Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards

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Accepted by Urban Stormwater Work Group: **April 30, 2012**
Revised based on Watershed Technical Work Group feedback: **May 29, 2012**
Resubmitted to Watershed Technical Work Group: **July 15, 2012**
Conditionally Approved by Watershed Technical Work Group: **August 1, 2012**
Conditionally Approved by Water Quality Goal Implementation Team: **August 13, 2012**
Errata Correction Approved by USWG: **September 14, 2012**
Resubmitted to WQGIT **September 28, 2012**
Final Approval by WQGIT: **October 9, 2012**
Revised: **January 20, 2015**

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List of common acronyms used throughout the text

BMP	Best Management Practices
CAST	Chesapeake Assessment Scenario Tool
CBP	Chesapeake Bay Program
CBWM	Chesapeake Bay Watershed Model
ESD	Environmental Site Design
GIS	Geographic Information Systems
GPS	Global Positioning System
LID	Low Impact Development
RR	Runoff Reduction
ST	Stormwater Treatment
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USWG	Urban Stormwater Workgroup
WIP	Watershed Implementation Plan
WQGIT	Water Quality Group Implementation Team
WTM	Watershed Treatment Model

Note: text in blue denotes additional language added by Watershed Technical Work Group and/or Water Quality Goal Implementation Team

Summary of Panel Recommendations

All of the Bay states are shifting to a new paradigm for managing urban stormwater runoff from both new development and redevelopment projects. The new paradigm is reflected in new performance standards that require greater levels of stormwater treatment using Low Impact Development (LID) and site design practices to mimic predevelopment hydrologic conditions.

The Panel noted that this new stormwater paradigm has increased capability to reduce runoff and pollutant loads generated by future development and redevelopment that occurs across the Chesapeake Bay watershed. The Panel also wrestled with the fact that each state has adopted (or will soon adopt) unique regulations, performance standards, compliance models and design criteria to implement the new stormwater paradigm.

Given this diversity, the Panel decided that assigning a single universal removal rate for BMPs designed to the new standards was not practical or scientifically defensible. Instead, the Panel elected to develop a protocol whereby the removal rate for each individual development project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides. The Panel conducted an extensive review of recent BMP performance research and developed a series of new BMP adjustor curves to define sediment, nitrogen and phosphorus removal rates.

The Panel then developed specific calculation methods tailored for different development situations. Jurisdictions will only need to report the number of acres treated under the new performance standards and the acreage of non-complying projects. They will no longer have to report a pollutant removal efficiency for each individual BMP or site design credit installed at each development project, which should greatly reduce the administrative and reporting burden for jurisdictions. The Panel has included numerous design examples to illustrate to users how the removal rates are calculated.

The Panel also developed a method to account for pollutant load reduction associated with the implementation of more stringent redevelopment stormwater requirements on existing sites with untreated impervious cover. While stormwater standards for redevelopment tend to be lower than for new development, they have the potential in the long run to incrementally reduce pollutant loads from untreated urban areas as redevelopment progresses. Larger communities with high redevelopment rates could be expected to attain substantial pollutant reductions in the next several decades.

The Panel also stressed that verification of BMP installation and subsequent maintenance is critical to ensure that pollutant reductions are actually achieved and maintained across the watershed. To this end, the Panel recommended that the pollutant removal rates are initially limited to a duration of 6 to 10 years, and can be renewed after a field inspection verifies the BMPs still exist, are adequately maintained and are operating as designed.

Section 1
The Expert Panel and its Charge

EXPERT BMP REVIEW PANEL New Stormwater Performance Standards	
Panelist	**Affiliation**
Stewart Comstock	Maryland Department of the Environment
Randy Greer	Delaware Department of Natural Resources and Environmental Control
Shoreh Karimpour	New York Department of Environmental Conservation
Sherry Wilkins	West Virginia Department of Environmental Protection
Fred Rose	Fairfax County Department of Public Works and Environmental Services
Peter Hill	District of Columbia Department of the Environment
Dave Hirschman	Center for Watershed Protection
Ken Murin/Jennifer Orr	Pennsylvania Department of Environmental Protection
Scott Crafton	Virginia Department of Conservation and Recreation
Jeff Sweeney	U.S. Environmental Protection Agency, Chesapeake Bay Program Office
Facilitator, Tom Schueler	Chesapeake Stormwater Network
The Panel would like to acknowledge the following additional people for their contribution: Norman Goulet, Chair Urban Stormwater Workgroup Lucinda Power, U.S. Environmental Protection Agency, Chesapeake Bay Program Office Davis Montalli, West Virginia Department of Environmental Protection Joe Kelly, Pennsylvania Department of Environmental Protection	

The Panel was charged to review all of the available science on the pollutant removal performance and runoff reduction capability of BMPs that are used to comply with the new state-wide performance standards for new development and redevelopment.

The Panel was initially charged to evaluate:

(a) Whether full implementation of each new state stormwater performance standard can achieve sufficient nutrient and sediment removal at a new development site, and qualify as being "nutrient neutral" with respect to the Bay TMDL.

(b) How to assess situations at new development projects that only partially achieve the standard.

(c) What, if any, pollutant load reduction should be offered when the standards are applied to redevelopment projects that treat existing impervious cover that was not previously treated by any BMP.

(d) What are the proper units that local governments will report to the state to incorporate into the Chesapeake Bay Watershed Model.

Beyond this general charge, the Panel was asked to:

- Determine whether to recommend if an interim BMP rate be established prior to the conclusion of the panel for WIP planning purposes.

- Provide a specific definition of how the performance standard approach is applied in each state, including runoff capture volume, degree of runoff reduction, and the potential situations where development projects may not fully comply with the standard.

- Recommend procedures for reporting, tracking and verifying the removal rates achieved under the new performance standards.

- Critically analyze any unintended consequence associated with the removal rates and any potential for double- or over-counting of load reductions.

While conducting its review, the Panel followed the procedures and process outlined in the WQGIT BMP review protocol (WQGIT, 2010) to ensure rates are consistent, transparent and scientifically defensible. The Panel recommendations will be reviewed by the Urban Stormwater Workgroup (USWG), and other CBP management committees before they are officially adopted by the Chesapeake Bay Partners. Appendix E documents the process by which the expert panel reached consensus, in a series of meeting minutes. Appendix F documents how the panel satisfied the requirements of the BMP review protocol.

Section 2
Background on Bay State Stormwater Performance Standards

In the last 5 years, all of the Bay states have worked to revise their regulations to improve the performance of the stormwater practices applied to development sites. All of the states have increased the volume of runoff that must be treated on-site and either require or strongly encourage the use of runoff reduction practices and environmental site design. This represents a sharp departure from the "pipe to pond" stormwater paradigm used in the 1990's.

The new approach utilizes many different Low Impact Development (LID) practices distributed across the development site rather than a single centralized facility. In addition, the Bay states have all adopted more stringent design criteria to improve the performance and longevity of individual LID practices, with a greater emphasis on design features that can enhance pollutant removal capability.

A comparative summary of the stormwater performance standards for new development sites is provided in Table 1 for each Bay jurisdiction. It should be noted that the engineering design criteria underlying each set of individual state standards is too complex to fit into a single table. Readers should consult the more detailed descriptions in Appendix A to gain a more complete understanding of state requirements (or directly access the state stormwater agency web links provided in Table 2).

Also, most Bay states only require redevelopment projects to treat a fraction of the runoff volume required at new development sites. Performance standards for redevelopment sites are discussed separately in Section 4 of this report.

As can be seen in Table 1, there are considerable differences among the Bay states in the terminology they use to describe their new stormwater performances standards including terms such as environmental site design, low impact development, runoff reduction, on-site retention, resource protection events and the water quality volume.

While it is tempting to compare the state performance standards in terms of the rainfall depth controlled, this can be misleading because of differences in the models used to compute runoff and technical assumptions regarding the pre-development hydrology baseline. Some states use a curve number (CN) approach, whereas others use a runoff coefficient (R_v) approach. The CN approach yields different runoff volumes, depending on the existing hydrologic soil group, the pre-existing land cover, and the change in impervious cover.

Table 1 lists the performance standard for new development sites in each jurisdiction across the Bay along with any qualifying conditions. The rain depth column indicates the rainfall depth that must be managed on the site.

Table 1
Comparison of Bay State Stormwater Performance Standards for New Development Sites [1] [2]

STATE	Performance Standard	Rain Depth	Base-line	Model	RR or LID?	Manual
DC	Retain runoff volume on-site	1.2 in	Zero	R_v	R	2012
DE	Provide runoff reduction to have zero effective impervious for RPE	2.7 in	Open Space	CN	R	2012-U
EPA	Control 95% storm event on-site using RR to METF	1.4 - 1.7 In	Varies	Varies	R	2010
MD	Use ESD to the MEP to achieve runoff for woods in good condition	2.7 In	Woods in good condition	CN & R_v	R	2009
NY	Provide runoff reduction for a fraction of WQv for 90% rain event	0.8 - 1.2 In	Zero	R_v	R	2010
PA	No increase in total runoff volume for all events up to the two year storm	2.8 In	Meadow or better	CN	E	2006
VA	TP load from new development may not exceed 0.41 lbs/ac/yr	1.0 In	Zero	R_v	E	2012
WV	Provide on-site runoff reduction	1.0 In	Zero	Rv	R	2012

[1] for redevelopment comparison, see Section 4
[2] Please consult Appendix A to get a more detailed description of state stormwater performance standards

CN = Curve Number using TR 55
ESD = Environmental Site Design
LID = Low Impact Development
RPE = Resource Protection Event
RR = Runoff Reduction
R_v = Runoff coefficient
MEP = Maximum Extent Practicable
METF = Maximum Extent Technically Feasible
TP = Total Phosphorus
WQv = Water Quality Volume

R= Required E= Encouraged U= Update of Existing Manual

The baseline column refers to the fact that each state requires stormwater to be treated to a different predeveloped hydrologic baseline. That baseline often reflects the runoff prior to development based on the specified land cover and hydrologic soil groups present at a site. In other cases, a state may simply require a basic stormwater treatment volume independent of the predevelopment condition.

The next column addresses the question of what method is used in each state's compliance tool or model to calculate the runoff volume produced at a site. Most states employ either the Curve Number (CN) or Runoff Coefficient (Rv) approach. The RR or LID column indicates whether state stormwater regulations specifically require or encourage the use of Runoff Reduction (RR) or Low Impact Development (LID) practices for stormwater management.

Finally, the Manual column addresses when the stormwater manual for each jurisdiction was released and/or whether or not it is currently being updated (U).

In addition, the Bay states differ with respect to the years that their new stormwater performance standards will take effect. Implementation within a state may also be staggered due to delayed local ordinance approval, exemptions, grandfathering provisions and a host of other factors. In addition, certain development sites may not need to fully comply with the standards if they can demonstrate they have tried to the maximum extent practical or technically feasible.

The practical implication is that many localities may end up with a mix of practices designed under the old and new standards from approximately 2009 to 2014, which complicates efforts to track the net change in nutrient loads from new development going forward.

The Panel concluded that these "apples to oranges" problems meant that (a) any general protocol had to be specifically adapted for each Bay state to reflect its unique performance standard formulation and (b) the protocol had to account for the differential rates for development projects built under old and new performance standards.

Table 2 Key Web Links for State and Federal Stormwater Agency Regulations[1]	
EPA	http://cfpub.epa.gov/npdes/home.cfm?program_id=6
DC	http://ddoe.dc.gov/stormwater
DE	http://www.dnrec.delaware.gov/swc/pages/sedimentstormwater.aspx
MD	http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SedimentandStormwaterHome/Pages/Programs/WaterPrograms/sedimentandstormwater/home/index.aspx
NY	http://www.dec.ny.gov/chemical/8468.html
PA	http://www.pacode.com/secure/data/025/chapter102/chap102toc.html
VA	http://www.dcr.virginia.gov/stormwater_management/stormwat.shtml
WV	http://www.dep.wv.gov/WWE/Programs/stormwater/Pages/sw_home.aspx
1 links current as of 3.19.2012	

Section 3
Protocol for Defining Removal Rates for New Development Projects

Basic Approach

Given the diversity in state stormwater performance standards, the Panel decided that assigning a single universal removal rate for BMPs designed to the new standards was not practical or scientifically defensible. Instead, the Panel elected to develop a protocol whereby the removal rate for each individual development project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides. The Panel conducted an extensive review of recent BMP performance research to develop this new protocol which is summarized in Appendix B.

The Panel initially developed a new BMP removal rate adjustor table that provides increasing sediment and nutrient removal rates for new development projects that treat more runoff and/or employ runoff reduction practices. For ease of use, the adjustor table was converted into a series of three curves, which are portrayed in Figures 1 to 3. Readers that wish to see the technical derivation for both the adjustor table and the curves should consult Appendix C. The new BMP removal rate curves make it easy to determine pollutant removal rates for new development. The designer first defines the runoff volume captured by the project (on the x-axis), and then determines whether the project is classified as having runoff reduction (RR) or stormwater treatment (ST) capability (from Table 4). The designer than goes upward to intersect with the appropriate curve, and moves to the left to find the corresponding removal rate on the y-axis (see example in Figure 1).

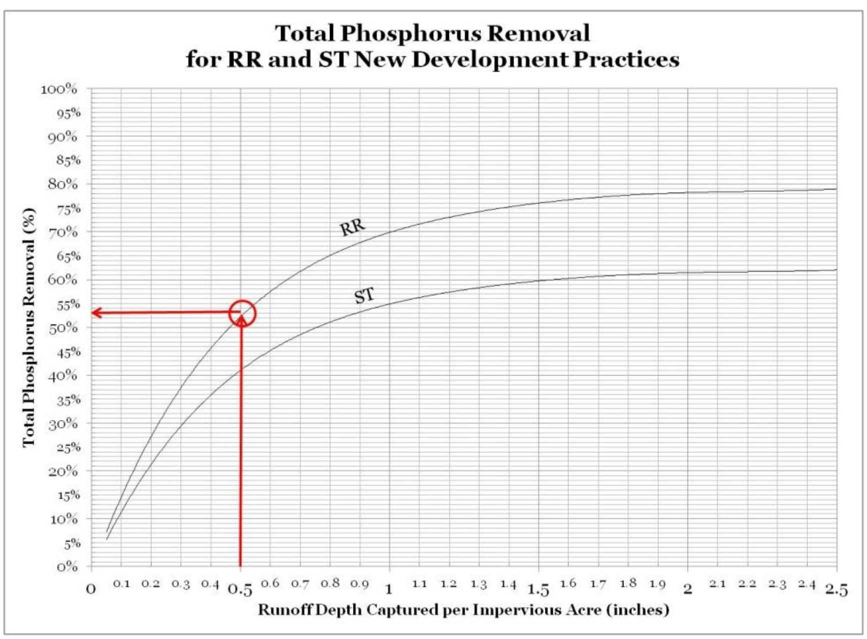

Figure 1. New BMP Removal Rate Adjustor Curve for Total Phosphorus

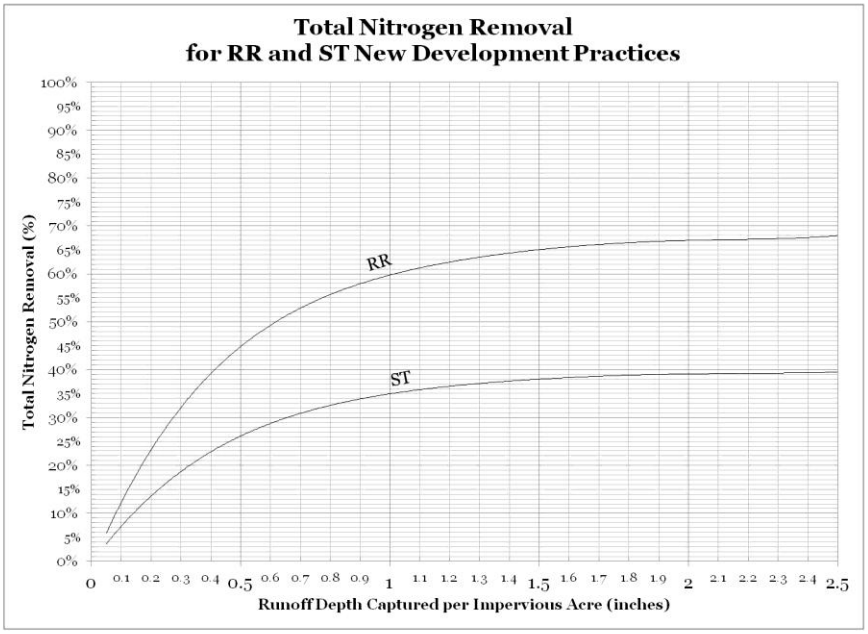

Figure 2. New BMP Removal Rate Adjustor Curve for Total Nitrogen

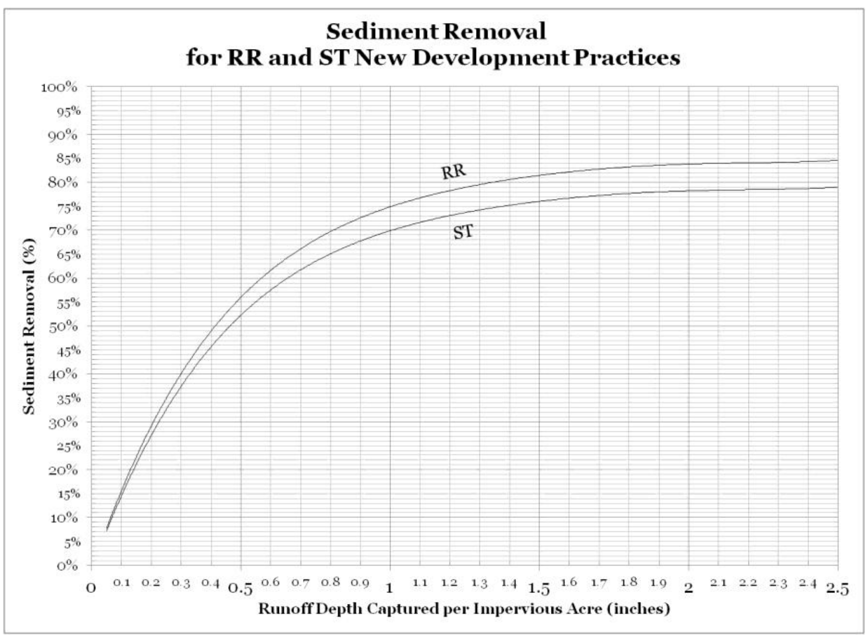

Figure 3. New BMP Removal Rate Adjustor Curve for Sediment

In the rare cases that the runoff volume captured by the practice exceeds 2.5 inches, simply use the pollutant removal values associated with 2.5 inches.

Table 3 How to Define Runoff Capture for New Development in Each Bay State		
	Specific Engineering Parameter (EP) Defining Runoff Volume Captured	**Source**
DC	Divide SWRv (stormwater retention volume, cubic feet) by 43,560 and insert into Equation X	Cell C-30 in 2012 DDOE Compliance Spreadsheet
DE	Runoff Reduction Depth (inches)	Directly from DE DURMM v. 2 Model Output
FED	D (95% rainfall depth, inches) less initial abstraction for predevelopment condition	EPA, 2009 and DOD, 2010
MD	Divide ESD Runoff Volume (cubic feet) by 43,560 and insert into Equation X	Cell C-66 in MD ESD TO MEP Spreadsheet (2012)
NY	Insert WQv (water quality volume, acre-feet) into Equation X	See 2010 Design Manual
PA	Divide 2-year Volume Increase of Runoff Volume between the proposed conditions and the existing conditions (cubic feet) by 43,560 and insert into Equation X	Cell C-51 in Tab WS4 of 2012 CSN PA Stormwater Spreadsheet
VA	Post Development treatment volume (acre-feet) inserted into Equation X	Cell B-49 on Site Data page (tab 1) in 2012 VA DCR Compliance Spreadsheet
WV	Target Tv (treatment volume, acre-feet) inserted into Equation X	Cell A-80 in 2011 WVDEP Compliance Spreadsheet

Equation X is a site specific conversion factor equation:

$$= \frac{(12 * EP)}{IA}$$

Where:
EP = State-Specific Engineering Parameter (in acre-feet)
IA = Impervious Area (acres)

Runoff reduction is defined as the total post-development runoff volume that is reduced through canopy interception, soil amendments, evaporation, rainfall harvesting, engineered infiltration, extended filtration or evapo-transpiration. Stormwater practices that achieve at least a 25% reduction of the annual runoff volume are classified as providing runoff reduction (RR), and therefore earn a higher net removal rate. Stormwater practices that employ a permanent pool, constructed wetlands or sand filters have less runoff reduction capability, and their removal rate is determined using the stormwater treatment (ST) curve.

Table 4 assigns all of the stormwater practices referenced in Bay State stormwater manuals into the ST or RR category, so that designers can quickly determine which curve they should use based on the primary treatment practice(s) employed at their site. In situations where a mix of ST and RR practices are used within the same development project, the designer should use the curve based on either the largest single practice used in the project or the one(s) that provide the majority of the runoff capture volume.

Table 4 Classification of BMPs based on Runoff reduction capability[1]

Runoff Reduction (RR) Practices	*Stormwater Treatment (ST) Practices [2]*
Non-Structural Practices	
Landscape Restoration/Reforestation	Constructed Wetlands
Riparian Buffer Restoration	Filtering Practices (aka Constructed Filters, Sand Filters, Stormwater Filtering Systems)
Rooftop Disconnection (aka Simple Disconnection to Amended Soils, to a Conservation Area, to a Pervious Area, Non-Rooftop Disconnection)	Proprietary Practices (aka Manufactured BMPs)
Sheetflow to Filter/Open Space* (aka Sheetflow to Conservation Area, Vegetated Filter Strip)	Wet Ponds (aka Retention Basin)
Non-Structural BMPs, PA 2006 BMP Manual, Chapter 5	Wet Swale
Practices	
All ESD practices in MD 2007	
Bioretention or Rain Garden (Standard or Enhanced)	
Dry Channel Regenerative Stormwater Conveyance (aka Step Pool Storm Conveyance)	
Dry Swale	
Expanded Tree Pits	
Grass Channels (w/ Soil Amendments, aka Bioswale, Vegetated Swale)	
Green Roof (aka Vegetated Roof)	
Green Streets	
Infiltration (aka Infiltration Basin, Infiltration Bed, Infiltration Trench, Dry Well/Seepage Pit, Landscape Infiltration)	
Permeable Pavement (aka Porous Pavement)	
Rainwater Harvesting (aka Capture and Re-use)	

*May include a berm or a level spreader

[1]Refer to DC, MD, PA, VA or WV State Stormwater Manuals for more information

[2] Dry ED ponds have limited removal capability , their efficiency is calculated using rates in Table B-4, Appendix B

Protocol for New Development Projects

To determine the sediment and nutrient removal rate for an individual new development project, the designer should go the appropriate curve and find the unique rate for the combination of runoff treatment and runoff reduction that is achieved. The designer should also estimate the total number of acres that are collectively treated by the system of BMPs.

The removal rates determined from the new BMP removal rate adjustor curves are applied to the entire site area, and not just the impervious acres. Also, the reporting unit is the entire treated area of the site, regardless of whether it is pervious or impervious. Several examples are provided in Section 6 to illustrate how the protocol is applied.

Retrofit Reporting Units

To be eligible for the removal rates in the model, localities need to check with their state stormwater agency on the specific data to report BMPs for new or redevelopment projects, and must also follow the BMP reporting and tracking procedures established by their state. The Panel recommends that the Chesapeake Bay Program consider the following information to report:

a. List of practices employed
b. GPS coordinates
c. Year of installation (and expected duration)
d. 12 digit watershed in which it is located
e. Total drainage area treated
f. Runoff volume treated and BMP "type" (i.e., whether the BMP system is classified as ST or RR)
g. Projected sediment, nitrogen and phosphorus removal rates

The Baseline Load Issue

The Panel decided that jurisdictions do not need to calculate a pre-development baseline load when it comes to reporting new BMPs that serve future new development or redevelopment sites. The precise load reduction achieved under the new performance standards is computed by the Chesapeake Bay Watershed Model. Jurisdictions need only report the removal rate derived from the new BMP removal rate adjustor curves and the total treated acres for each individual development project.

The Panel acknowledges that many jurisdictions may want to estimate pre-development baseline loads so they can track the aggregate impact of the implementation of stormwater practices on pollutant loads from the developed land sector over time. This tracking effort can estimate pollutant load reductions that occur when the new performance standards are applied to redevelopment sites and estimate the pollutant removal benefits associated with BMP implementation at new development sites. Most importantly, tracking can help jurisdictions forecast trends in pollutant loads due to land use change (and BMP implementation) in the future. The Panel recommends that such information would be useful to include in:

1. Local watershed implementation plans
2. Comprehensive land use plans
3. MS4 permit annual reports

Analyzing New BMPs in the Context of CAST, SB and the CBWM

The Panel acknowledges that the new BMP removal rate protocol may require adjustments in the BMP assessment and scenario builder tools recently developed to assist states and localities to evaluate BMP options to develop watershed implementation plans (i.e., each development project has a unique removal rate and consequent load reduction, while the CAST tools apply a universal rate for each type of BMPs).

The CBPO modeling team has expressed a willingness to incorporate the adjustor curves into the CAST modeling framework in the next year or so. Until these refinements are made, the Panel felt that it was reasonable for each state to select a single removal rate to characterize the performance of a generic BMP system used to meet new performance standards at a new or redevelopment site. This generic rate can be used for planning purposes to allow communities to analyze the loading impact from alternate future land use and stormwater management scenarios. For example:

A jurisdiction might assume that their future new development projects will fully meet the performance standard, and then use the curves to derive a standard removal rate for the aggregate drainage area expected to be treated in the future. The resulting load can be compared against the pre-development load to determine if future development will be nutrient neutral or not. Localities may also want to run scenarios whereby full compliance with the performance standard is not achieved to get a better sense of how this might impact their baseline load allocation.

A locality might also assume that their future redevelopment project fully meet the performance standard, and then assign the derived removal rate to the aggregate impervious area that is expected to be redeveloped over a defined time horizon. Since pre and post development land use are both impervious, this will provide a quick estimate of the load reductions possible under different redevelopment scenarios in the future.

As noted, each state is encouraged to work with localities to develop new and redevelopment stormwater scenarios that are consistent with their unique scenario assessment tools.

Important Note on State Pollutant Load Calculations

Several states in the Bay watershed require a site-based spreadsheet pollutant load calculation as part of stormwater review for individual development projects. The calculations require designers to achieve target post development loads using a series of removal efficiencies for individual LID and site design practices at the development site. Examples include the Maryland Critical Area Phosphorus compliance spreadsheet (CSN, 2011), the Virginia state-wide stormwater compliance spreadsheet (VA DCR, 2011), and the Pennsylvania stormwater manual worksheets (2006).

The Panel considers the technical and scientific basis for these site-based tools to be sound and appropriate for the scale of individual site analysis and BMP design. The Panel strongly emphasizes that the pollutant removal protocol it has recommended for Bay TMDL tracking in no way supersedes these site-based compliance tools. The regulated community must still meet their state's stormwater regulatory requirements established by regulations, permits, and/or design manuals.

The Panel agreed on the continuing need to monitor the effectiveness of stormwater BMPs at both the project and watershed scale to provide greater certainty in the removal rate estimates. The Panel also noted the importance of monitoring both runoff reduction and stormwater treatment BMPs in varied applications, terrain and climatic conditions.

Section 4
Protocol for Estimating Redevelopment Load Reduction

Background on Redevelopment and the Bay

Redevelopment is generally defined as the process whereby an existing development is adaptively reused, rehabilitated, restored, renovated, and/or expanded, which results in the disturbance of a defined footprint at the site. Redevelopment normally occurs within urban watersheds that are served by existing water, sewer and public infrastructure. When redevelopment is done properly, it is a key element of smart growth, sustainable development and urban watershed restoration (US EPA, 2005, 2006 and CSN, 2011a).

Historically, new development in the suburbs and rural areas of the Chesapeake Bay watershed has far exceeded the amount of redevelopment, in terms of land consumed and new impervious cover created. In recent years, however, there is evidence that urban sprawl may be cresting as a result of high energy prices, road congestion, falling housing prices, reduced job mobility and other economic forces, including the recent recession. Recent land use statistics show a slowdown in the rate of land conversion for sprawl development in the last five years.

At the same time, there is some evidence that redevelopment is increasing as a share of total development, at least in some portions of the watershed. More recent statistics show a sharp increase in residential redevelopment projects in core cities and inner suburbs of major metropolitan areas, including five in the Bay watershed (US EPA, 2010b).

The trend is being driven by increasing numbers of urbanites seeking the amenities of city life. This “back to the city” trend is reinforced by surveys of real estate investors that forecast increasing infill and redevelopment activity in coastal cities (ULI, 2010). In any event, the increasing age of existing residential and commercial development in metropolitan areas suggest that much of it will need to be rehabilitated or redeveloped in the future (Jantz and Goetz, 2008).

Stormwater Performance Standards for Redevelopment in the Bay States

Most jurisdictions in the Bay watershed have traditionally waived, exempted, relaxed or otherwise avoided stormwater requirements for redevelopment projects (with some notable exceptions). Most Bay states, however, have applied more stringent stormwater performance standards for redevelopment projects in the last few years. A comparative summary of the stormwater redevelopment requirements is shown in Table 5.

Most Bay states only require redevelopment projects to treat a fraction of the stormwater volume required at "green-field" development sites, in recognition of the challenging design constraints in urban areas, and to create an incentive for smart growth. As can be seen from Table 5, most states allow for offsets if full on-site compliance is not feasible. Most Bay states provide a credit for reducing existing impervious cover as part of the redevelopment design process, and some states "penalize" redevelopment projects that create more impervious cover than the predevelopment condition (i.e., the new increment of impervious cover is subject to the new development performance standard).

There are two notable exceptions: the District of Columbia and Federal Facilities require the same runoff reduction volume for both new and redevelopment projects.

Protocol for Defining Redevelopment Pollutant Removal Rates

This protocol is used to account for nutrient reduction associated with the implementation of more stringent redevelopment stormwater requirements on existing, untreated impervious cover. While the stormwater standards tend to be lower than for new development, they have the potential to incrementally reduce pollutant loads from untreated impervious areas during the redevelopment process. In particular, large cities and counties with high forecasted redevelopment rates can expect substantial pollutant reductions over the next 15 years, which can be deducted from their baseline pollutant load allocation target.

The protocol applies to individual redevelopment projects that meet the new redevelopment standards from 2010 and going forward. The protocol is fairly similar to the protocol for new development, but has several nuances. For example, the designer:

- Needs to confirm that the project is properly classified as redevelopment and is not served by any prior stormwater treatment practices.

- Tracks the acreage of *impervious cover* that is either treated or reduced during the redevelopment process. This is different from the reporting unit for new development which is *total site area*.
- Determines the runoff capture volume and degree of runoff reduction achieved by the combination of LID practices used to meet the redevelopment standard. As noted earlier, the runoff capture volume will usually be lower than that achieved at new development sites. Most Bay states have a separate compliance computation or spreadsheet that applies strictly for redevelopment situations (See Table 6 for state-specific parameters).
- Estimates the pollutant removal rates using the appropriate new BMP adjustor curves (Figures 1 to 3).

Table 5
Examples of Redevelopment Stormwater Requirements in the Chesapeake Bay Watershed [1]

Jurisdiction	Redevelopment Requirement	Min. Area (sf)	Offset?	Status*
District of Columbia	On-site retention of runoff from the 1.2 rainfall event	5,000	Yes	2012
Delaware	50% reduction in existing effective impervious for the site	5,000	Yes	2012
Federal Facilities	On-site runoff reduction for the 95% rainfall event	5,000	Yes	2010
Maryland	Reduce existing imperviousness by 50%, or treat runoff from 1.0 inch of rainfall, or combination	5,000	Yes	2009
New York	Reduce by 25% through IC reduction, BMPs or alternative practices	43,560	Yes	2010
Pennsylvania	20% WQ treatment for the site	43,560	UD	2008
Virginia	Reduce existing phosphorus load by 10 to 20% depending on disturbed area	43,560[3]	Yes	2011
West Virginia	0.25 - 0.8 inch of on-site runoff reduction [2]	43,560	Yes	2011

[1] Some states and localities may also impose further stormwater storage or runoff reduction volumes for channel protection or flood control purposes, depending on downstream conditions and how much new impervious cover is created at the redevelopment site.
[2] Depth varies depending on the number of redevelopment credits the project qualifies for thresholds for land use intensity and/or vertical density, involvement of brown-field remediation, or inclusion of mixed use or transit oriented development elements (WV DEP, 2009).
[3] May be smaller in the Chesapeake Bay Preservation Area
* Refers to the projected year that the redevelopment requirement will be adopted; the actual effective date for individual projects is likely to extend beyond that.

UD = Under development

Table 6 How to Define Runoff Capture for Redevelopment in Each Bay State		
	Specific Engineering Parameter (EP) Defining Runoff Volume Captured	**Source**
DC	Divide SWRv (stormwater retention volume, cubic feet) by 43,560 and insert into Equation Y	Cell C-30 in 2012 DDOE Compliance Spreadsheet
DE	Runoff Reduction Depth (inches)	Directly from DE DURMM Model Output
FED	D (95% rainfall depth, inches) less initial abstraction for predevelopment condition	EPA, 2009 and DOD, 2010
MD	Divide Redevelopment treatment volume requirements (cubic feet) by 43,560 and insert into Equation Y	Cell F-44 in MD ESD TO MEP Spreadsheet (2012)
NY	Insert WQv (water quality volume, acre-feet) into Equation Y	See 2010 Design Manual
PA	Divide 2-year Volume Increase (cubic feet) by 43,560 and insert into Equation Y	Cell C-51 in Tab W4 of 2012 CSN PA Stormwater Spreadsheet
VA	Post Development treatment volume (acre-feet) inserted into Equation Y	Cell F-57 on Site Data page (tab 1) in 2012 VA DCR Redevelopment Compliance Spreadsheet
WV	Target Tv (treatment volume, acre-feet) inserted into the following equation: (12 * EP)/IA, where IA where= acres of impervious area associated with the redevelopment project. The removal rate from the adjustor curve is then applied to the entire drainage area of the redevelopment project	Cell B-80 in 2011 WVDEP Compliance Spreadsheet

Equation Y is a site specific conversion factor equation:

$$= \frac{(12 * EP)}{SA}$$

Where:

EP = State Specific Engineering Parameter (acre-feet)
SA = Redevelopment Site Area (acres)

Section 5
Protocol for Non-Conforming Projects

What Are Non-Conforming Projects?

Non-conforming projects include new development or redevelopment projects installed after 2011 that are:

- Designed under old state stormwater performance standards due to grandfathering provisions, gradual rollout of new standards, waivers or delayed local adoption of stormwater ordinances or review procedures, or
- Designed under the new state stormwater standards, but only partially meet them due to site constraints, waivers, exemptions, etc. AND are not mitigated by an acceptable stormwater offset

Why are Non-Conforming Projects an Issue?

The transition to more stringent stormwater performance standards will not be a hard and fast event in most Bay states. Through 2017, many jurisdictions will need to keep two sets of BMP books to reflect the simultaneous implementation of BMPs under the old and new standards.

At the same time, jurisdictions are seeing a shift to a mix of LID and site design practices in many projects, even if they are not sized according to the new standards. Many of these new LID BMPs are not easily classified under the existing CBP-approved urban BMP rates. Simple BMP reporting mechanisms are needed to accurately account for the differential nutrient reduction achieved during this transition period.

Recommended Process for Reporting Non-Conforming BMPs

If the development project is served by a single BMP that can be classified under an existing CBP-approved BMP category, then use the appropriate existing removal rate.

If the project is served by multiple BMPs, determine the runoff treatment volume per impervious acre and whether the BMPs achieve RR or ST, and enter the appropriate removal rate from Figures 1 to 3. In addition, the following site data should be reported: year installed, treated drainage area, % IC, predevelopment land cover and GPS coordinates.

If a project does comply with the applicable standard due to the use of a stormwater offset or mitigation fee, the locality should track the aggregate equivalent impervious acreage which must be mitigated in the future, and the status of offset retrofit project construction. Any BMP built under a local offset program to meet state performance standards is not eligible for any additional load reduction (i.e., beyond the load reduction they are credited for meeting the state stormwater performance standard for the site).

Section 6
Design Examples

This section presents examples on how to apply the new BMP protocol to estimate nutrient and sediment removal rates for four development scenarios, as interpreted under different state stormwater performance standards. The examples include a low density residential subdivision, a planned unit development and a high density "big box" retail project, as well as an urban redevelopment project.

It should be noted that the design examples simply illustrate how nutrient and sediment removal rates are calculated in the context of the Chesapeake Bay TMDL. Designers must still follow the appropriate stormwater sizing, design criteria and compliance tools established by each state to implement its new performance standards.

Common Scenario #1 – Low Density Residential Subdivision

A developer plans to develop a 25 acre site into a half-acre lot residential subdivision in Pennsylvania. The predevelopment land cover is 50% forest and 50% meadow and has 100% C soils. After development the site will be 25% impervious, 50% turf and 25% forest. The developer will install a mix of LID and site design practices that qualify as RR practices. The calculation for PA is shown below as an example.

Using the site data above and the PA stormwater compliance worksheets, we can determine the target runoff reduction volume (in acre-feet) for this site. The rainfall depth to be controlled is assumed to be 2.8 inches. Once the EP has been calculated, it is then entered into Equation X to determine the site runoff capture depth.

$$Equation\ X = \frac{(12 * EP)}{IA}$$

$$Equation\ X_{PA} = \frac{(12 * 1.16)}{6.25} = 2.23\ in$$

State	Engineering Parameter (acre-feet)	Runoff Captured (inches)
PA	1.16	2.23

Once the runoff capture depth has been defined, the designer then uses the New BMP Adjustor Curves (Figures 1-3) to determine the associated pollutant removal values. One starts with the runoff capture depth on the x-axis and draws a line vertically until the curve for the practices is intercepted. From there, a horizontal line drawn back to intersect the y-axis will yield the pollutant removal rate.

State	TP	TN	TSS
PA	78%	67%	84%

Common Scenario #2 – Residential Planned Unit Development

A 100-acre site is built with a mix of single-family homes, apartments and townhouses in Maryland. The existing land cover consists of 100% forest with C soils. The new residential development will result in 50% impervious cover and 50% turf cover. After review of Table 4, it was determined that the stormwater management practices employed at the site should be classified as ST practices.

Entering the site data above into the MD stormwater compliance spreadsheet, one can quickly determine the EP (in acre-feet) for the site. The EP can then be used in Equation X to determine the amount of runoff in inches that needs to be captured.

$$Equation\ X_{MD} = \frac{(12 * 7.5)}{50} = 1.80\ in$$

State	Engineering Parameter (acre-feet)	Runoff Captured (inches)
MD	7.50	1.80

Once the runoff capture depth for the site is known, the New BMP Adjustor Curves (Figures 1-3) are used to determine the associated pollutant removal rate, as shown below.

State	TP	TN	TSS
MD	61%	39%	78%

Common Scenario #3 – Commercial Retail

An existing 10-acre site is developed into a big-box retail store in Virginia. The new site will have 80% impervious cover and 20% turf cover, which will replace the predevelopment meadow cover. The site has 100% B soils. After consulting Table 4, the reviewer determines that the stormwater practices employed at the site qualify as ST practices. The calculations for VA have been done as an example.

The above site data is entered into the Virginia stormwater compliance spreadsheet to quickly determine the EP (in acre-feet) for the site. The EP can then be used in Equation X to determine the amount of runoff in inches that needs to be captured.

$$Equation\ X_{VA} = \frac{(12 * 0.67)}{8} = 1.01\ in$$

State	Engineering Parameter (Acre-feet)	Runoff Captured (inches)
VA	0.67	1.01

Once the runoff capture depth for the site is known, the New BMP Adjustor Curves (Figures 1-3) are used to determine the associated pollutant removal rate, as follows.

State	TP	TN	TSS
VA	55%	35%	70%

Common Scenario #4 – Redevelopment Project

A developer is redeveloping a 2-acre facility to build a new warehouse in the District of Columbia. The predevelopment conditions are 50% impervious and 50% turf land cover. The redeveloped site will also consist of 50% impervious and 50% turf land cover. There are 100% D soils at the site and the site will be developed using RR practices. The District of Columbia's calculations have been done for demonstration below.

Table 6 tells us how we can calculate the runoff reduction volumes for redevelopment in each Bay state. In this case, the project data is entered into the DDOE stormwater compliance spreadsheet to determine the EP value for the site. Equation Y is then used to calculate the target runoff reduction volume (inches).

$$Equation\ Y = \frac{(12 * EP)}{SA}$$

$$Equation\ Y_{DC} = \frac{(12 * 0.12)}{2} = 0.72\ in$$

State	Runoff Captured (Acre-feet)	Runoff Captured (inches)
DC	0.12	0.72

Once the runoff capture volume is known, we can refer to the New BMP Adjustor Curves (Figures 1-3) to determine the associated pollutant removal values.

State	TP	TN	TSS
DC	62%	53%	67%

Section 7
Accountability Procedures

The Panel concurs with the conclusion of the National Research Council (NRC, 2011) that verification of BMP installation and subsequent performance is a critical element to ensure that pollutant reductions are actually achieved and sustained across the watershed. The Panel also concurred with the broad principles for urban BMP reporting, tracking and verification contained in the revised memo to the Urban Stormwater Workgroup (CSN, 2012). The Panel recommends that the Chesapeake Bay Program consider the following reporting, tracking and verification protocols for BMPs installed to comply with new state performance standards at new development and redevelopment projects.

Basic Reporting Unit. Jurisdictions will track the number of treated acres each year that fully meet the state's new performance standard. The typical duration for the BMP system 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 as part of their MS4 permit. In some cases, states are still developing and refining their BMP reporting systems. 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 NEIN standards), and periodically update data based on the local field verification of BMPs.

Local Reporting to the State. Localities will need to submit documentation to the state once a year as part of their MS4 annual report on the acres of new development and redevelopment projects that were treated to the state performance standard in the preceding year. To be eligible for the removal rates in the model, localities 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 recommended that following information should be reported:

- 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 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 MS4 community 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 should maintain a project file for each new or redevelopment project. This may include a 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. The lower nutrient removal rate for each non-conforming project can be computed using the new BMP removal rate adjustor curves, and reported separately to the state. The state may elect to use CAST or other similar tools to determine the aggregate nutrient increase associated with non-conforming projects in a locality, and increase their local load allocation target.

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. It is recommended that these rapid investigations be conducted as part of every other routine stormwater BMP inspection required under their MS4 NPDES permits.

Appendix D provides an example of an inspection form to quickly assess urban BMP performance in the field using simple visual indicators. This approach was refined and tested through an extensive analysis of hundreds of BMPs located in the James River Basin of the Chesapeake Bay watershed. More detail on the methods and results can be found in Hirschman et al (2009).

The basic form in Appendix D can be modified, simplified or customized to meet the unique BMP terminology and design criteria employed in each Bay state. Each state may elect to develop or adapt their own indicators, checklists and field inspection procedures. In some situations, localities can reduce the inspection effort by sub-sampling a representative fraction of BMPs at new development sites designed to the new standard to calculate the proportion of their BMPs that are performing or not performing.

Inspectors should evaluate BMPs once every other inspection permit cycle, 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, the pollutant reduction rate for the BMP would be eliminated, and the jurisdiction would report this to the state in its annual MS4 report. If corrective maintenance actions were verified for the BMP system at a later date, the jurisdiction could take credit for the load reduction at that time.

Special Procedures for Urban BMPs Installed in Non-MS4s. Several states such as PA and WV are expected to have considerable development occurring in non-MS4 communities, which tend to be very small in size and fairly new to stormwater BMP review. It is acknowledged that these non-MS4s may not currently have the budget and/or regulatory authority to fully meet the new BMP verification protocol. The Urban Stormwater Work Group will recommend alternative verification procedures for non-MS4 communities.

Stormwater Offsets and Mitigation. The full site pollutant reduction rate for non-conforming sites is allowed if a new stormwater practice(s) is built (and verified) that fully offsets, compensates or otherwise mitigates for a lack of compliance with new development stormwater performance standards. It should be noted that no additional load reduction may be taken for a retrofit when a stormwater offset is provided.

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