runoff and reduce physical pollutants through filtering.
- Slide #2 Qualifying Conditions
  - Change to "minimize" the use of fertilizer.
  - Fertilizer application needs to be based on soil test rather than random application every Spring/Fall.
- NY-In some states that have minimum size requirements, credit is a function of the size. "In order to qualify for the bay model, it has to be XX size or XX ratio". (see comments below)
- Meet state requirements first. Recent revisions to State stormwater manuals reflect up-to-date minimum requirements for vfs (e.g. slope, sheetflow etc)
- Qualifying conditions most pertinent for retrofit projects.
  - Remove "a dense stem density" everyone in agreement.
    - Link requirements for soil amendments to state specifications.
    - D soils—design manual calls for width parallel to flow to be increased with a filter strip. ACTION-Neely and Dave to talk about specific conditions as applicable to NY.

Stream Buffer Upgrade

- ACTION: Form small team to attack Stream buffer upgrade definition with treatment train definition (Neely, Sally, Al).
- Panel challenged to differentiate 'upgrade' beyond specifying treatment train approach with VFS. Many of the qualifying conditions reflect assumptions for forest buffer
- Issue remains that urban areas are limited in area to implement 30 ft minimum buffer width. Science limited to support buffers less than 30 ft and even less research in urban areas
- Panel asked to consider the following:
  - Define based on area vs width
  - Reconnect to stream channel to facilitate denitrification; need to address 'double counting' with urban stream restoration; may not apply to headwater streams where there is no floodplain (vs riparian)
  - % canopy cover to consider 'gaps' or lower canopy cover

Credit Development for VFS

- Panel recommendation:

- Select 0.5 inch starting point to define removal efficiency. This runoff depth roughly equates to a moderate runoff reduction credit for a filter strip practice using Bay State and DC stormwater guidance.
- The 0.5" depth is representative of a sizing ratio of 0.4. This would be the minimum sizing criteria a jurisdiction could get credit for by the Bay Program
- Need to adjust removal rate to account for nitrate loss to groundwater, or not credit TN

ACTION: NY—need to have meeting with TMDL group to run this by them.

- Panel agreed that removal efficiency based on 0.5" runoff depth was acceptable for TP
- Sediment

a. Load reduction-impressive numbers.
b. 55% for 0.5 inch. Same methodology dealing with N and P.
c. Randy to review additional literature to assess need to apply multiplier to adjust credit
d. Issue of fine grain sediment and its impact on the Bay. Filter strips designed for coarse sediment trapping. Longer flow path than we give credit for.
e. Large literature review---look at the most relevant results.

- Panel recommendation to apply the outlined approach to define removal efficiencies for VFS with caveats as noted in meeting minutes

Next Steps:

- Draft report with definitions and qualifying conditions at next meeting to review.
- Randy will look into a justifiable sediment number to support for older filter strips.
- Tom and Neely will conference with Ryan and Sally about nitrate leaching.
- NY will share and get input with TMDL folks.
- Neely will confirm Sept meeting via doodle poll.

Urban Filter Strip/Stream Buffer Upgrade Expert Panel

Meeting 7 Notes

Tuesday, Sept. 23,2013

1:00-3:30PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Joe Battiata	Center for Watershed Protection	Y
Jennifer Zielinski	Biohabitats	N
Ryan Winston	North Carolina Extension, NCSU	N
Curtis Hardman	WV DEP	Y
Scott Crafton	VA DCR	N
Tom Jordan, PhD	SERC	Y
John McLeod	Star Homes Program Manager, Elizabeth River Project	N
David Gasper	NYDEC	Y
David Follansbee, PhD	NY DEC	Y
Randy Greer	DNREC	N
Steve Stewart	Baltimore County DEPRM	Y
Al Todd	Alliance for the Chesapeake Bay	Y
Neely Law	Coordinator, Center for Watershed Protection/CBPO	
Other panel support: Hannah Martin, CRC		Y

Meeting 6 Minutes:

- Revised Meeting 6 minutes to add David Gasper to participant list
- Minutes Accepted with this change.

Action Items

- NYDEC report back on soil amendment discussion
- Sally Claggett, Al Todd and Neely Law discussed stream buffer upgrade as part of this BMP. Report out presented in minutes.

Stream Buffer Upgrade

- Sally Claggett reported on the following points of agreement:
    - Stream Buffer Upgrade (SBU) would be limited to define a 'treatment train' approach where a urban filter strip is implemented upland of a forested buffer
    - Insufficient research on two fronts 1) narrower buffers widths, less than 30 ft and 2) urban buffers, in general. Al mentioned that the 30 ft minimum is debatable as is
    - Although the area approach may be an option, this practice could be counted as other tree-based BMPs. That is, it was thought that the upgrade already exists in the form of urban forest buffer
  - In general, panel members agreed with this rationale.
  - October meeting review draft to define SBU as a treatment train approach. This is consistent with credit already given to filter strips discharging to riparian buffers, conservation areas or open space in Bay State stormwater manuals as an accepted practice.
  - **Neely to meet with modelers about incorporating this approach (treatment train, and UFS described below) before next meeting**

Review Draft Report

- Neely led panel members through the draft report seeking panel input and comment. Note the draft report is incomplete. Looking for general agreement on key definitions and protocol to credit new and "legacy" urban filter strips.

ACTION: Request all panelists to review the current draft and provide comments to Neely by October 7th.

Section 2.1: Definitions

- "Disconnection Length"—clarify this term and review it's use in the report
- "Loading ratio" – review loading ratio definition and how it is used in protocol definition.

Section 2.2: Qualifying Conditions:

- Qualifying conditions included in the report address general design and function of filter strips and rely on State stormwater management design specifications. A review of the State specifications appear to be up-to-date.

Discussion:

- New York manual has language to allow soil amendments but it does not require it. Current soil specs will meet NY permit intent but not credit for Bay TMDL purposes (David F). It will be priority to be consistent with CBP and will revise when manual is updated

- Panel agreed that a residential lawn would not qualify as a filter strip. It will be recommended that the UFS must be engineered specifically as BMP with requisite reporting and tracking requirements.

Additions/Comments:

- Add that the amendments are to increase permeability
- Define “Hot Spots”
- Neely will follow up and double check these depth to groundwater (2-3ft)

Section 3.1

- **Neely requested input from panel members on application of urban filter strips. Request to provide information as part of October 7th comment period.**

Sections 3.2, 3.3, 4

- This section will provide a narrative overview of the State current requirements for filter strips. The table included as appendix (too technical for body of report)
- **Neely request that Section 3.3 written by CBP modeling team**
- Section 4: Add in caption of the table “EMC refers to concentration in runoff and load reduction refers to surface runoff”

Section 5

- To be written as part of October draft report

Section 6.1

- Neely provided overview of protocol recommendation with 4 options for panel to consider
- Clarify that UFS has storage capacity within the soil column itself but not storage capacity to retain water over 24 hrs as per definition for a stormwater practice. This difference in design separates UFS from other RR practices such as bioretention that are designed with surface water storage capacity.
- 0.4 ratio (defined as the ratio of disconnection length to contributing Length) selected based on ‘law of diminishing return for higher ratios).
    - Currently defined as a minimum ratio that must be met to receive credit for a filter strip.
    - Ratio used as opposed to having a sliding scale of varying UFS sizes. This ratio provides standardization in sizing UFS across Bay jurisdictions. The ratio is measurable and can be reported.
    - In consideration of minimum and maximum. Theoretically, a maximum would a ratio of 1; value in the added benefit questionable and available area. Current 0.4 ratio assumes a 35ft minimum filter strip length and maximum 75 ft impervious surface disconnection length
- **Panel to revisit ratio at next Panel meeting**
- Recognize that a single 0.4 sizing ratio does not provide an incentive for larger filter strips

Action: Request panel to ‘vote’ on preferred alternative and rationale for selected alternative pollutant removal reduction.

- Tom J. provided rationale for “D” due to a lack of monitoring data to suggest any number where ‘no credit’ is within the range of possibility. A lack of credit can provide an incentive for future research.
- Compare with other infiltrating BMPs (e.g.. Sally C urban tree planting expert panel addressing this issue)
- Despite lack of monitoring data, other panelists think some credit is warranted based on best professional judgment

Section 6.2

- Credit for legacy filter strips requested by Delaware given prevalence stormwater treatment practice historically for highway/transportation project
- Credit only for sediment as per their intent/design
- Proposed recommendation 20% TSS

Next Panel meeting: October 24, 1-4pm

Urban Filter Strip/Stream Buffer Upgrade Expert Panel

Meeting 8 Notes

October 24,2013

1:00-3:30PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Joe Battiata	Center for Watershed Protection	N
Jennifer Zielinski	Biohabitats	Y
Ryan Winston	North Carolina Extension, NCSU	N
Curtis Hardman	WV DEP	Y
Scott Crafton	VA DCR	N
Tom Jordan, PhD	SERC	Y
David Gasper	NYDEC	Y
David Follansbee, PhD	NY DEC	Y
Randy Greer	DNREC	Y
Steve Stewart	Baltimore County DEPRM	Y
Al Todd	Alliance for the Chesapeake Bay	Y
Neely Law	Coordinator, Center for Watershed Protection/CBPO	Y
Other panel support: Jeff Sweeney, CBP, Hannah Martin, CRC		Y

Meeting 7 Minutes:

- approved

Action Items

- Neely will review how the term “treated” is applied and edit text as needed
- **All-review section 3.2 about design specifications to make sure they are accurately captured in the table**
- Neely will add “design ratio” in definition section
- Jeff Sweeney will send information on how urban land use loading rates are defined
- Request panel input on 0.4 or rounding up to 0.5 as sizing ratio (based on the 35 ft length of UFS to 75 ft impervious flow length)
- **Jennifer Z, Joe B and Rand G develop method and recommendations to address point source discharges to UFS/stream buffer**.
- Neely discuss grass filter strip N credit with Mark Dubin
- **Randy to look into PSD for coastal plain for 80% discount factors**

General comments on draft report

- Need to define how we are going to verify/document fertilizer applications to filter strips and maintenance practices. BMP Verification Committee will provide comments on latest version of urban stormwater BMPs. Neely will provide to panel for review and edit to incorporate UFS material when available
- Review use of loading ratio, design ratio and simplify where needed
- Need to state this is a minimum ratio of 0.4
- Go back to 0.5” for runoff depth captured

Section 6.1

- Panel in agreement for TP and TS credit
- Review statements to determine areas of consensus for panel regarding TN fate in UFS

Statement 1: Current research on UFS does not adequately assess the fate of infiltrated nitrate. **Panel in agreement**

Statement 2: The permanent loss of nitrogen from UFS is 1) denitrification and 2) removal of clippings. **Panel in agreement. Note that there may be others but these are the ones identified in literature**

Statement 3: Current research on UFS does not adequately assess the potential transfer of other N species stored in soil and vegetation. Research suggests that these forms may be mobilized and be available for export via surface runoff or groundwater loss.

  - Verchot paper shows source and one a sink for infiltrating nitrate to groundwwater. Add something like the magnitude of the N flux amongst soil, veg and groundwater pools highly variable (acts as source, sink); nothing on urban.

Statement 4: TN concentrations in urban runoff are close to the irreducible concentrations where BMPs may have little if any impact on further reductions

- Jeff Sweeny to provide model documentation re how loads assigned to land use and how 2.0 mg/L is applied.
- Panel to explore model implications for TN credit
  - Scenario of increase in N concentration leached would not increase load coming from this BMP
  - Neely to discuss grass filter strip TN credit with Mark Dubin. This BMP not recently reviewed.
  - Need for panel to clearly articulate rationale for TN credit as it will likely differ from other, and recently approved methods by other urban BMP expert panels

<u>Section 6.2</u>

- Panel conditional approval for older filter strips, comments still welcome
- Randy G to look into particle size distribution for coastal plain for 80% discount factors
- Need to specify timeframe for old filter strips , vary by state

<u>Other topics</u>

- Concern for concentrated flow to filter strip despite use of level spreader
- Randy G/ Jennifer Z review 75 ft max. and its interpretation for UFS design (e.g., sheetflow concentrates afterwards and would need level spreader if impervious cover >75ft)
- Panel still interested to pursue treatment train (3 practices, stand along, treatment train and buffer) – although buffer existing BMP. May be a recommendation on how model treats BMPs as 'stackable'. Need to resolve issues of drainage area/impervious cover treated by BMPs when stacked or in a 'treatment train'
- Is a treatment train definition of SBU a prevalent practice and worthy of definition? If so, need a method for jurisdictions to report as a treatment train (and for modelers)

Urban Filter Strip/Stream Buffer Upgrade Expert Panel
Meeting 9 Notes

November 18,2013

1:00-3:00PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Joe Battiata	Center for Watershed Protection	Y
Jennifer Zielinski	Biohabitats	N
Ryan Winston	North Carolina Extension, NCSU	Y
Curtis Hardman	WV DEP	Y

Scott Crafton	VA DCR	N
Tom Jordan, PhD	SERC	Y
David Gasper	NYDEC	Y
David Follansbee, PhD	NY DEC	Y
Randy Greer	DNREC	N
Steve Stewart	Baltimore County DEPRM	N
Al Todd	Alliance for the Chesapeake Bay	N
Neely Law	Coordinator, Center for Watershed Protection/CBPO	Y
Other panel support: Jeff Sweeney, Gary Shenk, CBP, Emma Giese, CRC		Y

<u>Meeting 8 Minutes:</u>
- Approved

<u>Action Items</u>
- Neely will follow up with panelists by email, asking them to articulate any additional comments on TN removal efficiency
- Randy, Jennifer, Joe, and Neely will have a follow up discussion regarding qualifying condition information needed for this practice.

<u>Gary Shenk presented modeling TN reductions from urban filter strips</u>
- How were the loads derived for the model?
    - National stormwater database was used to come up with large scale concentrations of N and P as the starting point, and then the loads were adjusted by water quality measurements at a local scale.
- Upland benefit for urban BMP acres is 1:1 for nitrogen.
- Panel is reviewing nitrogen by species, rather than by total N.
- How does the BMP reduction actually work? Does the model remove 55% of TSS or is the water slowed down to reduce scour by 55%?
    - Can be modeled either way, based on what is happening on a watershed scale. If the BMP is slowing the water down, it should be modeled as an erosion reduction.
    - The 55% efficiency came from the runoff reduction curve.
    - The runoff reduction BMPs account for the amount of total runoff reduction as well as pollutant removal.
- Should filter strips and buffers be modeled similarly to agricultural BMPs with a land use conversion?
    - Design specs for filter strips lend themselves to ratio modeling.
    - Grass filter buffers in urban areas are not given a land use conversion currently, because they already are being converting from pervious to pervious.
    - Application of ag grass filter strips takes agricultural land and converts it to a lower loading land cover.
    - Panel agreed that land use conversion may not be justifiable for this BMP.

- How will the panel address infiltrated nitrate?
    - Panel address groundwater loss (see notes below)
    - Runoff reduction curve may be adjusted further for this BMP.

TN removal efficiency (Ryan Winston)

- Ryan Winston presented rationale for TN removal efficiency around 19% that focuses on filter strip trapping particulate N, provides zero credit for soluble N (estimated at 30% of TN)
- **Neely will follow up with panelists by email, asking them to articulate any additional comments on TN removal efficiency.**

Information updates

- Report out from Joe Battiata on meeting with Randy Greer and Jennifer Zielinski discussed how to address concentrated flow to filter strips (such as an outfall pipe creating an eroding channel to the stream).
- Issue: How best to define the qualifying conditions when there is flow coming from a pipe, and how to distribute it to sheetflow?
        - NRCS guidance suggests that beyond 75 feet of contributing flow path, sheet flow will begin to concentrate.
- Ryan presented NC method for calculating length of level spreader based on cfs. The equation leads to 13ft/cfs, (reduced to 10ft/cfs, based on field performance).
    - The size of drainage area is effectively limited by the length of the level spreader.
    - A qualifying condition for concentrated flow from a pipe could be meeting a maximum discharge that would be related to maximum allowable length.
- Concern about crediting the BMP when used in combination with other BMPs in a “treatment train” approach.
    - This could create inconsistency when accounting for acres treated.
- **Randy, Jennifer, Joe, and Neely will have a follow up discussion regarding qualifying condition information needed for this practice.**

Urban Filter Strip/Stream Buffer Upgrade Expert Panel
Meeting 10 Notes

December 16,2013

1:00-3:00PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Joe Battiata, P.E.	Center for Watershed Protection	Y
Jennifer Zielinski, P.E.	Biohabitats	Y
Ryan Winston	North Carolina Extension, NCSU	Y

Curtis Hardman	WV DEP	Y
Scott Crafton	VA DCR	N
Tom Jordan, PhD	SERC	Y
David Gasper	NYDEC	Y
David Follansbee, PhD	NY DEC	Y
Randy Greer, P.E.	DNREC	Y
Steve Stewart	Baltimore County DEPRM	N
Al Todd	Alliance for the Chesapeake Bay	Y
Neely Law	Coordinator, Center for Watershed Protection/CBPO	Y
Other panel support: Jeff Sweeney, CBP, Hannah Martin, CRC		Y

Meeting 9 Minutes:

- Approved

Action Items

- Neely will send out Retrofit Expert Panel report and request panel review recommendation for UFS as a new retrofit
- Tom Jordan to provide additional text rationale on no TN credit
- Randy Greer to provide write-up on methods to determine qualifying conditions for concentration flow conditions
- Neely to provide additional description on methods to estimate 20% TN pollutant removal credit as an appendix to report
- Forward all comments to Neely by January 8th. Request to review full report with specific attention to Sections 5.2, 6.1 and 6.3, and 8 (Future Research and Management Needs)
- Neely to follow-up with Tom Schueler to clarify local reporting needs to States and NY reporting requirements

Minutes:

Meeting 9 Minutes-Approved

Review Panel Scope

- Panel reviewed specific elements of the scope for the Expert Panel to identify remaining information needs
- Panel agreed that information on conservation landscaping does not support development of recommendations for this as a BMP. Urban filter strip research focused on turfgrass as vegetative cover.

- Pending further review by the panel, it was tentatively agreed that the method to credit UFS as a 'new retrofit' be the same as a new BMP. Input requested by panel members.
- Currently UFS are not credited by the CBP so technically would not be eligible as an existing practice. In future years, stormwater treatment urban filter strips may be upgraded as a runoff reduction UFS.

TN Removal Efficiency
- General consensus to recommend 20% TN credit
- Tom Jordan provide text to provide rationale for no TN credit

Qualifying conditions for concentrated flow entering UFS
- Randy presented three qualifications presented based on methods provided by Ryan to estimate length of level spreader with input from Jennifer Z and Joe B
- The purpose is not to specify calculation methods or UFS designs, rather define the conditions based on State compliance (e.g. design storms)
- The qualification to limit the maximum length of level spreader to 100-ft may not require condition to specify a drainage area.
- Randy will provide a write-up to explain methods to define the qualifications

Stream Buffer Upgrades
- Panel reviewed rationale for not recommending stream buffer upgrade as a BMP. Decision based on four potential definitions, with a fifth added on floodplain reconnection as per the recently adopted Urban Stream Restoration Expert panel protocol

Accountability Mechanisms
- Information to ensure this BMP functions as designed so that nutrient and sediment reductions are achieved year after year.
- Address accountability mechanisms or modify existing recommendations if we think BMP will have shelf life other than 10 yrs.
    - o If maintained with no erosion/good grass coverage, would these BMP typically last 10 yrs or would it be a shorter lifespan?
        - ▪ If maintained properly panel agreed UFS would last at least 10 yrs. No change to this element.
- Need to add verification for stormwater treatment filter strips. These are not non-conforming projects at they are designed and implemented with design specification at the time.
        - ▪ Edit this element but avoid confusion on this topic, use either non-conforming or older UFS.
- Elements to include for inspection:
    - o Ryan noted rudding issues due to mowing after rain events from the tires. Not scalping the grass with the mower (blade too low and killing grass).
    - o Grass clippings—nice if you bag and take off site, but it will most likely end up on most FS. Can't prescribe on bay wide basis.

- Follow-up with information recommendation for verification using local inspection information. NY DEC does not currently collect this information from the localities
- Locations where this BMP is not appropriate to be listed as a qualifying condition.

Future Research and MGMT needs (Section 8)

- Panel input requested. What information should we be collecting in the future expand understanding of this BMP?
- Hydric soils are more related to forest buffers. Need to encourage max permeability in these strips.

Next Steps Next meeting tentatively set for **January 21, 1-3pm** pending panel availability

Urban Filter Strip/Stream Buffer Upgrade Expert Panel
Meeting 11 Notes
January 29,2014
1:00-3:00PM, CBPO

Urban Filter Strip/Stream Buffer Upgrade Expert Panel		
Name	**Affiliation**	**Present**
Sally Claggett	USFS, CBP Forestry Work Group	Y
Joe Battiata, P.E.	Center for Watershed Protection	Y
Jennifer Zielinski, P.E.	Biohabitats	Y
Ryan Winston	North Carolina Extension, NCSU	Y
Curtis Hardman	WV DEP	Y
Scott Crafton	VA DCR	Y
Tom Jordan, PhD	SERC	Y
David Gasper	NYDEC	Y
David Follansbee, PhD	NY DEC	Y
Randy Greer, P.E.	DNREC	Y
Steve Stewart	Baltimore County DEPRM	Y
Al Todd	Alliance for the Chesapeake Bay	N
Neely Law	Coordinator, Center for Watershed Protection/CBPO	Y
Other panel support: Hannah Martin, CRC		Y

Meeting 10 Minutes: Approved
Action Items

- Neely will check with Matt Johnston about treatment trains in the model
- Include in Periodic BMP Inspections Visual indicators—if there is a level spreader involved with practice, verify integrity of the structure is intact as designed and installed.
- Neely will make revisions and send out by Feb 3rd asking for comments/revisions by Feb 10th and submit on the 11th.
- Draft report dated 1/27/2014 approved pending edits discussed. Final decision draft (2/3/2014) reviewed and no further comment provided by panel members

Updates:

Decision Draft Report Review

1. Definition (minor edits)
2. Clarify with example nuisance conditions associated with level spreader

3. Clarify use of "treatment train" in bay model and credit process for BMPs
4. Stormwater Treatment UFS credit availability.
    a. Leave it up to the state to credit as ST or RR given date BMP approved for usw (e.g some ST grandfathered in, despite RR current design standard).
    b. May have different dates for different states based on BMP guidelines adopted by the states
5. Accountability mechanisms
    a. Reference to USWG BMP verification guidance and New State Stormwater and Stormwater Retrofit expert panel report recommendations
    b. This section will provide additional guidance on what to look for in reference to this specific BMP; review language as verifying performance indirectly through visual inspections and whether it meets design specifications, but does not directly verify performance of pollutant removal. The performance is assumed based on design.
    c. States may include in Periodic BMP Inspections Visual indicators—if there is a level spreader involved with practice, verify integrity of the structure is intact as designed and installed.
6. Added section on double counting and unintended consequences

- Urban Stormwater Workgroup next meeting February 18th
- Approve the report- All "yes"

Appendix B: Method to Develop Qualifying Conditions for Concentrated Flow Entering a UFS

The Level spreader length is based on 10ft for every 1 cfs with a maximum 100 ft length. This sizing criterion is based on basic hydraulic properties of weirs and a maximum desired flow velocity through grass as follows:

- Maximum velocity of sheet flow through a grass filter strip = 1.3 feet per second (Winston et al. 2011). This value was derived from research that established a target maximum flow velocity of 4 feet per second through grass cover (Malcolm, 1993), and evidence that flow re-concentrates into approximately one-third of the available width of the filter strip. By the Continuity Equation (Chin, 2006), it was estimated that the resulting flow velocity would therefore increase, thereby prompting a simplistic corresponding reduction in the target velocity from 4 fps to 1.33 fps.
- The Manning-kinematic solution derived in NRCS Technical Note N4 (USDA SCS 2003) can be applied to any point in the length of the level spreader to determine the sheet flow velocity. However, for level spreader design purposes, the target design velocity is established at the level spreader weir using the Continuity Equation:

$$Q = VA$$

Where: Q = calculated peak discharge of water quality design storm (cfs);
V = target velocity of sheet flow through a grass filter strip = 1.33 ft/s;
A = cross-sectional flow area over weir = ${}^{2}/_{3}\,H$ (contraction of flow directly over a broad crested weir due to increase in velocity)

Solving for H with a unit peak discharge of 1 cfs;

$$H = {}^{1.12}/_{L}$$

  - The broad-crested weir equation (Chin, 2006) is similarly used to solve for H using a unit peak discharge of 1 cfs, and combined with the Continuity Equation to solve for the Length of the Level Spreader as follows: The Weir Flow Equation:

$$Q = CLH^{1.5}$$

Where: Q = calculated peak discharge (cfs) set to 1 cfs;
C = weir coefficient for broad crested weir = 2.8 (Brater and King)
L = length of rigid lip of the level spreader (feet)
H = depth of flow above the weir;

Solving for H:

$$H^{1.5} = {}^{0.357}/_{L}$$

Setting the two equations equal to each other:

$$\left({}^{1.12}/_{L}\right)^{1.5} = {}^{0.357}/_{L}$$

$$1.19(L) = 0.357(L)^{1.5}$$

$$L = 11.1\ ft$$

Substitute *11.1 ft* back into Weir Equation:

$$H = 1.2\ inches$$

Based on the criteria noted above combined with field observations and continued research, the level spreader length, L, was reduced to 10 linear feet per cfs of water quality design flow. (Winston et al .2011).

Appendix C: State and District of Columbia Stormwater Manual Design Specifications for UFS

State[1]	Slope	Soils	Geometry	Contributing Drainage Area	Vegetation
DE	Max 8% with 2% slope required for first 10ft	A/B soils have higher runoff reduction (25-40) compared to C/D soils (10-20); compost amendments on C soils	Length dependent on slope and practice option; min 25' for slopes up to 3%; min. 50' for slopes from 3% - 8%.	Typically < 5,000 ft^2; max. 75' imp. /150' pervious flow unless engineered level spreader provided	Lower reduction credits for turf vs. forested; achieve 90% coverage with herbaceous materials; invasive sp plan
MD	< 5%, may use terraces or berms if >5%[1] to maintain sheetflow	HSG A, B, C. HSG D or compacted soils may need soil amendments Soil type will affect target unified sizing criteria	The ratio of disconnection length from drainage area and the filter strip length may range from 0.2 to 1.	**Rooftop: Disconnection length** 15-75ft length, rooftop area max 500 ft^2	natural areas/veg buffers, lawns, grass channels or other landscaped areas
				Non-rooftop disconnection through vegetated area, 10-75ft Impervious disconnection flow length 75ft, Pervious disconnection flow length 150 ft .Treated area max 1000 ft^2	Turf grass, trees and shrubs and other herbaceous plants
NY	0-10 ft <2% Max overall 8%	Compost amendments		Treat 5,000 ft impervious cover Max.impervious flow length of 75 ft & 150 ft for pervious areas; modify based on combination of impervious and pervious cover	Dense turf cover

State[1]	Slope	Soils	Geometry	Contributing Drainage Area	Vegetation
PA[2]	Never exceed 8% < 5% preferred DA slope 5% unless dissipation provided Max lateral slope 1%	All soil types HSG A, B, C and D	Ratio of contributing drainage area (CDA) to filter strip area not exceed 6:1 Min width equal to width of CDA Required length varies based on slope, soil cover Min length 25ft Longer required length with turfgrass	Max. impervious flow length of 100 ft impervious and 150ft pervious cover	Turfgrass, meadow grasses, shrubs, native vegetation, trees, indigenous areas of woods and vegetation. An appendix provides list of acceptable vegetation (turf, meadow, woody, shrub). Min. 90% uniform vegetative cover is required with turfgrass. Not recommended as stand-alone practice
VA	Max 8%, width vary with slope Min 1% is recommended to encourage positive drainage	VFS: Amendments for HSG B, C, and D	Max. flow length of 75 ft for impervious areas & 150 ft for pervious areas	Treat 5,000 ft^2 impervious cover or turf intensive uses close to source	amended soils, dense turf or other specified veg
WV	Varies based on width with 8% max VFS, 6% CA 0-10ft must be ≤ 2%	HSG A, B, C and HSG D with soil amendments	Max. flow length of 75 ft for impervious areas & 150 ft for pervious areas	Treat 5,000 ft^2 impervious cover or 10,000 ft^2 turf intensive uses close to source	VFS 90% grass/herbaceous cover

State[1]	Slope	Soils	Geometry	Contributing Drainage Area	Vegetation
DC Disconnection to Compacted Cover	Maximum 2% slope (5% with reinforcement)		75' maximum impervious flow path for non-rooftop (typically sheet flow). Minimum 150 square feet of disconnection area. Minimum sizing: 10' wide by 15' long. Maximum sizing: 25' wide (unless sheet flow or a level spreader is utilized) by 100' long.	1,000 square feet for downspouts	
Disconnection to natural cover	Maximum 6% slope, and 2% for the first 10 feet		Inflow must be conveyed via sheet flow or a level spreader. Sheet flow: 75' maximum impervious flow path, 150' maximum pervious flow path. Minimum sizing: 10' wide by 40' long. Maximum length: 100' long.	Minimum 400 square feet of disconnection area.	

[1] List of websites to access State and District of Columbia stormwater guidance accessed on 12/11/13
Delaware - http://www.dnrec.delaware.gov/swc/Drainage/Pages/RegRevisions.aspx

State[1]	Slope	Soils	Geometry	Contributing Drainage Area	Vegetation
District of Columbia - http://ddoe.dc.gov/proposedstormwaterrule Maryland - http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/MarylandStormwaterDesignManual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.aspx New York - http://www.dec.ny.gov/chemical/29072.html Pennsylvania - http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-67997/6.4.9%20BMP%20Vegetated%20Filter%20Strip.pdf Virginia – http://www.deq.virginia.gov/Programs/Water/LawsRegulationsGuidance/Guidance/StormwaterManagementGuidance.aspx West Virginia - http://www.dep.wv.gov/WWE/Programs/stormwater/MS4/Pages/StormwaterManagementDesignandGuidanceManual.aspx [2] Limited applications in ultra-urban and industrial areas					

Table B. 2. State Stormwater Design Specifications for Level-Spreader or Engineered Level Spreader

State	Use of Level Spreader (LS) or Engineering Level Spreader (ELS)	Mass Load Reduction		
		TN	TP	TS
DE	Length of LS determined by the type of filter area and the design flow 13 ft of level spreader per every 1 cfs inflow filter strip with max LS length of 130 ft	Max 20% [1]	Max 20%[1]	Max 80%[1]
	Max flow velocities[2] by vegetation type provided in Table 9.5 of *DE BMP Standards and Specifications*	100% load reduction for all parameters for vegetated open space		
MD	LS as needed to dissipate energy at downspout or for conservation areas	Defined by ESD sizing criteria		
NY	ELS if slope >3% Grass filter: length of LS per 1 cfs of flow	n/a	n/a	n/a
PA	Level spreaders must be level. Specific site conditions, such as topography, vegetative cover, soil, and geologic conditions must be considered prior to design; level spreaders are not applicable in areas with easily erodible soils and/or little vegetation. Level spreaders should safely diffuse at least the 10-year storm peak rate; bypassed flows should be stabilized in a sufficient manner. Length of level spreaders is dependent on influent flow rate, pipe diameter (if applicable); number and size of perforations (if applicable), and downhill cover type. It is always easier to keep flow distributed than to redistribute it after it is concentrated; multiple outfalls/level spreaders are preferable to a single outfall/level spreader.	Varies on BMP, i.e. Filter Strip or Riparian buffer		
VA	Length of ELS 13 linear ft per 1cfs of inflow, 130 linear ft max	50%	50%	n/a
WV	Length of ELS 13 linear ft per 1 cfs	A/B Soil: 50% C/D Soil: 25% C/D with amendment: 50%	50% 25% 50%	75% 63% 75%

DC	Level Spreader: 75' maximum flow path, Length of level spreader = 13'/1 cfs flow for 90% ground cover in receiving area. Length of level spreader = 40'/1 cfs flow for forested cover in receiving area.	TBD	TBD	TBD

Appendix D: Urban Filter Strip Design Example

Design Example of a Urban Filter Strip draining a parking lot with the following site characteristics:

- Parking lot configuration consists of a drive aisle (24 ft) with parking spaces on either side (18 ft) for a total flow length of 60 ft (< 75 ft);
- Long edge of parking lot is 180 ft, for a total of 10,800 ft^2 or 0.25 ac;
- Long edge is level and drops to a gravel diaphragm;
- Tv = [P(Rv)(A)/12] = [1"(0.95)(10,800 ft^2)/12] = 855 ft^3 = 0.02 ac-ft
- Vegetated filter strip area consists of B soils and is graded and top soiled to a 2% slope;
- Required filter strip width is 35 ft;
- Permeable berm is added at the lower edge of the filter strip;
- The presumptive compliance credits a runoff volume reduction of 428 ft^3 or 0.01 ac-ft (computed using the Virginia Runoff Reduction Method Compliance Spreadsheet or calculator (no magic in the spreadsheet).

Appendix E: Rationale and Method to Calculate Total Nitrogen Reduction Credit

The New State Stormwater Performance Standards Expert Panel Report Recommendations describes the rationale to reduce the TN pollutant removal for RR BMPs (Appendix C in SPS EP 2013a). SPS EP (2013a) reduced the initial 70% TN removal for RR BMPs to 60% to account for loss of soluble N to groundwater via infiltration. This reduction is based on the assumption that 30% of the soluble nitrate migrates to groundwater and is not treated by the BMP.

In the absence of design features for UFS that may enhance nitrogen uptake or denitrification as part of other RR BMPs (e.g. inverted under drain elbows, enhanced media), the Expert Panel recommended that TN performance adjustor curve be further lowered to account for 100% of the soluble N loss to groundwater.

Following the approach used by SPS EP (2013a), the 1-inch rainfall event is used as the basis to modify the TN performance adjustor curve along with a nitrate:TN fraction. The fraction of nitrate: TN of 0.3 is used based on an analysis of 3,000 storm events in the National Stormwater Quality Database (Pitt et al. 2006). The expert panel recommends that 100% of the nitrate is infiltrated to groundwater and is not available or reduced by UFS. Consequently, the percent removal would be further reduced based on the proportion of TN that is nitrate.

$0.3\ x\ 1 = 0.3,$ or a discount factor 0.7

The 0.7 represents the TN that is available for treatment or reduction by the UFS. The TN removal is then estimated by,

$$70\ x\ 0.7 = 49$$

This new anchor of 49% for TN is applied to a runoff frequency spectrum for National Airport to develop a new, lower curve for TN removal. This results in an estimated 35% TN removal for the 0.5-inch rainfall depth. This 35% is further reduced by the sediment, or particulate trapping efficiency of 56% (Table 9), resulting in a 19.6% or 20% TN removal (35 x 0.56).

Appendix F : Particulate size fractions in urban runoff

Law et al 2006 provides a summary of particulate size distribution of urban runoff based on a review of street sweeping literature (Table B-1). The 63 microns particulate size fraction is used to separate silt/clay and sand-sized suspended sediment (Horowitz 1995 as cited in EWRI Gross Solids Technical Committee 2010) or 75 microns for coarse sediments (EWRI 2010). It is estimated that 3 – 25.9% particles are <63 microns and 74.1 – 97% are $\geq$ 63 microns. The results from Sartor and Boyd for the Baltimore are used where 82.1% is classified as sand and 18% as silt or clay particle size fractions. Therefore, a 80% discount factor is assumed, where it is assumed 80% of the particles are trapped by legacy urban filter strips.

Table B- 1: Street dirt particle size distribution of solids, percentage by total weight. (Source: Table 3, in Law et al 2006)

Reference	<63 μm	63-250	251 – 1,000	>1,000μm	Comments
Sartor and Boyd (1972)	7.9[a]	6.8[b]	20.4[c]	64.9[d]	Milwaukee
	25.9	35.8	20.9	17.4	Bucyrus
	18.0	31.8	22.3	28	Baltimore
	8.1	39.6	30.9	25.4	Atlanta
	7.7	29.1	16.7	36.5	Tulsa
NC DNRCD (1983)	5[a]	35[e]	45[f]	15	CBD
	3	26	49	22	Residential
Terstriep et al. (1982)	5	14	39	42	Mattis North
	4	13	37	46	Mattis South
	5	16	38	41	John North
	6	16	35	43	John South
Pitt and Bissonnette (1984)	9	20.5	31	45.5	No curbs
	2.5	8.5	33	56	No curbs
	9.5	25	41.5	24	Surrey Downs
	11.5	27.5	37.5	23.5	Lake Hills
Waschbusch et al. 1999	8	17	75[c]		
Waschbusch 2003	9	20.5	43.7	26.8	
[a] <43 μm, [b] 43 – 246 μm, [c] 246-840 μm, [d] > 840, [e] 45-212 μm, [f] 212 -1000μm					

Appendix G: Conformity of Report with BMP Review Protocol

The BMP review protocol established by the Water Quality Goal Implementation Team (WQGIT, 2010) outlines the expectations for the content of expert panel reports. This appendix references the specific sections within the report where the panel addressed the requested protocol criteria.

1. **Identity and expertise of panel members:** *See Table in Section 1*

2. **Practice name or title:** *Urban Filter Strip (UFS) is one practice. Stream Buffer Upgrade as a separate practice.*

3. **Detailed definition of the practice:** *See section 2.1 for detailed definitions of UFS with qualifying conditions*

4. **Recommended N, P and TSS loading or effectiveness estimates:** *See tables 9 and 10 (Sections 6.1 and 6.2) for recommended N, P and TSS removal rates*

5. **Justification of selected effectiveness estimates:** *See Sections 6.1 and 6.2, with supporting documentation provided in Appendix B to understand how the panel derived the effectiveness estimates. See Section 6 (page 22) for an explanation of the dissenting opinion for the N removal rate for UFS.*

6. **List of references used:** *See page 29*

7. **Detailed discussion on how each reference was considered:** *See Sections 4 and and 5 for details on the review of available science.*

8. **Land uses to which BMP is applied:** *UFS practices are applied urban land uses in the Phase 5.3.2 WSM and the equivalent land use in the future Phase 6 WSM.*

9. **Load sources that the BMP will address and potential interactions with other practices:** *The UFS BMP will address runoff from impervious surfaces in the Bay watershed. The report recommendations provide qualifying conditions to report the UFS as a stand-alone BMP as part of new development, redevelopment and/or retrofit.*

10. **Description of pre-BMP and post-BMP circumstances and individual practice baseline:** This is a new practice and there is no practice baseline.

11. **Conditions under which the BMP works/not works:** *Section2.1 describes conditions under which the UFS BMP would not apply*

12. Temporal performance of BMP including lag times between establishment and full functioning: *No lag time is assumed.*

13. Unit of measure: *Acres*

14. **Locations in CB watershed where the practice applies:** *Urban*

15. Useful life of the BMP: *Varies by specific ESC practice and duration of specific construction project. For the purposes of this report, however, the useful life of the practice is up to 10 years but may be longer based on verification.*

16. Cumulative or annual practice: *Annual*

17. Description of how BMP will be tracked and reported: *See Section 7for discussion of how state governments can track and report to the Bay Program.*

18. **Ancillary benefits, unintended consequences, double counting:** *See Section 7.1 for discussion*

19. Timeline for a re-evaluation of the panel recommendations: *Depends on continued research*

20. Outstanding issues: *See Section 8 for a discussion of future research needs to address outstanding issues related to UFS*

Appendix H: USWG BMP Verification Guidance

Information on Urban BMP Verification Guidance may be found at:
http://www.chesapeakebay.net/groups/group/best_management_practices_bmp_verification_committee

Appendix I: Technical Requirements for Reporting and Crediting of Urban Filter Strips in Scenario Builder and the Phase 5.3.2 Watershed Model

Technical Requirements for Reporting and Crediting of Urban Filter Strips in Scenario Builder and the Phase 5.3.2 Watershed Model
Presented to WTWG for Review and Approval: May 27, 2014

Background: In June, 2013 the Water Quality Goal Implementation Team (WQGIT) agreed that each BMP expert panel would work with CBPO staff and the Watershed Technical Workgroup (WTWG) to develop a technical appendix for each expert panel report. The purpose of this technical appendix is to describe how the Urban Filter Strips Expert Panel's recommendations will be integrated into the modeling tools including NEIEN, Scenario Builder and the Watershed Model.

Q1. What are the efficiency reductions a jurisdiction can claim for Urban Filter Strips in the Phase 5.3.2 Watershed Model?

A1. The expert panel recommended two types of urban filter strips that could receive credit in the Phase 5.3.2 Watershed Model. Reductions for these two new BMPs are listed in the table below.

Table 1. Percent of Nutrients Reduced Per Acre Treated by Urban Filter Strip BMPs

Practice Type	TN	TP	TSS
UFS Runoff Reduction	20%	54%	56%
UFS Stormwater Treatment	N/A	N/A	22%

More details about percent reductions can be found in Section 6 of expert panel report.

Q2. What is the definition of each new Urban Filter Strip BMP?

A2. Definitions are listed below.
UFS Runoff Reduction – Urban filter strips are stable areas with vegetated cover on flat or gently sloping land. Runoff entering the filter strip must be in the form of sheetflow and must enter at a non-erosive rate for the sit-specific soil conditions. A 0.4 design ratio of filter strip length to impervious flow length is recommended for runoff reduction urban filter strips (pg. 4).
UFS Stormwater Treatment – Urban filter strips are stable areas with vegetated cover on flat or gently sloping land. Runoff entering the filter strip must be in the form of sheetflow and must enter at a non-erosive rate for the sit-specific soil conditions. A 0.2 design ratio of filter strip length to impervious flow length is recommended for runoff reduction urban filter strips (pg. 4).
Additional qualifying conditions for both practices can be found on pp. 4-5 of the expert panel's report.

Q3. Is there a specific year that a state should begin reporting UFS as Runoff Reduction as opposed to Stormwater Treatment?

A3. There is no specific year that this transition of reporting to NEIEN should occur. The panel intended the stormwater treatment filter strip BMP to represent older practices that pre-date each state's stormwater design specifications (as of this writing in 2014). These older practices were often designed to be only 10-15 feet in length and were used solely for sediment trapping (p. 23). Jurisdictions should report all filter strips with a 0.4 design ratio of filter strip length to impervious flow length as UFS Runoff Reduction (pg. 4).

Q4. What do jurisdictions need to report in NEIEN in order to receive credit for the new UFS BMPs?

A4. Jurisdictions should report the following information to NEIEN:

- Practice Name: Urban Filter Strip RR; Urban Filter Strip ST
- Acres Treated: number of acres treated by the practice
- Approved NEIEN land uses: impervious or pervious urban lands (impervious urban with CSS will be the default land use group)
- Location: Latitude and Longitude: the coordinates for the center of the practice
- Date of Implementation: year the practice was installed

Q5. How will the reductions be calculated in Scenario Builder and the Watershed Model?

A5. Reductions for each BMP will be applied as percent reductions to loads exiting urban land uses. The impact of these reductions in the Watershed Model will vary across the watershed as a result of hydrologic conditions, application rates to land uses and nutrient export from land uses.

Q6. How will UFS BMPs be combined with other pracitces in Scenario Builder?

A6. UFS practices are typically designed as stand-alone practices to treat sheetflow runoff. As such, acres treated by UFS practices cannot also be treated by other urban practices in Scenario Builder. Additionally, an acre cannot be treated by two separate UFS practices.

Q7. Was any credit given for Stream Buffer Upgrades?

A7. No. The expert panel did not provide a recommendation for stream buffer upgrades because they did not locate sufficient data to evaluate how an upgraded stream buffer would function differently from existing BMPs already credited in the Watershed Model (pg. 24).