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Summary of Chesapeake Bay Program Approval of CMAC for the Enhancement and Conversion of Existing Best Management Practices

On November 15, 2016 the Chesapeake Bay Program, through deliberation and unanimous vote within the Urban Stormwater Workgroup (USWG), endorsed the use of Continuous Monitoring and Adaptive Control (CMAC) retrofits to obtain pollutant removal credits per the *Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects* (2015).

On October 20, 2015 Opti met with the USWG to formally discuss the merits and potential credit process for CMAC retrofits. Historically, the USWG has initiated Expert Panels to evaluate new BMPs and new retrofit practices. Under a new BMP decision request process, CMAC was approved as substantially similar to existing, approved retrofit approaches with existing, defined credit calculation strategies.

According to the USWG, CMAC retrofits map directly into two currently approved stormwater retrofit categories:

1. <u>Enhancement of existing BMPs</u> – increasing the treatment volume and/or increasing hydraulic retention time (i.e. upgrades to older stormwater ponds built in eras where water quality was not accounted for)
2. <u>Conversion of existing BMPs</u> – converting an existing BMP to a BMP that employs more effective treatment mechanisms (i.e. converting a dry pond to a wet pond; converting a wet pond to a wet extended detention pond, etc.)

The pollutant removal credits for these retrofit approaches can be calculated using the Retrofit Removal Adjustor Curves within the *Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects* (2015), using the total volume potentially controlled by the forecast-integrated actuated valve to compute runoff depth captured. Two example credit approaches are provided in the attached, approved proposal:

1. Enhancement of an Underperforming Wet Pond
2. Dry Pond to Wet Pond Conversion

CMAC enables the stored volume in all ponds to be retained with an actively-controlled release valve to achieve water quality and channel protection improvements. The technique uses water level sensors, an actuated control point, and cloud-based software to make automated, real-time control decisions based on National Weather Service forecast data.

Next Page: *Transmittal of USWG-Approved Continuous Monitoring and Adaptive Control (CMAC) Retrofit Variation - November 23, 2016*

Attachment A: *Overview of Continuous Monitoring and Adaptive Control for Enhancing or Converting Approved Stormwater BMP Types in the Chesapeake Bay Watershed - As Approved by USWG on November 15, 2016*

Attachment B: *Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects*

Date: November 23, 2016

From: Norm Goulet, Chair, Urban Stormwater Work Group
Tom Schueler, Chesapeake Bay Stormwater Coordinator

To: Matt Johnston and Lucinda Powers, EPA, CBPO
Ted Tesler, Chair, Watershed Technical Work Group
James Davis Martin, Co-Chair,
Water Quality Goal Implementation Team

Re: Transmittal of USWG-Approved Continuous Monitoring and Adaptive Control (CMAC) Retrofit Variation.

Background

On November 15, the USWG unanimously approved a proposal to credit the Continuous Monitoring and Adaptive Control (CMAC) technique for retrofitting existing stormwater BMPs, pursuant to the previously approved Stormwater Retrofit Expert Panel Report. The technique utilizes sensors to make real time weather forecasts to make automated decisions to actively manage stormwater storage and flows within existing stormwater ponds to improve their pollutant removal performance.

The CMAC proposal directly maps into two currently approved stormwater retrofit categories:

(1) enhancement of existing BMPs or,
(2) conversion of existing BMPs

A description of the CMAC approach and the rationale for integrating it into the retrofit credit system is provided in Attachment A.

The proposal is being forwarded to your committees for informational purposes only, and it is our understanding that no formal action or approval is needed under the BMP review protocol. A few other notes about the CMAC retrofit proposal are provided below:

- CMAC technology can be either proprietary or non-proprietary in nature.
- No additional BMP reporting data are needed for CMAC retrofits beyond the current retrofit reporting requirements that were previously approved by the WTWG and WQGIT.
- No changes in credit duration or retrofit verification are needed to accommodate the CMAC retrofit proposal.

Please do not hesitate to contact us if you have any questions or concerns.

Attachment A

Overview of Continuous Monitoring and Adaptive Control for Enhancing or Converting Approved Stormwater BMP Types in the Chesapeake Bay Watershed

presented to the Urban Stormwater Work Group October 20, 2015
revised February 9, 2016 - see Examples and References section
revised May 9, 2016 - Considerations for Use of CMAC in the Chesapeake Bay Watershed
Revised October 13, 2016 - revisions in response to MDE comments

Marcus Quigley, P.E., D.WRE. and Jamie Lefkowitz, P.E.

There are now reliable, robust, and secure solutions for cost effective continuous monitoring and adaptive control (CMAC) of stormwater infrastructure. These solutions have an important role to play in accelerating the enhancement and conversion of existing stormwater facilities and construction of new facilities. CMAC solutions integrate information directly from field deployed sensors with real-time weather forecast data (i.e., NOAA forecasts) to directly monitor performance and make automated and predictive control decisions to actively manage stormwater storage and flows. The approach is non-proprietary, commercially deployed throughout the county for other stormwater management applications, and the outcomes have been verified by separate independent research efforts.

Specifically CMAC BMPs can improve environmental outcomes by:

- Using a facility's storage volume to detain flow across all storm sizes.
- Dramatically improving water quality from facilities by increasing residence time and/or improving unit process effectiveness (e.g., settling, denitrification).
- Restoring pre-development hydrology and base flows by actively modulating release rates based on forecast information.
- Increasing the volume retained on site.
- Intelligently detaining flows in combined sewer systems for release during dry weather.
- Reduce the frequency of flooding events.
- Enabling durable and adaptable designs that are less dependant on site specific conditions.
- Being adaptable to future climatic conditions or changes in site characteristics without new infrastructure and with only operation changes.

and reduce technical, regulatory, and compliance risk by:

- Providing auditable performance and supporting data without additional cost.
- Increasing uptime of facilities through alerting of operational or maintenance issues.
- Providing direct verification of facility performance.

State of the Practice and Technical Discussion

Through empirical research, modeling, and widespread field deployments, CMAC solutions have been shown to result in significant increases in the performance of a range of existing stormwater BMPs while reducing operational and outcome risk.

Example Field Deployments and Existing Research:

- **EPA and the Water Environment Research Foundation (WERF)** published a report "*Transforming our Cities: High Performance Green Infrastructure"*, which was a pilot level study at eight locations around the country (WERF, 2014). The study concluded that distributed real-time control of green infrastructure can: significantly reduce contributions to combined sewers and mitigate post-storm combined sewer overflows, reduce stormwater runoff, conserve water, with particular benefits in drought-inclined areas, maximize reuse for irrigation. No other BMP can simultaneously accomplish these goals
- **Center for Research in Water Resources at the University of Texas at Austin and Geosyntec (2015)** showed that a passive dry pond conversion to a CMAC wet pond resulted in a facility that achieved a 73% reduction in Nitrate+Nitrite (Geosyntec, 2015) and a six fold reduction (from an average of 0.66 mg/L to 0.11 mg/L) in Nitrate+Nitrite over the pre-retrofit dry basin.
- **Muchalla et al. (2014)** found that retaining water using real-time rainfall-driven controls resulted in a 48 to 60% increase in removal of small particles from captured stormwater. "The removal efficiency for suspended solids could be significantly increased by all control strategies and the hydraulic peaks were reduced by at least 50%... [CMAC solutions] provide significantly higher removal efficiency for suspended solids and a possible flexible adaptation to future demands". Increasing retention time without increasing storage volume, such as with a dry pond to wet pond retrofit, has been shown to increase total suspended solids removal from 39 to 90% and ammonia-nitrogen removal from 10 to 84% (Carpenter et al., 2014 and Gaborit et al., 2012).
- **An analysis of the performance of the addition of CMAC on the harvesting systems installed in at USEPA headquarters in Washington DC** greatly improved the system's ability to mitigate stormwater volumes and flow rates and improve water quality. Total mass reductions estimated from this system during a one year monitoring period indicate removals based on residence time of 89% (TSS), 14% (TP) and 77% (TN), (Debusk, 2015).

Typical Applications in the Chesapeake Bay Watershed

CMAC of stormwater storage can have a particularly positive impact on the water quality improvement performance of existing approved best management practice (BMP) approaches while also restoring predevelopment flows. CMAC provides a mechanism for achieving both the BMP Conversion and BMP Retrofit categories of retrofits recognized by the Chesapeake Bay Program Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects (Scheuler et al., 2012) using existing approved retrofit approaches.

Stormwater BMPs with forecast-based adaptive control achieve better pollutant removal and runoff reduction outcomes because, among other benefits, they can increase the amount of time that stormwater remains in the treatment facility without compromising capture rate while also reducing the frequency of erosive flows. Further, the technology used to deploy the CMAC also collects performance continuously, allowing for accurate and precise quantification of a BMP's actual (not theoretical) performance. Direct continuous monitoring of facility performance should be the gold-standard in the Chesapeake Bay Watershed for quantifying and verifying load reduction credits and verifying implementation plan results. This direct documentation is available using CMAC solutions with approved BMP types.

Considerations for Use of CMAC in the Chesapeake Bay Watershed

CMAC is merely one component of a successful restoration project and can be used in conjunction with other retrofit activities to achieve restoration credit. As with all stormwater installations, the proposal to credit CMAC retrofit techniques should be fully vetted by the responsible governmental entity(ies) and comply with all state and local requirements, including dam safety requirements, for the proposed facility(ies). The design, installation, and operation of CMAC facilities must account for potential failure of the physical and control systems. Specifically CMAC enabled facilities must be designed to explicitly address loss of communication or power, lack of maintenance, intentional vandalism, and other potential failure modes. CMAC systems should be held to the same standards as existing controls. Beyond the requirements for designing and building inherently safe facilities we are particularly encouraged more broadly that CMAC systems are able to alert to conditions of potential concern.

Recommend additional verification requirement: A vigorous verification process (record keeping and reporting) should be followed for anyone using the technology who is seeking pollution reduction credit toward Bay or local TMDL WLAs. Proof of contractual agreement between CMAC service provider and facility owner or entity responsible for the facility should be provided.

CMAC provides a reliable, cost effective means for continuous monitoring and adaptively controlling new and existing stormwater quality facilities. Given that CMAC can provide significant and auditable performance enhancements to approved BMP types, credit should be given for directly demonstrated outcomes. Specifically:

- In the current credit system, a wet pond only gets credit for its volume. However, with CMAC, the precise volume that meets treatment requirements is continuously measured. Therefore, credit can and should be given for the actual treated volume, increasing the credit derived from an existing BMP.
- CMAC is an enhancement to BMPs; therefore, no new BMP types are required to be approved by the expert panel.
- Annual reporting of CMAC integrated project performance should accompany annual compliance reports under implementation plans. These reports should be verified by a professional engineer in the state of record.

Conclusions

Over the past decade, significant advances in hardware, software, communications infrastructure (i.e., the internet) and scalable computing architectures (i.e., cloud computing) have made it cost-effective to deploy reliable, secure, highly intelligent continuous monitoring and adaptive control solutions to help address some of our most challenging water quality issues. We have a significant opportunity to leverage these new technologies alongside the significant existing work of the Working Group and Expert Panel reports to help protect and restore the Chesapeake Bay.

Examples and References

The following examples demonstrate how two different CMAC retrofits and credits would work in practice, submitted in accordance with the Process for Handling Urban BMP Decision Requests, approved by the USWG on January 19, 2016. Table 1 (attachment) provides CMAC retrofit descriptions for Category A, B, and C BMP types recognized by the Chesapeake Bay Program and watershed jurisdictions (CBP, 2009). The following examples demonstrate how the retrofit removal adjustor curves for total phosphorus, total nitrogen, and sediment can be used to credit CMAC retrofits in accordance with the Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects (Schueler and Lane, 2012).

Retrofit Example 1: Enhancing the Performance of an Underperforming Wet Pond

An existing wet pond in Montgomery County, MD was underdesigned relative to the current watershed development and the current regulatory targets. Over time, the storage capacity of the pond has also diminished due to sedimentation and lack of maintenance. The pond currently provides adequate water quality treatment for 0.22 inches per impervious acre. The pond is retrofit with CMAC to use the storage between the existing passive outlet invert and the existing 2-year storm event overflow weir as extended detention water quality volume.

The retrofit involves installing an actuated valve on the existing passive outlet, a level sensor in the pond, and communication hardware to connect the valve and sensor to cloud-based decision software with forecast integration. The pond's water quality volume is increased to 1.2 inches per impervious acre by retaining stormwater in the available space above the permanent pool after storm events, while also protecting against flooding by actively monitoring the water level and forecast, and making a decision about when and how to draw down the extended detention volume in advance of the next storm. The retrofit removal adjustor curves for ST practices are then used to to determine the incremental pollutant removal rates associated with the pond restoration, as follows:

	TP	TN	TSS
Restored Rate (1.2 inches)	55%	34%	69%
Existing Rate (0.22 inches)	26%	17%	35%
Incremental Rate	29%	17%	34%

This example provides guidance for how to use the retrofit removal adjustor curves to calculate the credit available in a wet pond retrofit with CMAC. Additional considerations for obtaining the credits from Chesapeake Bay state regulators may include providing pre-treatment, forebay, wet pool, and vegetation requirements. As with other BMPs, individual states must work with local jurisdictions to establish a credit approval process.

Retrofit Example 2: Dry Pond to Wet Pond Conversion

A dry pond was built in 1988 in Prince George's County, MD that was designed to provide flood control only and receives no water pollutant removal credit. A CMAC retrofit is deployed that enables full capture and extended detention for 2 acre-feet of stormwater runoff, or 1.25 inches per impervious acre.

The retrofit involves modification of the passive outlet structure with an actuated valve and installing a level sensor in the pond storage area. Communication hardware connects the valve and sensor to cloud-based decision software with forecast integration. The pond's water quality volume is increased to the full 1.25 inches per impervious acre, as the software is configured to retain stormwater in the pond for 48 hours after a storm. When multiple events are forecasted within that period, the software responds by opening the valve to set the pond volume such that the flood storage capacity is adequate. Part of the design process for a specific facility is to install CMAC such that channel protection, flow-duration, and peaks meet state and local requirements. This is accomplished where needed through outlet valve modulation (adjustable flow independent of head). Furthermore, CMAC can be deployed to exceed requirements without additional cost (Kerkez et al. 2016). This is one of the benefits of the approach.

The retrofit removal adjustor curves for ST practices are used to to determine the incremental pollutant removal rates associated with the pond restoration, as follows:

	TP	TN	TSS
Restored Rate (1.25 inches)	56%	35%	70%
Existing Rate (0.0 inches)	-	-	-
Incremental Rate	56%	35%	70%

This example provides guidance for how to use the retrofit removal adjustor curves to calculate the credit available in a dry pond retrofit with CMAC. Additional considerations for obtaining the credits from Chesapeake Bay state regulators may include providing pre-treatment, forebay, wet pool, and vegetation requirements. CMAC provides an alternative approach for achieving one of the more cost-prohibitive and site constraint sensitive components of retrofitting dry ponds into water quality treatment BMPs - creating water quality and channel protection storage volumes. As with other BMPs, individual states must work with local jurisdictions to establish a credit approval process.

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Attachment B

Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects

Ray Bahr, Ted Brown, LJ Hansen, Joe Kelly, Jason Papacosma, Virginia Snead, Bill Stack, Rebecca Stack and Steve Stewart

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**
Resubmitted to WQGIT: **September 28, 2012**
Final Approval by WQGIT: **October 9 2012**

Prepared by:
Tom Schueler and Cecilia Lane
Chesapeake Stormwater Network

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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
GIS	Geographic Information Systems
GPS	Global Positioning System
ICPRB	Interstate Commission on the Potomac River Basin
LID	Low Impact Development
MS4	Municipal Separate Storm Sewer System
RR	Runoff Reduction
RT VM	Reporting, Tracking, Verification and Monitoring
ST	Stormwater Treatment
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
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 or Water Quality Goal Implementation Team

Summary of Panel Recommendations

Over the last two decades, the Chesapeake Bay states have pioneered new techniques for finding, designing and delivering retrofits to remove pollutants, improve stream health and maintain natural hydrology in developed watersheds. Several important regulatory drivers are likely to increase the amount of future stormwater retrofit implementation across the Chesapeake Bay watershed. Some communities need to install retrofits to meet pollutant reduction targets under recently issued municipal stormwater permits or meet local TMDLs. In addition, each of the seven Bay states are considering greater use of urban stormwater retrofits as part of an overall strategy to meet nutrient and sediment load reduction targets for existing urban development under the Chesapeake Bay TMDL.

Stormwater retrofits are a diverse group of projects that provide nutrient and sediment reduction on existing development that is currently untreated by any BMP or is inadequately treated by an existing BMP. The Panel classified retrofits into two broad project categories -- new retrofit facilities and retrofits of existing BMPs. These two categories encompass a broad range of potential local retrofit options and applications including new constructed wetlands, green streets or rain gardens, as well as conversion, enhancements or restoration of older BMPs to boost their performance.

Given the diversity of possible retrofit applications, the Panel decided that assigning a single universal removal rate was not practical or scientifically defensible. Every retrofit is unique, depending on the drainage area it treats, the treatment mechanism employed, its volume or size and the antecedent degree of stormwater treatment, if any.

Instead, the Panel elected to develop a protocol whereby the removal rate for each individual retrofit project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides. The Panel conducted an extensive review of recent BMP performance research and developed a series of retrofit removal adjustor curves to define sediment, nitrogen and phosphorus removal rates. The Panel then developed specific calculation methods tailored for different retrofit categories. To assist users, the Panel has included numerous design examples to illustrate how retrofit removal rates are calculated.

The Panel recommended simple retrofit reporting criteria to reduce the administrative burden on local and state agencies. The Panel also stressed that verification of retrofit installation and subsequent performance is critical to ensure that pollutant reductions are actually achieved and maintained across the watershed. To this end, the Panel recommends that the retrofit removal rate be limited to 10 years, although it can be renewed based on a field inspection that verifies the retrofit still exists, is adequately maintained and operating as designed. To prevent double counting, removal rates cannot be granted if the retrofit project is built to offset, compensate or otherwise mitigate for a lack of compliance with new development stormwater performance standards elsewhere in the jurisdiction.

Section 1
The Expert Panel and its Charge

EXPERT BMP REVIEW PANEL Stormwater Retrofits	
Panelist	Affiliation
Ray Bahr	Maryland Department of the Environment
Steve Stewart	Baltimore County
Ted Brown	Biohabitats, Inc.
LJ Hansen	City of Suffolk, VA
Jason Papacosma	Arlington, VA
Bill Stack	Center for Watershed Protection
Rebecca Stack	District Department of the Environment
Joe Kelly	Pennsylvania Department of Environmental Protection
Virginia Snead	Virginia Department of Conservation and Recreation
Jeff Sweeney	U.S. Environmental Protection Agency, Chesapeake Bay Program Office
Tom Schueler	Chesapeake Stormwater Network (facilitator)
The Panel would like to acknowledge the following additional people for their contribution: Norm Goulet, Chair Urban Stormwater Workgroup Lucinda Power, U.S. Environmental Protection Agency, Chesapeake Bay Program Office Chris Brosch formerly of University of Maryland and the Chesapeake Bay Program Office modeling team	

The charge of the Panel was to review all of the available science on the pollutant removal performance and runoff reduction capability of BMPs that can be used to derive methods or protocols to derive nutrient and sediment removal rates for individual retrofits.

Stormwater retrofits are a diverse group of projects that provide nutrient and sediment reduction on existing development that is currently untreated by any BMP or is inadequately treated by an existing BMP. Removal rates will need to be inferred from other known BMP pollutant removal and runoff reduction data. Every retrofit is unique, depending on the drainage area treated, BMP treatment mechanisms, volume or sizing and the antecedent degree of stormwater treatment, if any.

Stormwater retrofits can be classified into two broad project categories, as shown below:

a. New retrofit facilities
b. BMP conversions, enhancements, or restoration

The Panel was specifically requested to:

- Provide a specific definition for each class of retrofits and the qualifying conditions under which a locality can receive a nutrient/sediment removal rate.

- Assess whether the retrofit class can be addressed by using existing CBP-approved BMP removal rates, or whether new methods or protocols need to be developed to define improved rates.

- Evaluate which load estimation methods are best suited to characterize the baseline pre-retrofit for the drainage area to each class of retrofit.

- Define the proper units that local governments will report retrofit implementation to the state to incorporate into the Watershed Model.

Beyond this specific charge, the Panel was asked to:

- Determine whether to recommend if an interim BMP rate should be established for one or more classes of retrofits prior to the conclusion of the Panel for WIP planning purposes.

- Recommend procedures for reporting, tracking and verifying the recommended retrofit removal rates. The Panel also will look at the potential to develop regional monitoring consortium to devise strategies for future collaborative monitoring to better define the performance of various retrofit projects.

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

While conducting its review, the Panel followed the procedures and process outlined in the WQGIT BMP review protocol (WQGIT, 2010). The process begins with BMP expert panels that evaluate existing research and make initial recommendations on removal rates. These, in turn, are reviewed by the Urban Stormwater Workgroup, and other Chesapeake Bay Program (CBP) management committees, to ensure they are accurate and consistent with the Chesapeake Bay Watershed Model (CBWM) framework.

Appendix C documents the process by which the expert panel reached consensus, in the form of a series of five meeting minutes that summarize their deliberations. Appendix D documents how the Panel satisfied the requirements of the BMP review panel protocol.

Section 2
Background on Retrofitting in the Bay

Over the last two decades, communities across the Chesapeake Bay have pioneered new techniques for finding, designing and delivering retrofits to remove pollutants, improve stream health and maintain natural hydrology in developed watersheds (Schueler, 2007). Several important regulatory drivers are likely to increase the amount of future stormwater retrofit implementation across the Chesapeake Bay watershed.

For example, some communities need to install retrofits to meet pollutant reduction targets under recently issued municipal stormwater permits. Other communities are employing retrofits to control pollutants to meet local TMDLs. Each of the seven Bay states are considering greater use of urban stormwater retrofits as part of an overall strategy to remove nutrients and sediment loads, to meet reduction targets for existing urban development under the Chesapeake Bay TMDL. This section provides highlights about these retrofit strategies, which differ from state to state. More detail on individual state retrofitting strategies can be found in the stormwater sector section of their Phase 1 and Phase 2 Watershed Implementation Plans, the links to which can be found in Table 1.

PA DEP indicated that most of the retrofit activity in the Pennsylvania portion of the watershed to this point has involved various demonstration projects, many of which were funded under the Growing Greener program. The scope of retrofit activity will expand in the coming years as communities implement their new PAG-13 MS4 permits which require localities to develop strategies in the form of a local Chesapeake Bay Pollutant Reduction Plan by 2013.

VA DCR indicated that most of the retrofit activity in the Commonwealth included demonstration projects under state grants and revolving funds, although some suburban counties have also supported strong retrofit programs employing their own capital budgets. VA DCR intends to issue new Phase 1 MS4 permits during 2012 that will require as much as 40% pollutant reduction for existing development over a 15 year period. The pollutant reductions from existing development may be achieved by a variety of urban restoration practices, including stormwater retrofits. During the first permit cycle, communities are encouraged to conduct local watershed assessments to identify the most cost effective combinations of retrofits and other restoration practices.

MDE noted that Maryland has had a long retrofitting history. For more than a decade, Phase 1 MS4 communities have needed to treat 10% of their impervious cover in each five year permit cycle. Most communities have elected to meet that target through stormwater retrofits. Over the years, MDE has offered several grant programs to defray local retrofit project costs, but most communities have relied on their local capital budgets to finance the majority of their retrofits. MDE intends to issue new Phase 1 permits during 2012 that will expand the retrofit requirement to as much as 20% of untreated impervious cover during each permit cycle, and may also institute numerical retrofitting requirements for Phase 2 MS4 permits.

The District of Columbia has also had a long history of retrofitting, particularly in the Anacostia watershed. The focus of retrofitting in DC has evolved over the years to reflect the challenges and opportunities within their highly urban watersheds. DDOE currently relies on several residential and business incentive programs to build on-site LID retrofits, such as bioretention, rain barrels, green roofs or permeable pavers. The District is also implementing an extensive green street retrofit program on municipal streets. DDOE tracks these retrofits over time using a GIS tracking tool to record the aggregate acreage treated, and generally assumes a five year removal rate duration for on-site retrofits, which can be renewed based on inspection.

While Delaware has been involved in numerous retrofits over the years, they are not relying heavily on them in the small portion of their state that actually drains to the Chesapeake Bay. This part of the watershed area is primarily rural, and most of their urban restoration activity will involve septic system upgrades rather than retrofitting.

Similarly, the other upstream states (West Virginia and New York) are not expecting a great deal of stormwater retrofit activity in the coming years, and are focusing on other pollutant source sectors (e.g., agricultural, wastewater, abandoned mines) to achieve the bulk of their pollutant reductions. Both states, however, are expanding stormwater treatment requirements on new and redevelopment projects to prevent increased urban loading.

Stormwater retrofits have been uncommon at federal facilities until quite recently. The President's Executive Order on the Chesapeake Bay directed federal agencies to lead by example and demonstrate more pollution prevention and stormwater retrofits at the many federal properties in the watershed. Numerous federal agencies are now conducting retrofit and site benchmarking investigations at their facilities and it is likely that much more federal retrofit implementation will occur in the coming years.

Table 1 Key Web links for State and Federal Bay TMDL and WIP Guidance[1]

EPA	http://www.epa.gov/chesapeakebaytmdl/
DC	http://ddoe.dc.gov/service/total-maximum-daily-load-tmdl-chesapeake-bay
DE	http://www.dnrec.delaware.gov/wr/Information/Pages/Chesapeake_WIP.aspx
MD	http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx
NY	http://www.dec.ny.gov/lands/33279.html
PA	http://www.depweb.state.pa.us/portal/server.pt/community/chesapeake_bay_program/10513
VA	http://www.dcr.virginia.gov/vabaytmdl/index.shtml
WV	http://www.dep.wv.gov/WWE/watershed/wqmonitoring/Pages/ChesapeakeBay.aspx

1 links current as of 3.16.2012

Section 3
Retrofit Definitions and Qualifying Conditions

Definition: Stormwater retrofits are a diverse group of projects that provide nutrient and sediment reduction on existing development that is currently untreated by any BMP or is inadequately treated by an existing BMP. Stormwater retrofits can be classified into two broad project categories, as shown below:

1. New retrofit facilities
2. Existing BMP retrofits

1. New retrofit facilities: This category includes new retrofit projects that create storage to reduce nutrients from existing developed land that is not currently receiving any stormwater treatment. Common examples of new retrofit facilities include creating new storage:

(a) Near existing stormwater outfalls
(b) Within the existing stormwater conveyance system
(c) Adjacent to large parking lots
(d) Green street retrofits
(e) On-site LID retrofits

With the exception of (e), many new retrofit facilities are typically located on public land, and utilize a range of stormwater treatment and runoff reduction mechanisms. Due to site constraints, new retrofits may not always meet past or future performance standards for BMP sizing that applies to new development.

2. Existing BMP retrofits: are a fairly common approach where an existing BMP is either:

(a) Converted into a different BMP that employs more effective treatment mechanism(s).
(b) Enhanced by increasing its treatment volume and/or increasing its hydraulic retention time.
(c) Restored to renew its performance through major sediment cleanouts, vegetative harvesting, filter media upgrades, or full-scale replacement.

Most ***BMP conversions*** involve retrofits of older existing stormwater ponds, such as converting a dry pond into a constructed wetland or wet pond, although many other types of BMP conversions are also possible. BMP conversions can be located within existing BMPs located on public land, or at privately-owned BMPs. BMP conversions can utilize a wide range of stormwater treatment mechanisms.

BMP enhancements utilize the original stormwater treatment mechanism, but improve removal by increasing storage volume or hydraulic residence time. An example of a BMP enhancement is an upgrade to an older stormwater pond built under less stringent sizing and design standards. These upgrades may increase treatment volume, prevent short circuiting, extend flow path or hydraulic residence time, or add internal design features to enhance overall nutrient and/or sediment reduction. BMP enhancements typically occur within existing BMPs located on public land, or at privately-owned BMPs.

BMP restoration applies to major maintenance upgrades to existing BMPs that have either failed or lost their original stormwater treatment capacity. The method to calculate the removal rate increase depends on whether or not the BMP has previously been reported to EPA.

If the BMP has been previously reported, a lower removal rate is calculated using the curves that reflects the existing level of treatment, and this value must be reported for at least one progress reporting cycle. After the qualifying BMP restoration is completed, the curves are used to derive a higher rate for the increased treatment volume in subsequent years. If the BMP was not previously reported to EPA, it is considered a new retrofit, and the curves are used to define the removal rate based on the total treatment volume provided.

Only four types of BMP restoration are allowed:

(a) *Major Sediment Cleanouts* – Removal of sediment, muck and debris that is equal to or greater than 1/10 the volume of the facility. For wet ponds, the volume of the facility would be where the normal water elevation or invert of the outfall pipe is. For dry ponds or enhanced extended detention facilities, the volume would include the volume of any fore bays, to their overflows, and ½ the height of the dewatering structure.

(b) *Vegetative Harvesting* – Removal of excessive, non-planned vegetative growth with off-site sequestration or composting. Appropriate plant species shall be re-planted and re-established when the vegetative harvesting causes an erosive or denuded condition.

(c) *Filter Media Enhancements* – Removal and sequestration of contaminated material and replacement with a media that is superior to those originally proposed in the design specification (i.e., replacing sand with a sand/organic or sand/zeolite mixture).

(d) *Complete BMP Rehabilitation* – Complete rehabilitation of a failed BMP to restore its performance (e.g., converting a failed infiltration basin into a constructed wetland). This restoration option only applies to older BMPs that were not previously reported to EPA.

Figure 1. Examples of New Retrofit Facilities and their Potential Applications

New retrofit facilities provide stormwater treatment in places that treatment did not previously occur. There are many opportunities for new retrofit facilities in the urban landscape. Some common examples are listed below.

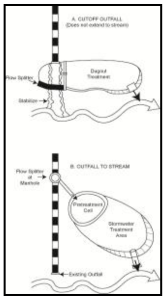	
Near Existing Stormwater Outfalls	Within the Existing Stormwater Conveyance System
	
Adjacent to Large Parking Lots	Green Street Retrofits
	
On-Site LID Retrofits	

Figure 2. Examples of Existing BMP Retrofit Facilities and their Potential Applications

BMP Conversion: from a Dry Pond (left) to a Constructed Wetland (right) to allow for more effective treatment of stormwater.

BMP Enhancement: by adding a berm you can increase the flow path thereby extending the hydraulic retention time within the practice leading to better treatment.

BMP Restoration: increasing performance of a BMP by conducting major repairs or upgrades. In this example, an underperforming pond is dredged for sediment thereby restoring it to its full performance capacity.

Important Notes:

- No pollutant removal rates are given for routine maintenance of existing stormwater practices.
- Routine maintenance is essential to ensure the pollutant removal performance of any stormwater practice.

- The WTWG added a further qualifying condition that the proposed BMP restoration activities must be significant enough to achieve the intent of the original water quality design criteria in the era in which it was built (e.g., sediment cleanouts would, at a minimum, need to recover the original water quality storage capacity under the prevailing design standards at the time the BMP was constructed).

- Individual state stormwater agencies are encouraged to develop more detailed guidance on the qualifying conditions for acceptable BMP restoration.

- Applying more stringent stormwater requirements at redevelopment sites that had not previously treated stormwater runoff is functionally equivalent to a new retrofit facility. However, the Performance Standards Expert Panel recommended a protocol to compute load reductions at redevelopment projects.

Section 4
Protocol for Determining Retrofit Removal Rates

Basic Approach

Given the diversity of possible retrofit applications, the Panel decided that assigning a single universal removal rate was not practical or scientifically defensible. Instead, the Panel opted to develop a protocol whereby the removal rate for each individual retrofit project is determined based on the amount of runoff it treats and the degree of runoff reduction it provides. This approach is generally supported by a review of the recent pollutant removal and runoff reduction research, which is summarized in Appendix A.

The Panel initially developed a retrofit removal rate adjustor table that provides increasing sediment and nutrient removal rates for retrofits 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 3 to 5. Readers that wish to see the technical derivation for the adjustor curves should consult Appendix B.

In order to determine the runoff volume treated by a retrofit practice, the designer must first estimate the Runoff Storage volume (RS) in acre-feet. This, along with the Impervious Area (IA) in acres, is used in the standard retrofit equation to determine the amount of runoff volume in inches treated at the site:

$$= \frac{(RS\ )(12)}{IA}$$

Where:

RS = Runoff Storage Volume (acre-feet)
IA = Impervious Area (acres)

Once the amount of runoff captured by the practice is determined, the retrofit removal adjustor curves make it easy to determine pollutant removal rates for individual stormwater retrofits. The designer first defines the runoff depth treated 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 2). The designer then 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 3).

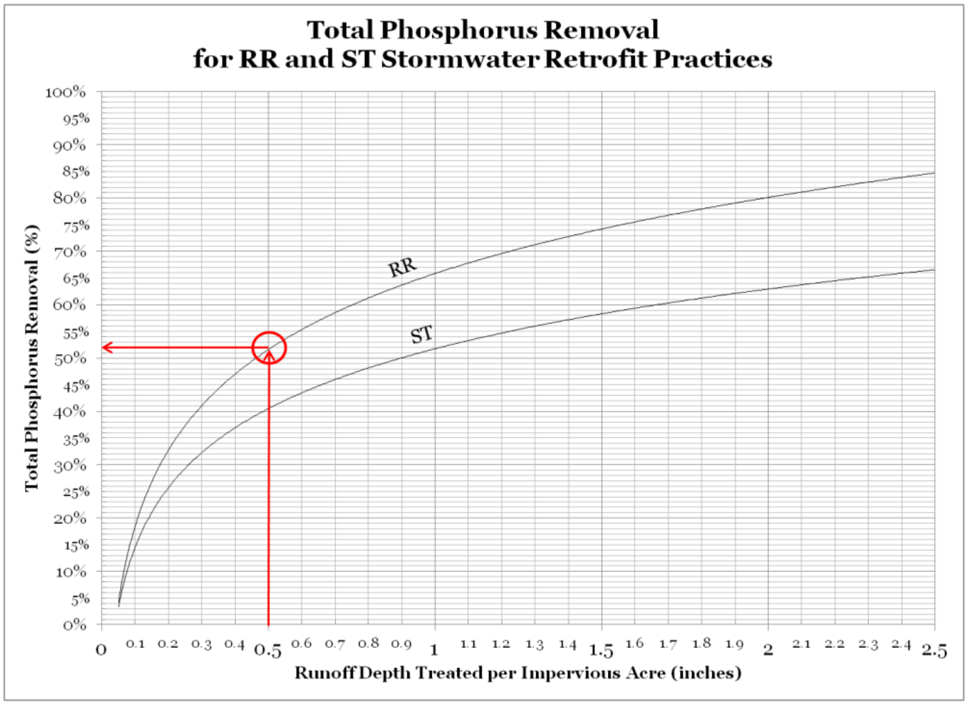

Figure 3. Retrofit Removal Adjustor Curve for Total Phosphorus

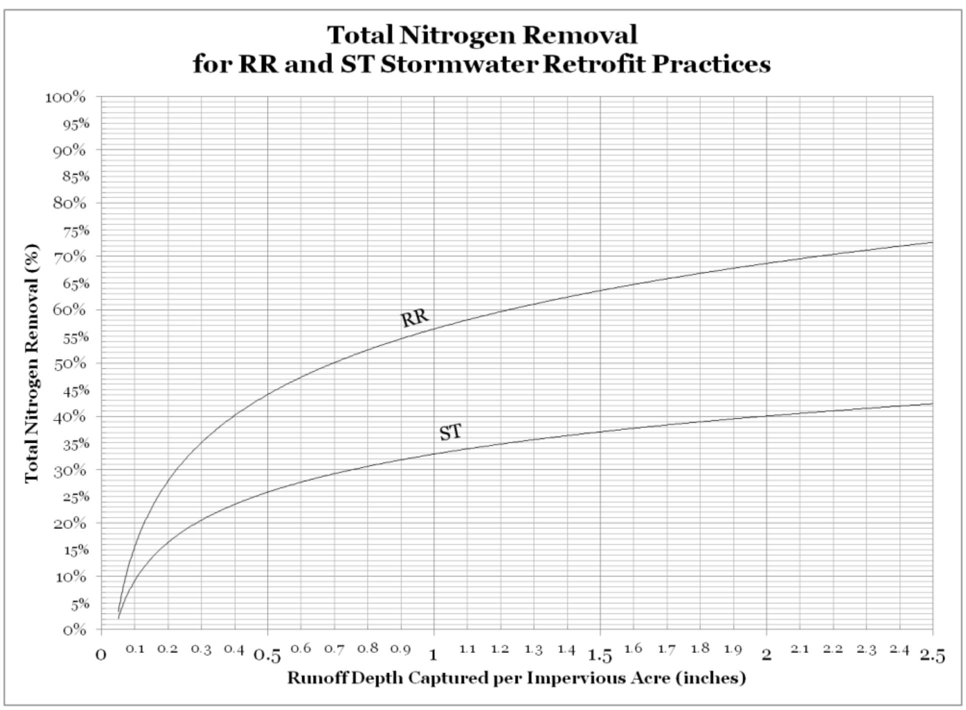

Figure 4. Retrofit Removal Adjustor Curve for Total Nitrogen

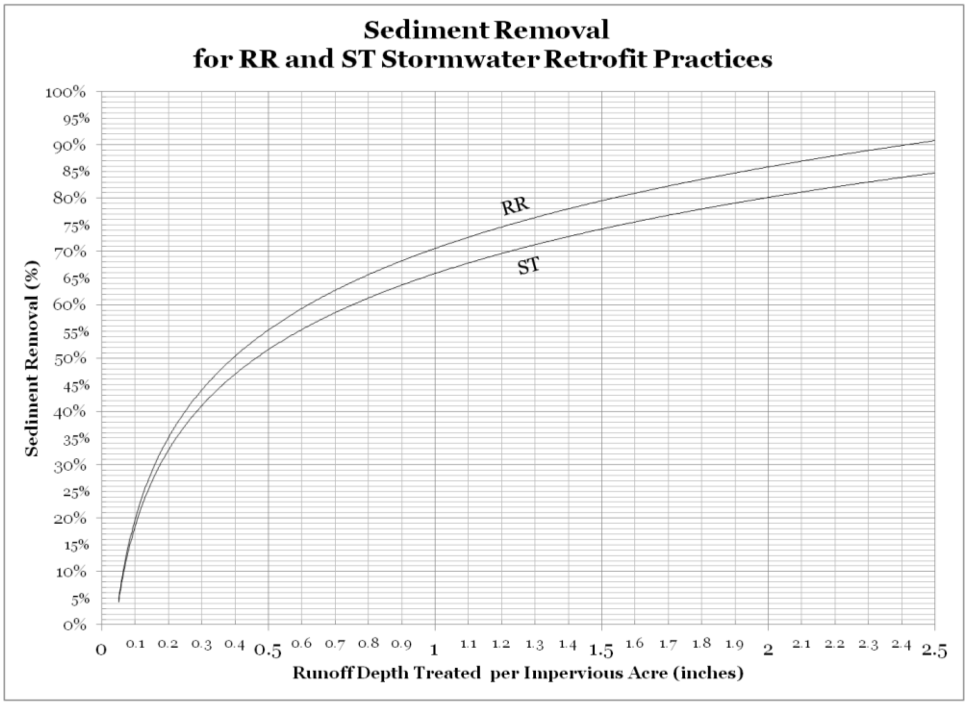

Figure 5. Retrofit Removal Adjustor Curve for Sediment

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. Retrofit projects 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. Retrofit projects 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 2 assigns all of the stormwater practices referenced in Bay State stormwater manuals into either the ST or RR category, so that designers can quickly determine which curve they should use based on the primary treatment practice employed by the retrofit. In situations where a mix of ST and RR practices are used within the same retrofit project, the designer should use the curve based on either the largest single practice used in the project or the ones that provide the majority of the retrofit treatment volume.

The removal rates determined from the retrofit removal rate adjustor curves are applied to the entire drainage area to the retrofit, and not just its impervious acres. Also, the retrofit reporting unit is the entire treated area, regardless of whether it is pervious or impervious.

Table 2 Classification of BMPs based on Runoff reduction capability[1]	
Runoff Reduction Practices (RR)	*Stormwater Treatment Practices (ST)* [2]
Site Design/Non-Structural Practices	
Landscape Restoration/Reforestation	
Riparian Buffer Restoration	Constructed Wetlands
Rooftop Disconnection (aka Simple Disconnection to Amended Soils, to a Conservation Area, to a Pervious Area, Non-Rooftop Disconnection)	Filtering Practices (aka Constructed Filters, Sand Filters, Stormwater Filtering Systems)
Sheetflow to Filter/Open Space* (aka Sheetflow to Conservation Area, Vegetated Filter Strip)	Proprietary Practices (aka Manufactured BMPs)
All Non-structural BMPS – Chapter 5 of the 2006 Pennsylvania Stormwater BMP Manual	Wet Ponds (aka Retention Basin)
Practices	Wet Swale
All ESD practices in MD 2007	
Bioretention or Rain Garden (Standard or Enhanced)	
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 A-4, Appendix A	

Protocol for New Retrofit Facilities

To determine the sediment and nutrient removal rate for an individual new retrofit project, the designer should go the appropriate curve and find the unique rate for the combination of runoff depth captured and runoff reduction/stormwater treatment that is achieved. The designer should also estimate the total contributing drainage area to the retrofit. Several examples are provided in the next section to illustrate how the protocol is applied.

Protocol for Existing BMP Retrofit Facilities

The method used to define removal rates differs slightly for each of the three classes in this category, as follows:

BMP Conversion: The specific method for defining the removal rate depends on the type and age of the BMP being converted:

- *If the BMP being converted is a dry detention pond or flood control structure that currently is providing no effective water quality treatment*, then the existing BMP will have a zero removal rate. A higher CBP-approved BMP rate that reflects the improved stormwater treatment mechanism associated with the conversion can be taken directly from Table A-5 of Appendix A (i.e., dry ED, wet pond, constructed wetland or bioretention)

- *If the BMP being converted involves a significant increase in runoff capture volume and/or an increase in runoff reduction, than an incremental rate is used*. The removal rate for the existing BMP should be determined from the adjustor curve. A higher removal for the converted BMP will reflect the higher degree of runoff treatment and/or runoff reduction associated with the retrofit, as determined from the retrofit removal adjustor curves (Figure 3 to 5). This method will generally be the most applicable to the majority of conversion retrofits.

In all cases, the designer should also estimate the total contributing drainage area to the retrofit. Examples are provided in the next section, that illustrate how both of these methods are applied to conversion retrofits.

BMP Enhancement: The sediment and nutrient removal rates for individual BMP enhancement retrofits are also expressed as an incremental removal rate (enhanced BMP - existing BMP).

- The rate for the existing BMP is defined based on its combination of runoff treatment and runoff reduction using the retrofit removal adjustor curves. Designers may reduce the actual amount of runoff treatment in the existing BMP that is not effective (e.g., treatment volume that is ineffective because of short-circuiting or other design problems that reduce the hydraulic retention time).

- The enhanced BMP will have either a greater runoff treatment volume and/or achieve a better runoff reduction rate. Designers can determine the higher rate for the enhanced BMP using the retrofit removal adjustor curves.

- The removal rate for the BMP enhancement is then defined as the difference between the enhanced rate and the existing rate. An example of how to apply this protocol for BMP enhancements is provided in the next section.

BMP Restoration: The removal rate for BMP restoration depends on whether the existing BMP has been previously reported to EPA.

- If the BMP has <u>not</u> been previously reported, it is considered to be a new retrofit facility and the removal rate is determined by the retrofit removal adjustor curves for the drainage area contributing to the BMP.

- If the BMP was previously reported to EPA, then the removal rate for a restored BMP is expressed as an incremental removal rate (restored BMP - existing BMP). The existing BMP removal rate is defined using the curves based on the original BMP sizing and design criteria. The restored BMP rate is defined using the retrofit removal rate adjustor curve for the runoff treatment volume "restored" (i.e., by sediment cleanouts, vegetative harvesting or practice rehabilitation) and/or shifting to RR runoff reduction (i.e., media replacement).

  To prevent double counting, the removal rate credit is reported to EPA by the jurisdiction in a two step process. First, it must be reported at the degraded condition (lower removal rate) for at least one annual progress run. Second, the incremental rate improvement associated with the BMP restoration is then reported the next progress year.

Other Key Issues:

What Data to Report

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 individual retrofit projects, and must meet the BMP reporting and tracking procedures established by their state. The Panel recommended that the following information be reported:

a. Retrofit class (i.e., new retrofit facility or existing BMP retrofit)
b. GPS coordinates
c. Year of installation (and expected rate duration)
d. 12 digit watershed in which it is located
e. Total drainage area and impervious cover area treated
f. Runoff volume treated and identify “type” of BMP
g. Projected sediment, nitrogen and phosphorus removal rates

Jurisdictions will also be responsible for other tracking and verification procedures as outlined in Section 6 of this memo.

The Baseline Load Issue

The protocol developed by the Panel does not require jurisdictions to define a pre-retrofit baseline load. The Panel acknowledges, however, that many jurisdictions may want to estimate pre-retrofit baseline loads when it comes to finding the most cost-effective combination of retrofit projects to pursue in their subwatershed retrofit investigations.

Analyzing Retrofit Options in the Context of CAST/MAST/VAST

The Panel acknowledges that its retrofit assessment protocol does not fit easily within the context of assessment and scenario builder tools that have been recently developed to assist states and localities to evaluate BMP options to develop watershed implementation plans (i.e., each retrofit has a unique rate and consequent load reduction, while the CAST tools apply a universal rate for all retrofits).

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 planning purposes, for each state to assign a single removal rate to characterize the performance of a generic type of retrofit to evaluate alternate BMP scenarios.

As an example, a state might assume a generic stormwater retrofit that is a 50/50 blend of RR and ST practices and treat 1 inch of runoff from impervious area. This generic retrofit rate could be used in the context of CAST to compare load reductions for different levels of local drainage area treated by retrofits. As noted, each state would elect to develop its own scenarios to be consistent with their unique scenario assessment tools.

Section 5
Retrofit Examples

The following examples have been created in order to demonstrate the proper application of the retrofit removal adjustor curves for the purpose of determining the nutrient and sediment removal rates of retrofits.

New Retrofit Facilities

Constructed Wetland. A Bay County has discovered an un-utilized parcel of parkland where it is feasible to build a constructed wetland. The engineer has estimated that the retrofit storage in the constructed wetland is 1.67 acre-feet. The proposed retrofit will treat the runoff from a 50 acre residential neighborhood with 40% impervious cover. The engineer determines the number of inches that the retrofit will treat using the standard retrofit equation:

$$\frac{(RS\ )(12)}{IA} = x\ inches \qquad\qquad \frac{(1.67\ )(12)}{20} = 1.0\ inch$$

The constructed wetland retrofit will capture and treat 1.0 inch of rainfall. Table 2 informs that constructed wetlands are considered to be a ST practice.

By referring to Figures 3-5, we can see that this proposed retrofit will have the following pollutant removal rates:

TP	TN	TSS
52%	33%	66%

Green Street. A Bay City is considering a plan to construct green streets as part of a revitalization project for the downtown commercial area. Their engineering consultant plans to employ permeable pavement, expanded tree pits and street bioretention to treat runoff and she estimates the runoff storage volume for the combined practices to be 0.27 acre-feet. Since the 4.3 acres of 100% impervious urban land that drain to the existing street have not provided stormwater management in the past, the new green street project is classified as a new retrofit. The engineer determines the number of inches that the retrofit will treat using standard retrofit equation:

$$\frac{(0.27)(12)}{4.3} = 0.75\ inches$$

Collectively, the new LID practices will treat 0.75 inches of runoff and fall under the RR practice category. Based on this information, the City uses the retrofit removal adjustor curves (Figures 3 to 5) to determine the following removal rates for the green street retrofit project:

TP	TN	TSS
60%	51%	64%

On-Site LID Retrofits. A Bay Township creates an incentive program for residential homeowners to install rain gardens on their property and would like to determine the pollutant removal rates associated with such a program. Each homeowner has an average roof size of 500 ft^2 and if 100 homeowners participate in the program, treatment can occur for a combined drainage area of 1.15 acres, at 100% impervious. The runoff storage volume associated with the combined retrofits is estimated to be 0.05 acre-feet. The amount of runoff volume treated by the rain gardens is calculated using standard retrofit equation:

$$\frac{(0.05)(12)}{1.15} = 0.5\ inches$$

Each rain garden is assumed to treat 0.5 inches of rainfall and is classified as a RR practice. The township engineer uses the curves to estimate the projected removal rates associated with the rain garden incentive program:

TP	TN	TSS
52%	44%	55%

In all three of the above examples, the information that needs to be reported is the retrofit removal rates and the total contributing drainage area to the practices.

Existing BMP Retrofits

BMP Conversion. A dry pond was built in 1985 in Maryland which was designed to provide flood control only. The designer is able to create new water quality storage using a combination of a forebay with a permanent pool, a submerged gravel wetland cell and a final bioretention polishing cell. As a result, the facility now provides a runoff storage volume of 1.3 acre-feet for its 65 acre urban drainage area that is 40% impervious. The amount of runoff volume treated by the converted BMP is calculated using the standard retrofit equation:

$$\frac{(1.3)(12)}{26} = 0.6\ inches$$

Because the project is a dry pond conversion, the designer evaluated both methods to assess pollutant removal rates. The designer rejected the use of existing CBP-approved rates because the conversion involved three different stormwater treatment mechanisms. Instead the designer opted to use the retrofit removal adjustor curves, since the retrofit conversion produced a large increase in runoff treatment volume and a modest increase in runoff reduction. The comparative removal rate projections are shown below:

	TP	TN	TSS
CBP approved rates	N/A	N/A	N/A
Adjustor removal rates	55%	47%	59%

BMP Enhancement. A dry extended detention pond was built in a Bay County in 1995 that served a 10 acre commercial property. The facility was originally designed to under older standards that only required that the "first flush" of stormwater runoff be treated. Analysis of drainage area characteristics indicated that the dry ED pond was sized to capture only 0.3 inches of runoff per impervious acre. In addition, field investigations showed that the pond had a major short-circuiting problem, such that half of its storage volume was hydraulically ineffective.

The Bay County engineer realized that this site was a good candidate for a BMP enhancement retrofit, and modified the configuration of the pond to increase its hydraulic retention time, provide missing pretreatment and excavate several shallow wetland cells in the bottom of the pond to improve treatment.

Collectively, these design enhancements created an additional 0.3 inches of new runoff treatment volume per impervious acre, for a total runoff of 0.6 inches. For BMP enhancement retrofits, the removal rate is defined as the incremental difference between the new removal rate and the original removal rate. The engineer analyzed the retrofit removal adjustor curves, and computed the net effect of the BMP design enhancements, as follows:

	TP	TN	TSS
Enhanced Rate	44%	28%	55%
Original Rate	22%	14%	28%
Incremental Removal Rate	22%	14%	27%

*BMP Restoration***.** A wet pond was installed in Bay City in 1980, which captured 0.5 inches of runoff from the impervious cover of its contributing watershed. Bay City had previously reported the pond to Bay State. Over time, however, the storage capacity of the wet pond was seriously diminished due to sedimentation and growth of invasive plants. The maintenance crew noted that 60% of the pond's storage capacity had been lost, resulting in an actual capacity of a mere 0.2 inches of runoff treatment.

Bay City DPW conducted a major dredging effort to clean out the sediments and replanted the pond with native species. As a result of the pond restoration, 0.3 inches of storage were recovered, increasing the total storage in the pond to its original design volume of 0.5 inches of runoff depth captured. Bay County employed the retrofit removal adjustor curves for ST practices to determine the incremental pollutant removal rates associated with the pond restoration, as follows:

	TP	TN	TSS
Restored Rate (0.5)	40%	25%	48%
Existing Rate (0.2)	26%	16%	33%
Incremental Removal Rate	14%	9%	15%

Consequently, Bay City would report the existing rate to the state in the first year, and then submit the additional incremental rate for the restoration in subsequent years after the BMP is restored.

BMP Restoration (Non-Reported BMP). A sand filter was built in Bay City in 1998 and was sized to capture 0.5 inches of runoff from a municipal parking garage. Due to poor design, the sand filter had clogged over time and is no longer functioning as a BMP. Because the sand filter had never been reported to the state, it was eligible to get the full BMP pollutant reduction rate.

Bay City DPW upgraded the original sand filter to improve its retention time and replace the old media with a more effective bioretention mix. The removal rates are calculated from the retrofit removal adjustor curves:

TP	TN	TSS
52%	44%	55%

Non Eligible Restoration Example. Bay County inspectors concluded that it was time to clean out sediments trapped within the pre-treatment cell of a large bioretention facility. The facility was originally sized to capture 1.0 inch of runoff volume and achieves a 66% TP removal rate. This routine maintenance operation recovered 0.05 inches of runoff volume capacity in the bioretention area. Because this cleanout did not meet the 10% recovery threshold, it does not qualify for BMP restoration and no additional removal rate credit is given.

Section 6
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 draft memo to the Urban Stormwater Workgroup. The Panel recommends that CBP adopt the following reporting, tracking and verification protocols for stormwater retrofit projects:

1. *Duration of Retrofit Removal Rate.* The maximum duration for the removal rate will be 10 years, although it can be renewed based on a field performance inspection that verifies the retrofit still exists, is adequately maintained and operating as designed. The duration of the removal rate will be 5 years for on-site retrofits installed on private property, and can only be renewed based on visual inspection that the on-site retrofit still exists.

2. *No Double Counting*. A removal rate cannot be granted if the retrofit project is built to offset, compensate or otherwise mitigate for a lack of compliance with new development stormwater performance standards elsewhere in the jurisdiction. Instead, the removal rate can only be applied as an offset (i.e., the acres of new development that will now fully meet the state stormwater performance standard). The Panel also recommends more frequent inspection and verification process for any retrofit built for the purpose of stormwater mitigation, offsets, trading or banking, in order to assure the project(s) is meeting its nutrient or sediment reduction design objectives.

3. *Initial Verification of Performance*. Jurisdictions will need to provide a post-construction certification that the urban retrofit was installed properly, meets or exceeds the design standards under its retrofit classification and is achieving its hydrologic function prior to submitting the retrofit removal rate to the state tracking database. This initial verification is provided either by the retrofit designer or a local inspector as a condition of retrofit acceptance, as part of the normal municipal retrofit design and review process. From a reporting standpoint, the MS4 community would simply indicate in its annual report whether or not it has retrofit review and inspection procedures in place and adequate staff to implement them.

4. *Retrofit Reporting Units*. Localities will submit documentation to the state stormwater or TMDL agency to document the nutrient/sediment reduction claimed for each individual urban retrofit project that is actually installed. Localities should check with their state stormwater agency on the specific data to report for individual retrofit projects. The Panel recommends that the following reporting data be submitted:

a. Retrofit class
b. GPS coordinates
c. Year of installation (and expected duration)
d. 12 digit watershed in which it is located
e. Total drainage area and impervious cover area treated
f. Runoff volume treated and identify "type" of BMP
g. Projected sediment, nitrogen and phosphorus removal rates

5. *Retrofit Recordkeeping*. The agency that installs the retrofit should maintain a more extensive project file for each urban retrofit project installed (i.e., construction drawings, as-built survey, digital photos, inspection records, and maintenance agreement, etc). The file should be maintained for the lifetime for which the retrofit removal rate will be claimed.

6. *Ongoing Field Verification of BMP Performance*. Inspectors need to look at visual and other indicators every 10 years to ensure that individual retrofit projects are still capable of removing nutrients/sediments. If the field inspection indicates that a retrofit is not performing to its original design, the jurisdiction has 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 retrofit would be eliminated, and the jurisdiction would report this in its annual MS4 report. The retrofit removal rate can be renewed, however, if evidence is provided that corrective maintenance actions have restored retrofit performance.

Collaborative Monitoring of Retrofit Performance

The Panel agreed on the continuing need to monitor the effectiveness of retrofits 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 innovative and traditional retrofit techniques in varied applications, terrain and climatic conditions.

The Panel indicated the best route to acquire such monitoring data was through retrofit monitoring programs undertaken as part of municipal MS4 stormwater permit programs.

The Panel recommended that localities pool their scarce local MS4 monitoring resources together to create a monitoring consortium that could fund selected retrofit monitoring projects to be performed by monitoring experts (i.e., universities and qualified consulting firms).

In the interim, the Panel recommended that any local retrofit monitoring be conducted under a standard quality assurance project plan (QAPP) developed under the auspices of the USWG to ensure the performance data is reliable and accurate. Since several communities may be interested retrofit monitoring, USWG might not have the capacity to review all of the designs. The Panel therefore recommended that the CBP retain a consultant with expertise in "applied" monitoring to develop basic QAPP guidelines and make suggestions to monitoring plans. A possible model might be the 3-tiered QA certification process that increases in rigor with the increased need for data accuracy employed by the city of Suffolk and other Virginia communities (Details can be found at http://www.deq.virginia.gov/cmonitor/guidance.html).

The consultant would also be charged with identifying synergies among research to avoid duplication of effort and also prioritize monitoring needs. The initial guidelines would be fairly generic cutting across retrofit types and would be flexible to account for local site conditions. Ultimately, the Panel recommended that a standard methodology be established for each type of retrofit practice as long as it allows for local site variability.

The Panel also discussed the timeframe by which new retrofit monitoring data would be considered in adjusting future retrofit efficiencies, and recommended the Panel be reconvened at every two year WIP milestone, which fits in nicely with the "adaptive management" approach that is advocated by NRC (2011). One of the chief considerations should be whether the efficiency changes would be adjusted locally or applied globally across the Bay watershed.

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