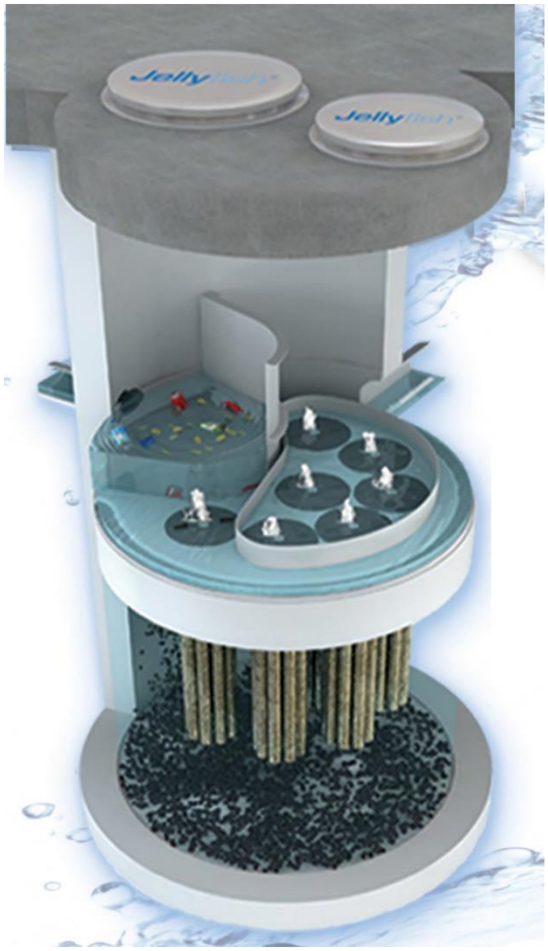
Evaluating Proprietary BMPs: Is it Time for a State, Regional or National Program?



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About the Scientific and Technical Advisory Committee

The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program (CBP) on measures to restore and protect the Chesapeake Bay. Since its creation in December 1984, STAC has worked to enhance scientific communication and outreach throughout the Chesapeake Bay Watershed and beyond. STAC provides scientific and technical advice in various ways, including (1) technical reports and papers, (2) discussion groups, (3) assistance in organizing merit reviews of CBP programs and projects, (4) technical workshops, and (5) interaction between STAC members and the CBP. Through professional and academic contacts and organizational networks of its members, STAC ensures close cooperation among and between the various research institutions and management agencies represented in the Watershed. For additional information about STAC, please visit the STAC website at www.chesapeake.org/stac.

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Executive Summary

Due in part to the Chesapeake Bay Total Maximum Daily Load (TMDL) issued by the U.S. Environmental Protection Agency (U.S. EPA 2010b), many Mid-Atlantic States have made major modifications to their stormwater programs. In most cases, providing some level of stormwater treatment through specific water quality Best Management Practices (BMPs) is required to meet nutrient (nitrogen, N, and phosphorus, P) and sediment (measured as total suspended solids, or TSS) reductions from site runoff. Treatment needs are usually met from a set of nonproprietary or conventional BMPs for which expected performance, while variable, has been established based upon research that normally includes field installation and monitoring. Alternatively, treatment needs could be met using manufactured treatment devices (MTDs). MTDs are structural BMPs that are most often used to treat runoff from ultra-urban or other high density developments. In these areas, it is often not practical to implement many of the land-based nonproprietary BMPs. A key property of MTDs is their reduced footprint. While capital and treatment costs may occasionally seem higher than a traditional BMP, MTDs can be the most cost-effective option when all costs are considered, including opportunity cost of land. Due to redevelopment needs, there is a potentially large opportunity for MTDs to provide a cost-effective treatment option in urban areas. Poor hydraulic and water quality performance from some MTDs as well as other BMPs, the use of arbitrary or assumed pollutant reduction credits, the lack of clear scaling and sizing criteria for design, and a lack of processes to evaluate MTDs have created an atmosphere of great uncertainty. This is the primary reason that the Chesapeake Bay Program (CBP) does not provide water quality credit for MTDs for modeling TMDL attainment. Despite the lack of credit, thousands of MTDs have been installed in urban areas. Nonetheless, the lack of credit, if continued, may eventually force local governments to make up the associated nutrient/sediment credits elsewhere in their CBP TMDL action plans.

Clearly, a challenge exists in balancing the need to monitor and verify nutrient and sediment removal performance of MTDs with the need to establish a reasonable process that continues to encourage innovation and MTD product development. Some may argue that testing is too expensive and presents a barrier to enter into the marketplace, thus stifling competition, or that monitoring may suppress design innovation. A need for equity exists with nonproprietary BMPs in terms of evaluation. While nonproprietary BMPs typically have a larger set of performance data available, it is undeniable that more is needed. A testing and verification requirement is not new to the industry and if applied carefully to MTDs and nonproprietary BMPs, can set a bar that levels the playing field and drives innovation to meet the requirements with more cost-effective technology.

Within the regulated stormwater community, there is a clear need for a rigorous, consistent, and scientifically defensible protocol and administrative process that is both transparent and affords vendors a clear path to approval. The private companies that have made significant investments in research and design have made these investments on faith that a consensus protocol for evaluating MTDs and assessing their pollutant removal may emerge. Implementing the protocol through the CBP in an area as large as the Chesapeake Bay watershed (CBW) represents a unique opportunity and market for vendors. While MTD vendors felt strongly that a lack of equity would likely hinder progress and be a disincentive for market entry, most workshop participants agreed that additional evaluation of both nonproprietary and proprietary BMPs is needed.

Workshop participants reached an overwhelming consensus that an MTD evaluation program is necessary, and that because of the water quality treatment needs associated with the Chesapeake Bay TMDL, the CBP may provide an excellent venue for such a program. Workshop participants strongly recommended that an expert panel of the Urban Stormwater Workgroup (USWG) be formed to design this program. The goals of this effort will be to develop a protocol that balances the need for verified performance with the need for innovation, and an administrative program that can implement it within the CBW states and District of Columbia.

Findings

The findings from the workshop, framed in the context of the workshop investigative questions, were as follows:

1. *What is the problem? Why do we need MTDs?*

Urban runoff quality is highly variable, especially for the constituents of concern in regard to the Chesapeake Bay TMDL, nutrients and sediment. The effectiveness of stormwater treatment practices are also highly variable. New stormwater treatment technologies are needed to meet increasingly stringent requirements of the Chesapeake Bay TMDL. Workshop participants agreed that MTDs could provide a source of new and innovative technologies that may provide unique and cost-effective treatment solutions in particular circumstances, helping to both improve water quality and reduce costs.

2. *Why do we need an evaluation/testing program?*

Workshop participants agreed on the need for MTD evaluation and testing data to provide confidence in estimates of treatment performance, and to assure we are making progress towards meeting the Bay TMDL. Currently, no reduction credit exists for MTDs in the Chesapeake Bay Watershed Model (CBWM), unless it is deemed fully equivalent to a nonproprietary BMP.

3. *What is the current process for evaluating nonproprietary BMPs in the Bay watershed? How do these get incorporated into the Bay Model (CBWM)?*

The current process for evaluating nonproprietary BMPs in the CBP was reviewed at the workshop. This process relies upon an expert panel approach, which assigns a conservative performance credit to each BMP. This credit is then used in the next revision of the CBWM. Most workshop participants felt that this process needs to be expedited to not unduly hinder the development of new technologies within MTDs.

4. *What is the state of the science on evaluating stormwater treatment performance?*

Workshop participants reviewed the state of the science of monitoring all BMPs, and MTDs in particular. The variability of runoff quality is directly related to the length of sampling required to evaluate a particular technology. Differences in monitoring protocols exist, potentially creating confusion and barriers to adoption. This supports the argument for a consistent approach across the CBP.

5. *What are some of the existing (and proposed, or formerly proposed) MTD evaluation programs?*

The MTD evaluation programs addressed included: the New Jersey Department of Environmental Protection (NJDEP) laboratory testing program for sediment; the Technology Acceptance Reciprocity Partnership (TARP) developed by the NJDEP (now defunct); the Washington State Technology Acceptance Protocol-Ecology (TAPE) program for sediment, metals, P, and oil/grease; and the Virginia Technology Assessment Protocol (VTAP) for N, P, and TSS (now defunct). The workshop also discussed the Water Environment Federation's (WEF) Stormwater Testing and Evaluation for Products and Practices (STEPP) Task Force which recommends a yet-to-be-defined national program.

6. *What would a Bay MTD evaluation program look like?*

Workshop participants agreed that a proposed Bay-wide testing and evaluation program, proposed here as the Chesapeake Bay Technology Assessment Protocol (CBTAP), should be a rigorous, consistent and scientifically defensible process that is transparent and affords manufacturers a clear path towards approval so that new technologies can be implemented rapidly, yet safely. CBTAP would create an evaluation protocol, funded entirely by vendors, which will produce N/P/sediment removal efficiencies which can then be incorporated into the CBWM with increased confidence. A consensus was reached that VTAP could be used as a starting point.

Recommendations

The workshop participants recommended the following:

1. A Chesapeake Bay-wide MTD evaluation protocol (Chesapeake Bay Technology Assessment Protocol or CBTAP) should be adopted, using VTAP as a starting point, which will be refined and expanded to accommodate the CBW as a whole. The ultimate protocol remains to be determined by an advisory panel.
2. A Bay-wide program for implementing the protocol needs to be created, based upon guidance to be developed by the same advisory panel. The panel will need to determine the programmatic scope and how CBTAP will be administered.
3. The advisory panel will include members of the various MTD sectors including industry, regulators (from municipal separate storm sewer system, (MS4) programs and states), consultants, academics, and Non-Government Organizations (NGOs). It is recommended that the Panel commence by fall 2016, and complete its recommendations by August of 2017. The scope of the panel will also include financial requirements for sustaining the program for discussion by the Executive Council.
4. The Panel and its ultimate program will be administered through the USWG.
5. Approval of recommended water quality performance credits through CBTAP will be integrated into the CBWM as soon as practical.

6. Much discussion, support, and interest was expressed in the STEPP effort by the WEF to develop a national MTD evaluation protocol and program to implement it. However, the STEPP program is not currently available. Due to the Chesapeake Bay TMDL schedule, workshop participants felt it was essential that CBTAP proceed; however, with the caveat that should an acceptable national program emerge, CBTAP would sunset and coordinate its activities with that program.

Ideally, the final CBTAP should result in a self-funded MTD testing protocol which will produce N/P/sediment removal efficiencies that can then be incorporated into the CBWM with a degree of confidence. Successful completion of the testing protocol and programmatic structure will also enable manufacturers to consistently market, design, size, and scale the device throughout the watershed, and be able to claim an associated load reduction that a developer/local government can then claim credit for in their respective TMDL Action Plans.

Introduction

The recently imposed Chesapeake Bay Total Maximum Daily Load (TMDL) requires significant reductions in nutrient and sediment runoff from newly-developed and redeveloped land, in addition to posing restoration goals for existing developed land. In both cases, these goals can be met through a variety of nonstructural and structural treatment practices commonly known as best management practices (BMPs). Manufactured treatment devices (MTDs) are structural BMPs that are typically proposed for ultra-urban or other high density developments. In many cases, it is not practical to implement many of the 15 nonproprietary BMPs, and cost-effective treatment is only achieved through the reduced (and generally more expensive) footprint of a proprietary BMP or MTD. Verifying the performance of MTDs can be difficult and protocols for their evaluations are evolving. This workshop was organized to address the following questions:

1. What is the problem? Why do we need MTDs?
2. Why do we need an evaluation/testing program?
3. What is the current process for evaluating nonproprietary BMPs in the Bay watershed? How do these get incorporated into the Chesapeake Bay Watershed Model (CBWM)?
4. What is the state of the science on evaluating stormwater treatment performance?
5. What are some of the existing (and proposed, or formerly proposed) MTD evaluation programs?
6. What would a Bay MTD evaluation program look like?

Based on the answers to the preceding questions, the outcome of the workshop sought to provide recommendations on the shape and function of a Bay-wide MTD evaluation program, leading to an advisory panel of the Chesapeake Bay Program's (CBP) Urban Stormwater Workgroup (USWG).

Introduction to MTDs. What is the problem? Why do we need MTDs?

Improving treatment of urban runoff faces a variety of challenges, the most critical of which are the high variability of urban runoff quality and the pollutant removal performance of stormwater treatment practices. Workshop participants agreed that new technologies are needed to meet the increasingly stringent requirements of the Chesapeake Bay TMDL. MTDs utilize new technologies to treat urban runoff in a highly customizable package. This flexibility and the fact that MTDs typically occupy a smaller footprint than other BMPs – often positioned underground – makes them an attractive treatment option. However, MTDs do not have a clear regulatory standard for sizing or performance evaluation. Without accepted benchmarks, a competitive market can lead to increasingly smaller MTDs treating increasingly larger drainage areas, a downward spiral inevitably resulting in failure. Lack of regulation is a disincentive to invest in product research and development, leaving the marketplace open to cheap, poorly performing products. There is general consensus among state and local stormwater officials about the benefits that the MTD industry can bring to the science and practice of stormwater treatment. Workshop participants agreed that MTDs could provide a source of new and innovative technologies that may provide unique and cost-effective treatment solutions in particular circumstances, helping to both improve water quality and reduce costs. The challenge is to balance MTD benefits − innovation and improved performance associated with research and development, cost-effective treatment strategies on challenging ultra-urban development projects, targeted performance for specific treatment objectives, etc. − with the need for validation of MTD performance, which is the degree of confidence in the performance assessment. Confidence can be estimated based on the number of monitored events and the variability of water quality from those events, as shown in Figure 1 (Sample et al. 2012). As Figure 1 illustrates, as variability increases, a large number of samples are required to achieve the same level of confidence. Any evaluation and testing program for MTDs must address this uncertainty and balance validation with the need for innovation.

Workshop participants agreed on the need for MTD evaluation and testing data to provide confidence in estimates of treatment performance, and to assure positive progress towards meeting the Bay TMDL. Currently, no reduction credit exists for MTDs in the CBWM, unless it is deemed fully equivalent to a nonproprietary BMP.

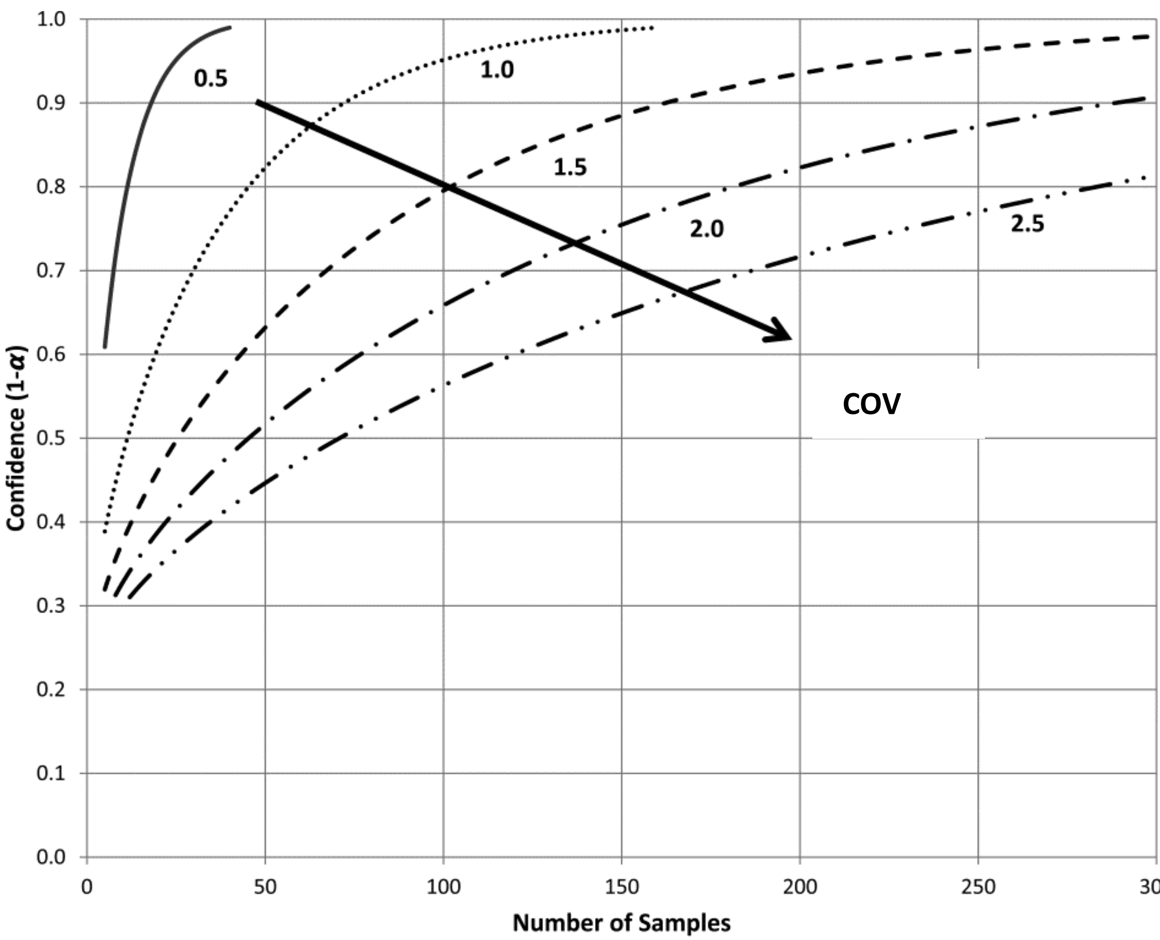

Figure 1. Tradeoff between number of samples, variability (coefficient of variance, and confidence level) for analyzing stormwater (source: Sample et al. (2012).

What is the current process for evaluating nonproprietary BMPs in the Bay watershed? How do these get incorporated into the Bay Model (CBWM)?

In the CBP, the evaluation and adoption of nonproprietary BMPs has been accomplished using a consensus driven expert panel process. For example, during the last four years, virtually all nonproprietary stormwater BMPs have been vetted by expert panels to define their sediment and nutrient removal rates for the purpose of compliance with the Chesapeake Bay TMDL. This process has revealed multiple issues that would be similarly experienced by an MTD evaluation program.

The first of these issues is timing, as it typically takes from months to years to complete each expert panel, assuming that performance monitoring studies supporting the panel are available prior to beginning the panels' work, and that a consensus among the experts can be achieved, which is not a given. The gap in timing necessary for the expert panel to deliberate may unnecessarily delay MTD evaluation and implementation.

The second issue is that the process must be closely linked to the CBWM, so the panel's recommendations can be integrated into the model and supporting tools. The CBWM is currently being updated: Phase 5 is in use, Phase 6 will be used for decision-making in 2017 concurrent with the use of the Phase 5 for tracking; Phase 6 will be used exclusively in 2018. Currently, there is no allowance for treatment by MTDs in the CBWM. This omission results in disconnect between state allowances and Bay-wide credits for the TMDL. MTDs are likely to be included in the CBWM Phase 6 model, depending upon panel actions, and may even be possible in Phase 5, if structural and schedule constraints are met. The MTD Advisory Panel will need to place any reductions at the correct scale of the CBW, in addition to addressing the same fundamental questions as any other panel: i.e., does the BMP act at the edge-of-field/parcel, or at a larger scale; does the BMP effect all forms of N, P, or TSS equally, or is there a difference in effectiveness for different species; does the BMP treat the entire flow, or just the surface water or stormwater; and how can the BMP performance variability be described over the life cycle of the BMP to fit within the CBP BMP verification framework?

The third issues is that many expert panels find that a BMP cannot be viewed in the context of a single performance metric, i.e., more complex protocols are needed, which can be difficult to incorporate into the CBWM. This issue may not be as significant for MTDs, which are usually placed at a small scale. A fourth issue is that CBP BMP panels are expected to make recommendations on how to report, track and verify urban BMPs, which can be difficult given the need to balance the specific policies and rules of the six states and the District of Columbia.

Lastly, an alternative to the expert panel process for each MTD may be the ability to classify the MTD practice as either a runoff reduction (RR) or storage treatment (ST) practice already evaluated by an existing approved expert panel, assuming it could meet these standards. Specific types of MTDs could be lumped with nonproprietary practices (e.g., floating treatment wetlands). A final alternative may be to retroactively classify an MTD as linked to an existing BMP panel report or an older BMP.

What is the state of the science on evaluating stormwater treatment performance and MTDs?

Evaluating stormwater treatment performance requires monitoring of the mass load through the practice. Storm load concentrations vary across the hydrograph. Multiple samples across the hydrograph can yield information regarding how the pollutants are distributed, i.e., is there a "first-flush", which means pollutants are concentrated in the initial portion of runoff (and thus target treatment accordingly). However, this comes at an increase in monitoring costs. Typically, only knowledge of the mass flux per event is needed, i.e., an event mean concentration (EMC), which is determined through a flow weighted composite sample. Flow measurement requires a primary control device such as a weir, flume, or channel with a known depth-area-velocity profile whose purpose is to estimate flow at any point in time. In some cases where weirs or flumes cannot be conveniently installed, acoustic Doppler area-velocity (ADAV) meters can be used. These devices measure velocity through an observed Doppler shift from an acoustic signal beamed through the fluid. ADAV meters measure depth of flow with a known depth-area relationship, and compute discharge as the product of these two measurements. Sampling locations should be carefully chosen to ensure the sample is representative of the flow in the entire cross-section; this location varies by channel shape. As it is very difficult to appropriately collect samples across a hydrograph during a storm event, automatic samplers are typically employed. Since velocity approaches zero at the location of a weir, they tend to settle debris behind them; for this reason, weirs should only be used on the post treatment side of a practice. Maintenance of measurement weirs and flumes is important to remove accumulated sediment and debris, as these can result in incorrect high flow estimates. Therefore, proper monitoring design includes calibrating measurement flumes and/or weirs, appropriate use of samplers and flow monitoring, elimination of or accounting for bypass flows, and periodic field maintenance of monitoring equipment.

What is the history of some of the existing and proposed MTD evaluation programs and what lessons were learned?

There are a variety of existing MTD evaluation programs, the most prominent of which are summarized in Table 1. The two most widely cited testing procedures for MTDs are the Technology Acceptance Protocol-Ecology (TAPE 2002, 2008, 2011) administered by the Washington Stormwater Center, and the Technology Acceptance and Reciprocity Partnership (TARP 2003) which was initially formed as a partnership between the states of California, Illinois, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Virginia. The intent of TARP was to provide a uniform method for demonstrating the effectiveness of stormwater technologies and developing quality assurance plans for certification or verification of performance claims. The Virginia Technology Assessment Protocol (VTAP) was initially developed by the Virginia Department of Conservation and Recreation (DCR 2012), and while it has been suspended, this program adapted elements of TARP and TAPE to the Mid-Atlantic. While the goal was eventually to evaluate other constituents, TARP focused exclusively on sediment (NJDEP 2009). The current NJDEP (New Jersey Department of Environmental Protection) program is limited to laboratory sediment testing.

Table 1. Most commonly cited MTD Evaluation Protocols (adapted from (Water Environment Federation 2014).

Program Name	Coverage	Jurisdiction or Entity of Origin	Reciprocity Granted by Other States	Program Status
USEPA Environmental Technology Verification (ETV) Program	U.S./National	EPA, NSF International	Yes	Discontinued
Technology Acceptance Reciprocity Partnership (TARP) Program	Multi-state	Endorsed or recognized by CA, MA, MD, NJ, PA, VA, and NY	Yes	Partnership has dissolved, but protocol still used by many states
Technology Assessment Protocol – Ecology (TAPE) Program	State	Washington State	Yes	Active
New Jersey Corporation for Advanced Technology (NJCAT)	State	New Jersey	Yes	Active
Georgia Technology Acceptance Protocol (GTAP)	State	Georgia	No	Active
NC Preliminary Evaluation Program (NCPEP)	State	North Carolina	No	Active
Virginia Technology Acceptance Protocol (VTAP)	State	Virginia	No	Withdrawn

Originating in 1999 and overseen by the Washington Department of Ecology (WDOE) since 2002, the TAPE certification program is the only functioning MTD verification program that addresses constituents other than sediment. TAPE certifies treatment devices by assessing the removal of TSS, dissolved copper and zinc, total P, and hydrocarbons. A minimum percent treatment for each pollutant must be proven across a range of concentrations. In 2008, the TAPE program closed due to budget and staffing constraints, but was renewed in 2011. TAPE is operated by the Washington Stormwater Center and is funded by WDOE grants and fees collected from participants. Five technologies have been fully approved by TAPE since January 2011, 15 technologies have been approved since inception, and 12 are in active investigation. Important issues in TAPE that should be addressed by any program include: assuring a long-term sustainability of the program and sound business plan; creating consistent internal review policies independent of personality; providing the capability to handle Freedom of Information Act (FOIA) requests quickly, fairly, and consistently; providing a path to MTD approval and/or alternative configurations with a summary approval; focusing on minimizing time for review; addressing maintenance needs; and striving to collaborate and recognize reciprocity with other programs.

An emerging idea is the need for a national program. A key disadvantage of the state or local MTD evaluation frameworks is the creation of a patchwork of programs, negatively impacting the ability of resource managers to address local and regional water pollution and restoration efforts, and potentially creating disincentives for innovation in the MTD industry. In 2013, WEF began the National Stormwater Testing and Evaluation of Products and Practices (STEPP) Workgroup. This workgroup investigated the merits of developing a testing and evaluation program of national scale to meet the needs in the stormwater sector, culminating in the publication of a white paper in February 2014 (Water Environment Federation 2014), which determined that a national program was feasible and necessary, and outlined potential next steps in the developing a national program.

What are the costs of these programs?

The costs of stormwater BMP performance monitoring programs include both capital costs and those related to the time needed for evaluation and approval. A typical evaluation scenario consists of: engineering design and construction (approximately 9 months); site stabilization and pollutant load generation (1 year); development and obtaining approval of a quality assurance project plan (QAPP) (2 years); monitoring (18 months); and reporting (3-6 months), for a total of over five years. Factors can expedite the process, such as already having sites in the ground, retrofits, simultaneously working multiple sites to increase sampling success, or using dedicated test facilities. Monitoring costs include labor, laboratory analysis and sample handling, field equipment, and fees by the reviewing body. Costs will vary depending on the protocols which govern the number of samples and the pollutant parameters being analyzed: an approximate 18-month sampling campaign operated in-house could cost $184,000, with a consultant adding an additional $100,000 (Lenhart 2015; personal communication). Problems that can increase costs and cause delays include: too clean or too dirty a site; safety; odd hydraulic conditions; extreme weather; or even nuisance wildlife. Occasionally these issues force a restart of the process.

It is important to keep the costs of an evaluation program in perspective. While monitoring costs can be significant, the absence of a testing program leads to a downward spiral of sizing and performance claims. This stifles innovation in the MTD industry. MTD evaluation programs which set the bar and level the playing field entice entrepreneurs to innovate in order to clear the bar and eliminate worries about unverified claims undermining the market. The absence of a regulatory program, however, leads to a general mistrust of the industry and results in lower water quality in the field. Reducing costs and risk can include allowing for pilot testing and conditional approvals. Additionally, programs should distinguish between required criteria and guidelines for the field testing protocol, as well as establish climatic regions to reduce the number of tests needed nationwide. Agencies have costs, and funding must be assured to be sustainable; the alternative increases user costs associated with uncertainty and the confusion of false claims, which does not include the decline in water quality and impacts to the receiving waters, which are unacceptable to most. Workshop participants agreed that, while the effort and costs for both agencies and the industry are not minor, the rewards are significant, and that a CBP evaluation program must include some form of reciprocity. This could consist of a two-tiered program, with the first tier consisting of conditional approval based on criteria developed by an individual state program, then in a second tier, evaluation for Chesapeake Bay. Evaluation may be based on specific requirements, which could be developed after consulting existing programs such as TAPE, TARP, and VTAP.

What would a Bay MTD evaluation program look like?

One process for developing a Chesapeake Bay Technology Assessment Protocol (CBTAP) is the formation of an advisory panel of the USWG. The Panel would consist of 12-15 consultants, MS4 officials, vendors, academics, and state government officials. VTAP would be used as a starting point, modifying it as needed for application throughout the CBW (see Table C4 for a comparison of VTAP, TAPE and TARP). The panel would refine the protocol and develop a program that would address the six CBW states and the District of Columbia to eventually be adopted by the USWG for application throughout the CBP, possibly by adoption through the Executive Council of the CBP. Funding requirements for implementation of the CBTAP would also be in the scope of the Panel and presented to the Executive Council. To avoid duplication of efforts, workshop participants expressed the desire that CBTAP fold into STEPP should such a national program eventually become available; however, they were nearly unanimous on the need for CBTAP to meet TMDL requirements.

Findings

The findings from the workshop in the context of the workshop investigative questions are as follows:

1. *What is the problem? Why do we need MTDs?*

Based upon the workshop discussion, there is a need for continued development of new BMPs to meet water quality goals such as those being sought in the Chesapeake Bay TMDL. MTDs offer a source of new and innovative technologies that may provide unique and cost-effective treatment solutions in particular circumstances, both helping to improve water quality and reduce costs. Providing MTDs that are reliable treatment options increases the amount of choice available to those seeking stormwater treatment options. Thus, there is a tremendous opportunity for MTDs to serve an important function in providing cost-effective treatment options for urbanized areas.

2. *Why do we need an evaluation/testing program?*

Workshop presentations established the need for additional data to provide confidence in estimates of treatment performance for BMPs. While performance data is somewhat lacking for public domain BMPs, there is guidance available on their monitoring and evaluation (Geosyntec Consultants and Wright Water Engineers 2009), and there is a growing body of existing research and design experience. However, MTDs present unique challenges. Third party testing data, while available in some areas, may be lacking in others, particularly in areas without a formal evaluation program. Furthermore, the few robust testing programs available require very different testing parameters, making it difficult for the MTD user to evaluate and compare claims from competing manufacturers. The history of some poorly-performing MTDs currently in operation, the use of arbitrary or assumed performance credits, and variability in design, sizing, and scalability have created an atmosphere of great uncertainty about the devices that has resulted in the current decision by the CBP not to accept MTDs for modeling urban stormwater TMDL attainment. Thus, expanding venues for unbiased evaluation and testing are needed.

3. *What is the state of the science on evaluating stormwater treatment performance?*

Workshop discussion summarized the state of the science on evaluating stormwater treatment devices. Essentially, monitoring is conducted before and after treatment, and the amount of mass removed is quantified for each pollutant of concern. Monitoring follows a predetermined protocol that is designed to be consistent in application, and seeks to reduce inherent variability, bias, and error.

4. *What is the current process for evaluating nonproprietary BMPs in the Bay watershed? How do these get incorporated into the Bay Model (CBWM)?*

The current process for evaluating nonproprietary BMPs in the Bay watershed relies upon an expert panel approach; experts are selected based upon their qualifications and experience with the particular BMP in question. Performance credits are assigned based upon a review of published BMP studies that are applicable to the Bay watershed. These BMP performance data are then incorporated into the next revision of the CBWM.

5. *What are some of the existing (and proposed, or formerly proposed) MTD evaluation programs?*

Several existing and proposed MTD evaluation programs were discussed during the workshop. The New Jersey Department of Environmental Protection (NJDEP) TARP field and lab testing and evaluation program for sediment was discussed. NJDEP has ceased certification of field testing, and only provides laboratory testing using ground silica as the TSS surrogate. The Washington State TAPE program for testing sediment, metals, P, and oils was also summarized. This program is viewed nationally as the leading example in certification of water quality treatment performance of MTDs. Maryland and Virginia's existing programs were summarized; both are ad-hoc, interim procedures built upon TAPE and/or TARP. VTAP is described in DCR (2012). The previously described limitations and concerns in regard to existing protocols lead to Virginia's effort to develop the VTAP as a means of addressing MTDs within the Commonwealth. Unfortunately, after DCR conducted a 5-year consensus development effort, this protocol was recently withdrawn by the Virginia Department of Environmental Quality (DEQ) – following transfer of the Virginia Stormwater Management Program from DCR to DEQ – due to a variety of policy concerns between the two Virginia agencies. It is anticipated that the initial approach of the Panel will be to start the development of CBTAP utilizing the framework of the withdrawn VTAP. While the existing protocol will need to be refined to accommodate performance accreditation equivalency and the Bay Watershed as a whole, the VTAP framework should serve as an excellent starting point.

6. *What would a Bay MTD evaluation program look like?*

As MTDs are not currently incorporated into the modeling framework, the hundreds of facilities being installed within the watershed are not being captured in TMDL Action Plans or State Milestones, and local governments cannot claim nutrient/sediment credits from their use. There is a clear need for a rigorous, consistent, equivalent, and scientifically defensible process that is transparent and affords manufacturers a clear path towards approval. The proposed Bay-wide testing and evaluation program, named here as CBTAP, would address these issues. CBTAP would create a field testing and evaluation protocol, funded entirely by vendors, which will produce N/P/sediment removal efficiencies which can then be incorporated into the CBWM with a degree of confidence. Successful completion of the testing protocol will also enable the manufacturer to consistently market, design, size and scale the device throughout the watershed and be able to claim an associated load reduction that a developer/local government can then claim credit for in a TMDL Action Plan. These reduction credits could then be reported for inclusion in the CBWM. While the protocol will validate results linked to design, size, and scaling of vendor supplied evaluations, certification of those results will remain with the states.

Recommendations

The workshop affirmed that there is a tremendous need for new technologies to meet TMDL goals, and MTDs present a unique opportunity to meet this need. However, an atmosphere of great uncertainty about the performance of these devices has resulted in the decision by the CBP not to accept MTDs for modeling urban stormwater TMDL attainment. The hundreds of MTDs being installed within the watershed are currently not being captured in TMDL Action Plans and local governments cannot claim nutrient/sediment credits from their use. A challenge exists in balancing the need to monitor and verify nutrient and sediment removal performance of MTDs and the need to establish a reasonable process that encourages innovation and MTD product development. Existing MTD testing and performance evaluation program results have been mixed. Installation costs are still seen as high and maintenance could be intensive, potentially limiting market entry and innovation. Individual policies of MS4s may be inconsistent, and standardization is desirable. Programs may use inconsistent testing requirements and processes, leaving actual performance results in question.

From the perspective of each sector, the following are a selection of statements expressed by workshop participants:

Local Government

- Desire to have more tools in the toolbox, as growth continues; [we're] all for anything that can help people comply and get credit.
- Local government will ultimately be held accountable…have a unified set of standards in all the jurisdictions.
- Have to look for alternatives and consider all of the options available. Emphasize that this should be undertaken as soon as possible.

State Government

- Is there something we can do on an interim Bay-wide basis to gain credit while a regional approach is being developed?
- Caution spending money on few tests; more rigor/information is needed.
- Fully support; caution against stifling innovation.
- A regional approach is great, but there exists a question if the CBP is the right avenue to do it; [the CBP] does not have the capacity to take this on in light of other current activities.
- Emphasize need to level the playing field; keep the level of fairness, applying the same standard to all industry and manufacturers, etc. Any level of standardization would be helpful in verification.

Federal Government

- Implement at the governor's level (Executive Council of CBP) – start a political piece, then use that as the driver.
- Advocate for not starting from scratch – lots of lessons out there to be learned from and build on.

Industry

- Emphasize the need to level the playing field between MTDs and nonproprietary and conventional BMPs; keep the level of fairness, applying the same standard to provide accreditation to all treatment systems.
- Accreditation should be consistently linked to treatment system design, sizing and scaling methods tested.
- Testing program/verification needs to have a defined "carrot" at the end of the stick – one "carrot' would be inclusion into the CBWM.

Non-Governmental Organizations (NGOs):

- Inevitable, let's "get on with it". Close the gap between model implementation and what is observed on the ground.
- Uniformity between the states is necessary – but the MTDs can't be subjected to "pie-in-the-sky" criteria that are unrealistic and can't be met.
- Very beneficial to be under the CBP – then there is a commitment from the states to participate.

The workshop participants recommended the following:

1. That a Chesapeake Bay-wide MTD evaluation protocol (Chesapeake Bay Technology Assessment Protocol or CBTAP) be adopted, using VTAP as a starting point, which will be refined and expanded to accommodate the CBW as a whole. The ultimate protocol to be determined by an advisory panel.
2. That a Bay-wide program for implementing the protocol be created, based upon guidance to be developed by the same advisory panel. The panel will need to determine the programmatic scope and how CBTAP will be administered.
3. The advisory panel will include members of the various MTD sectors including industry, regulators (from municipal separate storm sewer system (MS4) programs and states), consultants, academics, and Non-Government Organizations (NGOs). It is recommended that the Panel commence by Fall 2016, and complete its recommendations by August of 2017. The scope of the panel will also include financial requirements for sustaining the program for discussion by the Executive Council
4. The Panel and its ultimate program will be administered through the USWG.
5. Approval of recommended water quality performance credits through CBTAP will be integrated into the CBWM as soon as practical.
6. Much discussion, support, and interest was expressed in the STEPP effort by the Water Environment Federation to develop a national MTD evaluation protocol and program to

implement it. However, the STEPP program is not currently available. Due to the Chesapeake Bay TMDL schedule, workshop participants felt it was essential that CBTAP proceed; however, with the caveat that should an acceptable national program emerge, CBTAP would sunset and coordinate its activities with that program.

Ideally, the final CBTAP should result in a self-funded MTD testing protocol which will produce N/P/sediment removal efficiencies which can then be incorporated into the CBWM with a degree of confidence. Successful completion of the testing protocol and programmatic structure will also enable the manufacturers to consistently market, design, size, and scale the device throughout the watershed and be able to claim an associated load reduction that a developer/local government can then claim credit for in their respective TMDL Action Plans.

Conclusion

Due in part to the Chesapeake Bay TMDL, many Mid-Atlantic States have revised their stormwater programs significantly. In most cases, stormwater treatment through specific water quality BMPs is required to meet nutrient/sediment load reductions. Treatment needs are usually met using a set of nonproprietary or conventional (public domain) BMPs, for which expected performance, while variable, has been established based upon research including field deployment, monitoring, and evaluation. MTDs are proprietary structural BMPs that are typically proposed for ultra-urban or other high density developments where land values are at a premium and, thus, their higher costs are more justifiable. In many cases, it is not practical to implement many of the larger land-based nonproprietary BMPs. MTDs provide increased performance with a reduced footprint, generally at a higher unit cost, but may satisfy an engineering constraint or opportunity cost. There is an existing gap in third party evaluation and accreditation programs for MTDs versus nonproprietary treatment systems. MTDs' field application and resulting performance has the propensity to be highly variable, and they are currently not provided performance credits in the CBWM. This situation is not ideal in terms of fostering innovation and implementation of new technologies, all of which will be necessary to achieve the goals of the Chesapeake Bay TMDL. The conclusion of the workshop was that a CBW-wide MTD evaluation protocol would be highly beneficial, and would result in a large market for such devices, which would be valuable to the vendors. It was suggested that to avoid potential duplication of effort, any CBW-wide effort have a sunset provision that kicks in when and if a national program becomes available. In addition, it was suggested that perhaps all BMPs, proprietary and nonproprietary, should be subjected to the same level of scrutiny. The proposed scope of CBTAP program was discussed, and it was agreed that the advisory panel of the USWG should move forward. The need to provide additional monitoring and evaluation of public domain BMPs is clear, however means must be identified to provide funding for this activity.

References

DCR. 2012. Guidance for Evaluating Stormwater Manufactured Treatment Devices Virginia Technology Assessment Protocol (VTAP). 42 pp.

DEQ. 2014. Interim use of stormwater manufactured treatment devices (MTDs) to meet the new Virginia Stormwater Management Program (VSMP) technical criteria, Part IIB water quality design requirements. Richmond, VA: DEQ. 7 pp.

EDND EP. 2014. Recommendations of the expert panel to define removal rates for the elimination of discovered nutrient discharges from grey infrastructure, Final panel report. Annapolis, MD. 113 pp.

EP DRRESCP. 2014. Recommendations of the Expert Panel to Define Removal Rates for Erosion and Sediment Control Practices, Final Approved Report. Annapolis, MD. 110 pp.

EP DRRISRP. 2012. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects, Final Report. Annapolis, MD. 60 pp.

EP DRRNSSPS. 2012. Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards. Annapolis, MD: Chesapeake Stormwater Network,. 76 pp.

EP DRRSMP. 2014. Recommendations of the Expert Panel to Define Removal Rates for Shoreline Management Projects. Annapolis, MD. 192 pp.

EP DRRURFSSBUP. 2014. Recommendations of the Expert panel to define removal rates for urban filter strips and stream buffer upgradge practices. Annapolis, MD. 94 pp.

EP DRRUSRP. 2012. Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects. Annapolis, MD. 62 pp.

Geosyntec Consultants and Wright Water Engineers. 2009. "Urban Stormwater BMP Performance Monitoring." http://www.bmpdatabase.org/.

Lenhart, J.H. 2015. "Personal communication with J. Lenth and J. Pedrick."

Maidment, David R. 1993. *Handbook of hydrology*. New York: McGraw-Hill.

Maryland Department of the Environment. 2009. Maryland Stormwater Design Manual , Volumes I and II, October 2000, Revised May 2009. Annapolis, MD. 591 pp.

Maryland Department of the Environment. 2014. NPSWA MS4 Permit MD0068284 for Prince Georges County. 39 pp.

Maryland Department of the Environment. 2015a. "Alternative/Innovative Technology Review Checklist."2.

Maryland Department of the Environment. 2015b. Certification of Innovative Stormwater Management Technologies for Retrofit Applications. Baltimore, MD. 2 pp.

Maryland Department of the Environment. 2015c. "Maryland's Stormwater Program & Alternative/Innovative Technologies." http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/Documents/Unified%20%20Innovative%20Technologies%20Policy%2007%202014.pdf.

NJCAT. 2010. "NJCAT, Corporation for Advanced Technology: Promoting Emerging Energy and Environmental Technologies." http://www.njcat.org/.

NJCAT. 2013. Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology. 11 pp.

NJDEP. 2009. Protocol for Total Suspended Solids Removal Based on Field Testing Amendments to TARP Protocol. Trenton, NJ. 8 pp.

Sample, D.J., T.J. Grizzard, J. Sansalone, A.P. Davis, R.M. Roseen, and J. Walker. 2012. Assessing performance of manufactured treatment devices for the removal of phosphorus from urban stormwater. *Journal of Environmental Management* 113(0): 279-291. doi: 10.1016/j.jenvman.2012.08.039.

SC EP. 2011. Technical Memorandum: Recommendations of the expert panel to define removal rates for street cleaning practices. Annapolis, MD. 62 pp.

Schueler, T. 2013. "Application of CBP-Approved Urban BMP Protocols to Credit Nutrient Reduction Associated with Installation of Homeowner BMPs." Annapolis, MD.

TAPE. 2002. Guidance for Evaluating Emerging Stormwater Treatment Technologies. Olympia, WA. 52 pp.

TAPE. 2008. Guidance for Evaluating Emerging Stormwater Treatment Technologies. Olympia, WA. 59 pp.

TAPE. 2011. Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies. Olympia, WA. 73 pp.

TARP. 2001. Protocol for Stormwater Best Management Practice Demonstrations. 37 pp.

TARP. 2003. Protocol for Stormwater Best Management Practice Demonstrations. 37 pp.

U.S. EPA. 2010a. Chesapeake Bay Phase 5.3 Community Watershed Model, EPA903S10002. CBP-TRS-303-10. Annapolis, MD: Chesapeake Bay Program Office. 553 pp.

U.S. EPA. 2010b. Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus, and Sediment. Philadelphia, PA. 261 pp.

UNM EP. 2013. Recommendations of the expert panel to define removal rates for urban nutrient management, Final panel report. Annapolis, MD. 62 pp.

Water Environment Federation. 2014. Investigation into the Feasibility of a National Testing and Evaluation Program for Stormwater Products and Practices A White Paper by the National Stormwater Testing and Evaluation of Products and Practices (STEPP) Workgroup Steering Committee. Alexandria, VA: Water Environment Federation. 40 pp.

Appendix A: Workshop Agenda

Evaluating Proprietary BMPs:
Is it Time for a State, Regional or National Program? Scientific and Technical Advisory Committee Workshop March 24th, 2015
Northern Virginia Regional Commission Office, Fairfax, VA
http://www.chesapeake.org/stac/workshop.php?activity_id=243

Workshop Objective: The recently imposed Chesapeake Bay Total Maximum Daily Load (TMDL) requires significant reductions in nutrient and sediment runoff from new- and re-developed land, as well as restoration goals for existing developed land. In both cases, these goals can be met through a variety of nonstructural and structural treatment practices commonly known as best management practices or BMPs. Manufactured treatment devices (MTDs) are structural BMPs that are typically proposed for ultra-urban or other high density developments. In many cases, it is not practical to implement many of the 15 nonproprietary BMPs, and cost-effective treatment is only achieved through the reduced footprint (and generally more expensive) of a proprietary BMP (MTD). Verifying the performance of MTDs can be difficult and protocols for their evaluations are evolving. This workshop will seek to address the following questions:

1. What is the problem? Why do we need MTDs?
2. Why do we need an evaluation/testing program?
3. What is the state of the science on evaluating stormwater treatment performance?
4. What is the current process for evaluating nonproprietary BMPs in the Bay watershed? And how do these get incorporated into the Bay Model (CBWM)?
5. What are some of the existing (and proposed, or formerly proposed) MTD evaluation programs?
6. What would a Bay MTD evaluation program look like?

Based on the answers to the preceding questions, the outcome of the workshop would be to provide recommendations on the shape and function of a Baywide MTD evaluation program, leading to an Expert Panel of the Urban Stormwater Workgroup.

	Time
Registration, Light breakfast (Provided)	8:30-9:00 am
1. Introductions, Review of objectives *Norm Goulet (NVRC), 15 minutes*	9:00-9:15 am

<u>Session 1: Setting the Stage on MTDs and the Bay Program</u>

2. Introduction to MTDs. What is the problem? Why do we need MTDs? *Joe Battiata (CWP), 20 minutes*	9:15-9:35 am
Why do we need an evaluation/testing program for MTDs? *Stewart Comstock (MDE), 15 minutes*	9:35-9:50 am
BMP Evaluation and Design Improvement *David Sample (Virginia Tech), 10 minutes*	9:50-10:00 am
3. What is the current process for evaluating nonproprietary BMPs in the Bay watershed? How do these get incorporated into the Bay Model (CBWM)?	
Tom Schueler (CSN), 20 minutes	10:00-10:20 am
Gary Shenk (USGS-CBPO), 15 minutes	10:20-10:35 am
Facilitated Discussion (*Ginny Snead – Louis Berger Group, Inc.)*	10:35-10:50 am
Break	10:50-11:00 am

<u>Session 2: Monitoring, Evaluation, and Existing programs</u>

4. What is the state of the science on evaluating stormwater treatment performance and MTDs?	
William Hunt (NC State, author of ASCE Task Committee Report on MTD evaluations), 30 minutes	11:00-11:30 am
5. What is the history of some of the existing and proposed MTD evaluation programs? What lessons were learned?	
Seth Brown (Water Environment Foundation), 20 minutes	11:30-11:50 am
Kurt Marx (Marx Environmental), 20 minutes	11:50-12:10 pm

Lunch (Provided) 12:10-1:10 pm

Facilitated Discussion (*Ginny Snead*) 1:10-1:30 pm

6. What are the costs of these programs?

Jim Lenhart (Contech Engineered Solutions), 20 minutes 1:30-1:50 pm

Break 1:50-2:00 pm

<u>Session 3: What should an MTD evaluation program look like?</u>

7. Development of an outline, lead

Norm Goulet, 15 minutes 2:00-2:15 pm

Facilitated Discussion (*Ginny Snead*) 2:15-4:00 pm

Adjourn 4:00 pm

Appendix B: Workshop Participants

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Appendix C: Presentation Summaries

Session 1: Setting the Stage on MTDs and the Bay Program

1. Introduction

Due in part to the Chesapeake Bay TMDL, many Mid-Atlantic States have significantly revised their stormwater programs. In most cases, providing some level of stormwater treatment through specific water quality BMPs is required to meet nutrient and sediment reductions from site runoff. Treatment needs are usually met from a set of nonproprietary or conventional BMPs, for which expected performance, while variable, has been established based upon research that normally includes field installation and monitoring. Alternatively, treatment needs could be met using MTDs. MTDs are structural BMPs that are most often used to treat runoff from ultra-urban or other high density developments. In these areas, it is often not practical to implement many of the land-based nonproprietary BMPs. Cost-effective treatment may be possible using an MTD, which occupies a reduced footprint, usually in exchange for an increase in cost. Thus, there is a potentially large opportunity for MTDs to provide a cost-effective treatment option for urbanized areas. The history of poor performance of some of the currently installed MTDs, and the use of arbitrary or assumed performance credits have created an atmosphere of great uncertainty about the devices. This is the primary reason that the CBP does not provide water quality credit for MTDs for modeling TMDL attainment. Despite the lack of credit, thousands of MTDs have been installed in urban areas. This may eventually force local governments to make up the associated nutrient/sediment credits elsewhere.

<u>Existing Testing Protocols</u>: While not universal, a variety of MTD evaluation programs have emerged over the past two decades, and are summarized in Table C1. At the national level, the USEPA's Environmental Testing and Verification program (ETV) was developed to evaluate and verify products and practices across the country. This program was first established in 1995 and was administered by the USEPA's Office of Research. The goal was to "provide credible performance data for commercial-ready environmental technologies to speed their implementation for the benefit of purchasers, government agencies, vendors and the public". The program stopped accepting applications for technology verifications in 2013 and has since been discontinued. The two most widely cited testing procedures for MTDs are the Technology Acceptance Protocol-Ecology (TAPE 2002, 2008, 2011) administered by the Washington Stormwater Center, and the Technology Acceptance and Reciprocity Partnership (TARP 2003) which was initially formed as a partnership between the states of California, Illinois, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Virginia. The intent of TARP was to provide a uniform method for demonstrating the effectiveness of stormwater technologies and developing quality assurance plans for certification or verification of performance claims. While the goal was eventually to evaluate other constituents, TARP's focus was exclusively on sediment (NJDEP 2009). In its current form, is limited to only laboratory sediment testing. The Virginia Technology Assessment Protocol, or VTAP was initially developed by the Virginia Department of Conservation and Recreation (DCR 2012), and while it has been suspended, this program adapted elements of TARP and TAPE to the Mid-Atlantic.

In general, for the CBW, there exists concerns regarding the regional viability of existing protocols for Chesapeake Bay sediment, N, and P. The concerns with these two protocols are that TARP only provides for testing of sediment removal using laboratory, not field conditions, and while one of the protocols for TAPE provides for evaluation of total P treatment, the Washington state climatic conditions (gentle rainfall) are unlike those observed in the Mid-Atlantic, which include heavier, more intense rainfall. Most of the CBW localities target the 90th percentile rainfall depth for system sizing and volume capture; monitoring data quality objectives should take into account the shorter duration and higher intensity storms of the Mid-Atlantic.

Potentially even more important than the performance data, the expected operational life of the MTD will be influenced by the higher loads associated with the higher intensity. Likewise, there could be questions regarding the transferability of a TP performance credit based on the presence of dissimilar sediment particle size distributions and therefore particulate P (volcanic geology versus the aged fractured rock geology of the Mid-Atlantic). The TAPE protocol also lacks an evaluation of dissolved P constituents which is extremely important because it is the dissolved fraction that is most difficult to treat.

Table C1. Most commonly cited MTD Evaluation Protocols, adapted from Water Environment Federation (2014)

Program Name	Coverage	Jurisdiction or Entity of Origin	Reciprocity Granted by Other States	Program Status
EPA Environmental Technology Verification (ETV) Program	U.S./National	EPA, NSF International	Yes	Discontinued
Technology Acceptance Reciprocity Partnership (TARP) Program	Multi-state	Endorsed or recognized by CA, MA, MD, NJ, PA, VA, and NY	Yes	Partnership has dissolved, but protocol still used by many states
Technology Assessment Protocol – Ecology (TAPE) Program	State	Washington State	Yes	Active
New Jersey Corporation for Advanced Technology (NJCAT)	State	New Jersey	Yes	Active
Georgia Technology Acceptance Protocol (GTAP)	State	Georgia	No	Active
NC Preliminary Evaluation Program (NCPEP)	State	North Carolina	No	Active
Virginia Technology Acceptance Protocol (VTAP)	State	Virginia	No	Withdrawn

While not easy, verifying the performance of stormwater MTDs with their unique geometry and unique collection of water quality treatment processes should be relatively simple; as compared to some of the more complex land-based BMPs being implemented in the CBW. However, the treatment innovations and the uniqueness of that geometry makes this evaluation process complicated.

2. Introduction to MTDs. What is the problem? Why do we need MTDs?

Joseph Battiata, P.E., Center for Watershed Protection, presented on the question: "Why do we need MTDs?" MTDs for stormwater were introduced and gained a foothold in the stormwater management toolbox in the mid '90s. The economy was growing and the pace and style of development projects were a perfect fit for the readily designed and installed MTDs (construction plans couldn't be approved fast enough and the percent of impervious cover grew eight times faster than population). As stormwater management requirements expanded nationwide with the NPDES MS4 Permit program, the MTD industry expanded as well. Many new companies started up with innovative designs, and many existing companies quickly developed new products. All of these products were developed with the singular goal of packaging the unit processes of stormwater treatment into a smaller footprint in order to provide challenging development sites, including ultra-urban high density developments, with a means to effectively address water quality requirements without sacrificing developable land.

The complexity of the design and sizing of MTDs is addressed by the manufacturer in terms of the internal configuration of baffles, flow controls, and other features. The site designer needs only to identify the drainage area, the invert elevations of the drainage system, and the overall system footprint. Since MTDs are frequently placed under the pavement or other areas of the site, they do not limit the maximum use of the land as do many traditional stormwater BMPs.

Unfortunately, without a regulatory standard for measuring performance, system sizing, or accountability for long term performance, the competition for MTD sales has spurred aggressive sizing methodologies and performance claims. Civil (stormwater) engineers and site designers are generally not required to verify the performance of stormwater BMPs, as the land development industry has become reliant on prescriptive design standards and specifications that govern almost every aspect of land development.

Furthermore, as the project proceeds from design and local approval to construction, the MTD specified on the approved plans may further evolve as well. The developer/contractor continually entertains value engineering proposals to reduce costs, and is even more accepting of manufacturer recommendations. The design engineer may or may not be asked to approve the plan change and, based on the unverified claim of equivalency, the change may or may not go to the plan approving authority for approval. In any case, neither the designer nor the plan approving authority are equipped with the resources needed to verify the sizing methodology or the performance or equivalency claims.

The result is generally described as a downward spiral of stormwater treatment as ever increasingly developed areas are routed to smaller and smaller MTDs. The effort to address this challenge is illustrated by the state programs that have actively attempted to regulate MTD use with a testing and approval program. Their collective experiences convey both successes and failures. The wide variety of products available, the advanced complexity of hydraulic design, and the variability of rainfall and pollutant loads requires a very dynamic process with constant oversight. These features challenge even industry representatives to provide a consensus on how they should be regulated. Additionally, a call for no regulation can't achieve consensus since it takes away any incentive to invest in product research and development, leaving the marketplace open to cheap, poorly performing products.

There is general consensus among state and local stormwater officials about the benefits that the MTD industry can bring to the science and practice of stormwater treatment. The challenge is to balance MTD benefits − innovation and improved performance associated with research and development, cost-effective treatment strategies on challenging ultra-urban development projects, targeted performance for specific treatment objectives, etc.− with the need for validation of MTD performance. Local, state, and federal officials require that the long-term performance of all BMPs, including MTDs be verifiable. Design consultants need the resources to make value engineering decisions on the wide variety of site conditions encountered on typical (and challenging) development projects. In addition, the community at large (including the development community) requires that the investment in stormwater treatment infrastructure provide actual water quality benefits (otherwise those investments should be redirected to strategies that will provide benefits).

This workshop attempted to expand on these issues, while providing a historical perspective on the experiences from the state processes, and start the dialogue for identifying the essential elements required for the validation of performance of MTDs needed for their inclusion in the CBWM.

Stewart Comstock, Maryland Department of Environment presented on the question: "Why do we need an evaluation/testing program for MTDs?" Maryland state stormwater requirements include mandates for using specific design strategies (e.g., Environmental Site Design, or ESD), unified sizing criteria (e.g., water quality volume), and performance standards (80% TSS Removal, 40% TP Removal). A BMP is considered to be in compliance with this standard if it is sized to capture a specific volume, designed according to specific performance criteria, constructed properly, and maintained regularly.

Maryland has 11 Phase 1 MS4 jurisdictions, however, 10 are in some form of litigation, with one recently expired (SHA). MS4 permit litigation currently represents the largest workload in the attorney general's office. Common points of contention center on the following core permit elements:

- "…develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants…to the maximum extent practicable."
- "…permit must institute or impose all the controls and the highest levels of management and treatment that are capable of being put into practice – most decidedly not standard practices".
- "Under the terms of this Draft Permit, the [permittee] must attain applicable WLAs for each TMDL for each receiving water body."

Driving BMP retrofit standards are USEPA-approved TMDL conditions such as:

> *"In order to achieve the estimated P load reductions applied to urban land, which are necessary to meet the TMDL, current … County Phase I MS4 permit requires*

the jurisdiction to retrofit 10% of existing impervious area where there is failing, minimal, or no stormwater management ... every permit cycle (five years) (i.e., the jurisdiction needs to install/institute stormwater management practices to treat runoff from these existing impervious areas). Additionally, MDE estimates that future stormwater retrofits will have, on average, a 35% TP reduction efficiency."

Where a State or the USEPA has established a TMDL, NPDES permits must contain effluent limits and conditions consistent with the assumptions and requirements of the WLAs in the TMDL. Where the TMDL includes WLAs for stormwater sources that provide numeric pollutant loads, the WLA should, where feasible, be translated into effective, measurable WQBELs that will achieve this objective. For example, Prince George's County has a 5-year permit term for 20% of the previously developed impervious land (Maryland Department of the Environment 2014). Based on guidance from the CBP USWG, removal rates for individual developments are based on the amount of runoff treated and reduced. Charts were developed (Figure C1) for removal rates based on a review of BMP research, Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects, or EP DRRUSRP (2012). Based upon this analysis, it was determined that there is no need to report individual BMP removal rates for each development. BMPs (including MTDs) are classified as either Runoff Reduction (RR) or Stormwater Treatment (ST). The question remains: how are these accountable; that is, how are pollutant reductions for MTDs presently verified?

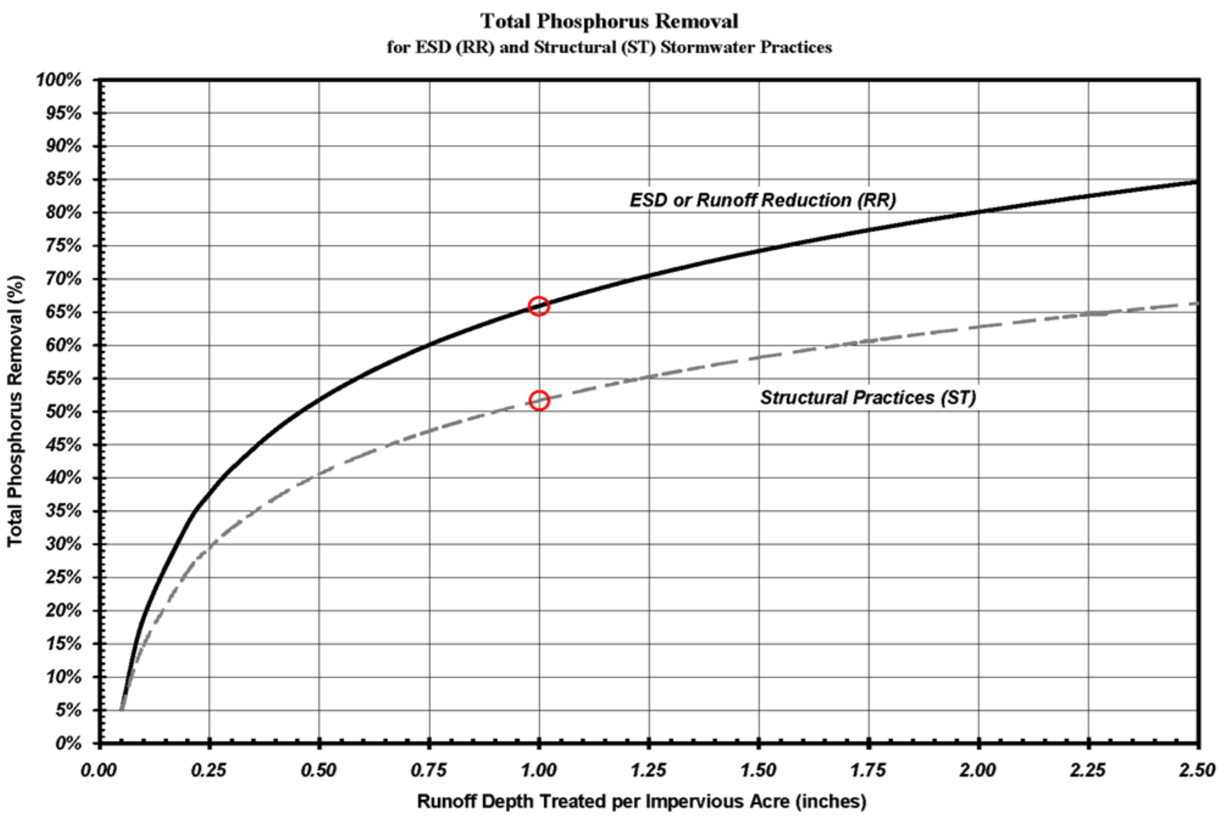

Figure C1. Estimated TP removal for runoff reduction and structural practices from EP DRRUSRP (2012).

So, MDE's BMP evaluation policy is as follows:

- If comparable to a generic practice found in the Manual, then an MTD may be used provided that it complies with performance standards, specifications, and design criteria found in the Stormwater Design Manual (Maryland Department of the Environment 2009).
- If not, then it must comply with the general performance criteria found in the Manual. Field monitoring data must conform to recognized standards (e.g., TARP, TAPE) and testing methods (e.g., ASTM).

Generally, MDE guidelines for MTDs are contained within Maryland Department of the Environment (2015c, 2015b). Field monitoring requirements that would pertain to testing are contained within Maryland Department of the Environment (2015a). For comparison with TAPE, TARP and VTAP, the following section has been taken from Maryland Department of the Environment (2015a):

> Field monitoring results are needed to support performance claims; laboratory testing is not acceptable. The monitoring plan should fully describe the procedures and techniques used to sample influent to and effluent from the alternative/innovative technology. MDE will accept field monitoring that conforms to the most current versions of the TARP Protocol (NJDEP 2009, NJCAT 2010, TARP 2001, 2003, NJCAT 2013) or the Technology Assessment Protocol – Ecology (TAPE), (TAPE 2008, 2011). Where this is not the case, monitoring procedures must conform to the following minimum standards derived from the TARP and TAPE protocol:
> <u>Location</u>: Water quality samples and flow measurements must be collected from both the inlet and outlet of an in-the-field installation of the stormwater practice.
> <u>Rainfall</u>: The following criteria are required for scientifically valid data:
>
> - A storm event must have a minimum total rainfall depth of 0.1 inches; A minimum of 20 storms need (Maryland Department of the Environment 2015c) to be sampled for device performance (sampled storms do not need to be consecutive);
> - A minimum inter-event period of 6 hours between successive storm events, where the period starts when runoff from the first storm ceases;
>
> To assess practice performance under large storm or surcharge events, the total rainfall from at least one storm shall exceed the 1 year, 24-hour design storm (e.g., 2.7 inches of rainfall); and the minimum total rainfall for all storms sampled shall be 15 inches.
> <u>Flow</u>: Influent, effluent, and bypass flows must be measured and continuously recorded over each storm event during the entire field monitoring period. Influent and effluent flow measurements should be recorded close to the stormwater practice. Bypass flow must not be measured in areas that are mixed with effluent. Any conditions that may affect flow measurement accuracy (e.g., high groundwater, backwater conditions) should be avoided.

Water Quality Sampling: Samples must be collected from both the inlet and outlet of each stormwater practice at a location where stormwater flow is well-mixed. Parameters shall include total suspended solids (TSS), total P (TP), and median particle size for each storm event. Sampling shall meet the following:

1. Sufficient discrete samples should be taken to represent a minimum of 70% of a sampled storm's total runoff volume;
    2. A minimum of 10 discrete water quality samples (i.e., 10 influent and 10 effluent) shall be collected using automated sampling methods for storms lasting 1 hour or more. Grab sampling is not acceptable.
    3. TSS sampling and testing shall meet the following:
        a. Standard method (SM) 2540 D shall be used to establish the TSS removal efficiency;
        b. The mean influent TSS concentration should be in the range of 100-300 mg/L; and
        c. The mean particle size should not exceed 100μm;
    4. TP sampling and testing: Acceptable testing methods for establishing TP removal efficiency include Environmental Protection Agency (EPA) 365.3 or 365.4; or SM 4500-P E or 4500-P F.
    5. Particle size distribution (PSD) sampling and testing – ASTM Method D3977-7 shall be used.
    6. Other parameters that are not required by MDE but may be sampled include pH, total petroleum hydrocarbons (TPH), bacteria, or total dissolved metals (e.g., Cu, Zn). Where these are included, the appropriate standard test methods shall be used to determine removal efficiency.

Documentation of Testing Results: The final report should include a description of site use (e.g., commercial parking lot, roadway, construction site), and pertinent characteristics of the area being treated (e.g., total area and percent impervious). There should be a list of the number of storms tested, each storm's peak rate, and the total volumes treated by the device. The report should also provide information on total rainfall, runoff, duration, intensity, and antecedent dry period for each storm tested. For each pollutant tested, results should be presented for each storm individually and summarized statistically for all storms.

David Sample, Virginia Tech presented a concept of continuous quality improvement in the design of stormwater BMPs in the context of adaptive management. Performance monitoring provides feedback for refining BMP designs. Monitoring quality and assessing BMP effectiveness are the key challenges in performance assessment. Runoff quality of the key water quality constituents (sediment, P, and N) varies substantially. BMP performance also varies (in some cases, it is negative, i.e., exporting pollutants), and can be difficult to evaluate.

An example of a monitoring study, a wet pond retrofitted for water quality located in Fairfax, VA, was provided to illustrate stormwater management and demonstrate how treatment effectiveness is assessed. BMP performance should improve as design improves, given sufficient data. Designs can be tested and evaluated with a variety of computational models and simple, physical models such as mesocosms. These provide significant advantages over evaluation of full-scale BMPs. The degree of confidence in our assessment results from a nonlinear relationship between the number of monitored events and the variability of water quality from those events, as shown in Figure C2. An evaluation and testing program for MTDs must incorporate this uncertainty − there isn't a zero risk solution. Any successful program will balance the competing interests – scientific inquiry, achievement of water quality standards, and the need for return on investment.

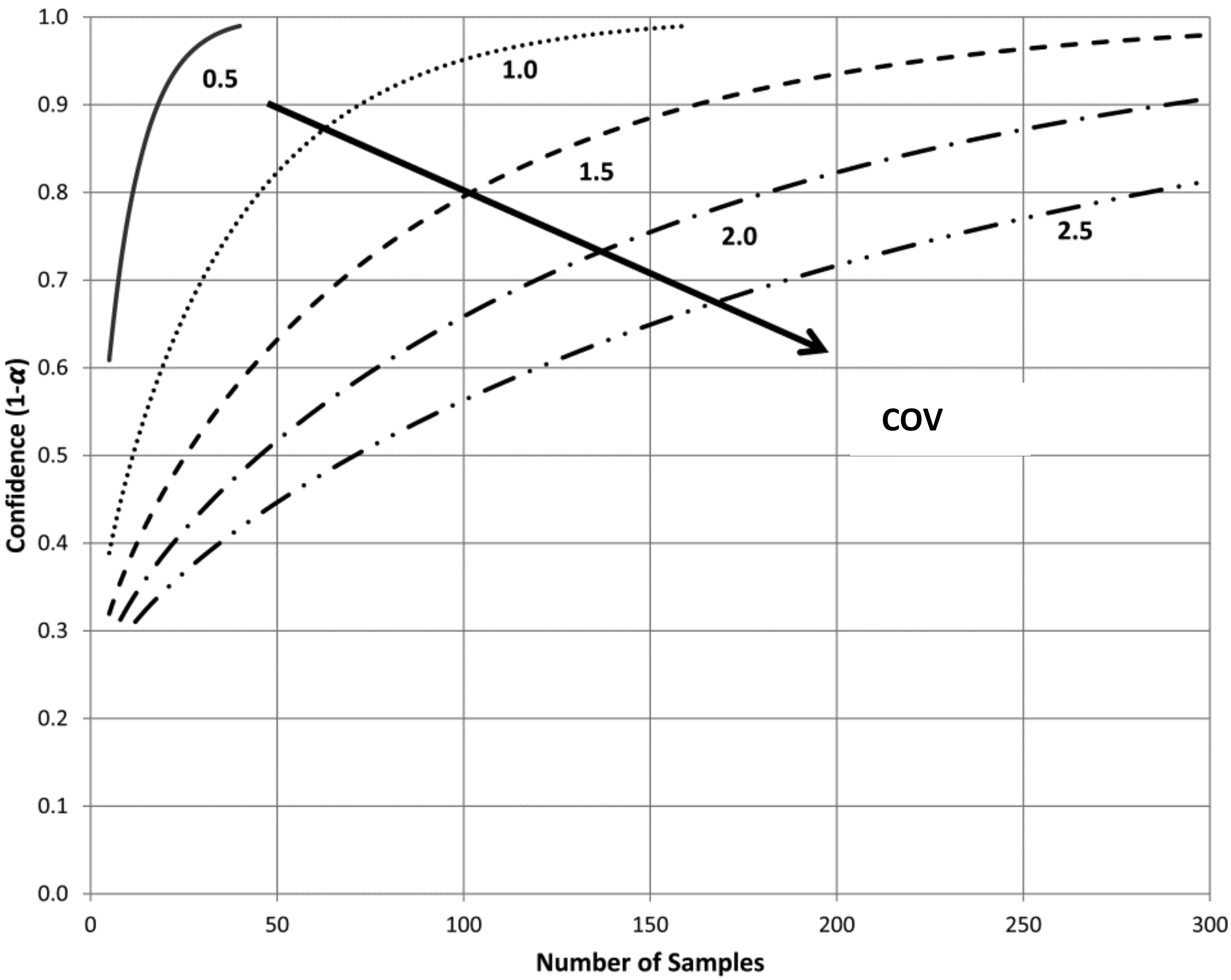

Figure C2. Tradeoff between number of samples, variability (coefficient of variance, and confidence level for analyzing stormwater Sample et al. (2012)

3. What is the current process for evaluating nonproprietary BMPs in the Bay watershed? How do these get incorporated into the Bay Model (CBWM)?

Tom Schueler, Chesapeake Stormwater Network, presented the process of how BMPs have previously been and are currently evaluated and adopted by the Bay program. The Chesapeake Bay Partnership has conducted many different expert panels over the last four years to define the sediment and nutrient removal rates associated with nonproprietary (public domain) urban BMPs used to comply with the Chesapeake Bay TMDL. These have included the following Expert Panel reports:

1. Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects (EP DRRUSRP 2012)
2. Expert Panel to Define Removal Rates for New State Stormwater Performance Standards (EP DRRNSSPS 2012)
3. Urban Nutrient Management Expert Panel (UNM EP 2013) and statewide fertilizer laws
4. Expert Panel to Define Removal Rates for Individual Urban Stream Restoration Projects (EP DRRISRP 2012)
5. Homeowner BMPs (Schueler 2013)
6. Expert Panel to Define Removal Rates for Erosion and Sediment Control Practices (EP DRRESCP 2014)
7. Expert Panel to Define Removal Rates for Shoreline Management Projects (EP DRRSMP 2014) and Expert panel to define removal rates for urban filter strips and stream buffer upgrade practices (EP DRRURFSSBUP 2014)
8. Elimination of Discovered Nutrient Discharges Expert Panel (EDND EP 2014)
9. Street Cleaning Expert Panel (SC EP 2011)

During the process, the CBP has identified many unique technical and policy issues that need to be addressed to achieve consensus for nonproprietary BMPs that may also need to be included into any assessment program for MTDs.

The first issue is that it takes from 12 to 24 months to develop scientific consensus within each Expert Panel, followed by 6 to 9 months to navigate the rest of the CBP approval process (WQGIT 2014). This means that most panels will take at least 2 years to complete, assuming that all the performance monitoring studies have already been completed. Additionally, there is no guarantee that an expert panel will come to consensus. It is acknowledged that this poses a significant delay in evaluation and implementation of MTDs.

The second key issue is that the process is closely linked to the CBWM, and the Panel's recommendations need to be tightly integrated into the model and supporting tools, such as Scenario Builder. One of the most common issues deals with the large scale at which the watershed model operates, which necessitates the use of a sediment delivery ratio to account for the fact that only a fraction of the sediment load generated at the site level actually reaches the Bay. The Panel also must directly address any double-counting issues (has another upstream BMP already removed the pollutant?), and over-counting issues (removing the pollutant not only in surface runoff but also from groundwater).

The third issue is that CBP BMP expert panels often go well beyond defining the percent removal of urban practices. In many cases, expert panels have concluded that a single percent removal rate does not apply to most BMPs, and more complex protocols are needed to define rates for individual BMPs based on site characteristics. While these protocols provide more accurate estimates, their complexity can be hard to wire into the CBWM (especially Scenario Builder).

The fourth issue is that CBP BMP panels are expected to make recommendations on how to report, track and verify urban BMPs. This includes defining a fixed credit duration for each BMP and the recommended process for verifying it in the field. Crafting these recommendations can be contentious, as there are many state-specific policies and rules to align among the seven Bay states.

Lastly, several strategies exist to get credit for a MTD without going through a formal expert panel process. The first is to be able to classify the MTD practice as either a runoff reduction or stormwater practice already evaluated by an existing approved expert panel. This works best if the MTD is designed on a runoff volume basis rather than a flow rate basis. The second strategy is to lump the MTD with nonproprietary practices (e.g., floating treatment wetland). Lastly, to retroactively classify it as linked to an existing BMP panel report or an older BMP (e.g., dry channel RCS as a stormwater retrofit, wet channel RCS as stream restoration practice). The final decision on which strategy is most acceptable requires CBP approval, starting with USWG.

Gary Shenk, USGS-CBPO addressed the implementation of MTDs in the CBP Watershed Model (CBWM). The CBP is in the process of developing the Phase 6 CBWM which is expected to be used for decision-making in 2017 concurrent with the use of the Phase 5 CBWM for tracking (U.S. EPA 2010a). Starting in 2018, the Phase 6 CBWM will be used exclusively. Given the timing of the implementation of new BMPs, it is likely that MTDs will be implemented in the Phase 6 model, although implementation in Phase 5 is still possible given structural and schedule constraints.

A MTD Panel will have to understand the structure and scale of the Phase 6 CBWM and place any reductions at the correct scale of the watershed. The Panel will have to answer the following questions:

1. Does the BMP act at the edge-of-field/parcel, or at a larger scale?
2. Does the BMP effect all forms of N, P, or TSS equally, or is there a difference in effectiveness for different species?
3. Does the BMP treat the entire flow, or just the surface water or stormwater?
4. How can the BMP performance variance be described over the life cycle of the BMP to fit within the CBP BMP verification framework?

The CBP generally regards panel results as the best representation of current science and accepts the results. During the implementation of panel recommendations, accommodations must occasionally be made to fit the recommendation into the context of the CBWM structure and to ensure that we are measuring actual changes on the ground rather than by using accounting differences.

Currently, there is no allowance for treatment by MTDs in the CBWM. This omission results in disconnection between state allowances and Bay-wide credits for the TMDL.

Facilitated Discussion

The facilitated discussion focused on the question: "How do we go about establishing an actual testing protocol – any thoughts on this on how to programmatically fit MTDs into the CBP, noting that the BMP protocols currently state that we cannot use MTDs in the model." The reasons why MTDs are not accounted for in the CBP was initially discussed. N. Goulet explained that USEPA didn't want to get involved with being perceived as favoring one manufacturer over another, and differences in products eventually led to disagreements about which is best or most efficient. Conventional BMPs (which are accounted for in the CBP) have been used extensively in the CBP and there is performance data available. The same level of information is not available for MTDs. A follow-up discussion explored the limitations of use of performance curves (Figure C1). According to Shenk, these curves were not designed for MTDs and their efficiencies. The design basis and maintenance frequency are the biggest differences between products and between these and conventional methods. R. Batiuk clarified that there are some MTD BMP processes being integrated into the CBP through expert panels (e.g., manure treatment), but confirmed that these are rare; it is a difficult process, and a more general means for MTDs to be assessed and approved needs to be provided. J. Lenhart stated that the differences between MTDs and nonproprietary technologies are shrinking as MTDs shift from flow-based to volume-control practices. BMPs may evolve that are hybrids: i.e., use a variety of technologies, both proprietary and nonproprietary. Despite these difficulties, S. Comstock noted that it is most important to keep permit requirements in mind – meeting state regulations vs. crediting for the Bay. G. Snead stated that for stormwater, states have taken different paths to reach their attainment standards; consistency across the CBP is needed. Closing the session, S. Crafton stated that there is a sense of urgency about this issue – permit cycles and approval processes take time. States must count removal rates and be in a position to test and process goals in the near future. Protocols must be developed as soon as possible and a timetable for implementation of the protocol into the new CBWM (Ver. 6.0) should be the goal.

Session 2: Monitoring, evaluation, and existing programs.

4. What is the state of the science on evaluating stormwater treatment performance and MTDs?

Dr. William Hunt, NCSU, began with a historical perspective. In North Carolina, approximately 18 years ago, massive fish kills occurred as the result of pollutants such as sediment and the nutrients N and P. The State's response was to require designers to use BMPs to remove N and P. BMPs were assigned nutrient removal rates that were, at best, educated guesses at the time. However, the assigned BMP performance values make calculation of loads delivered much easier; i.e., 10 lb. of N into a wet pond would equal 7.5 lb. out, in NC. Hunt pointed out that this approach does not lend itself to understanding how a BMP works for improving its performance. This leaves opportunities for research in (1) verifying removal rates, (2) understanding hydrology, (3) improving design, construction, and maintenance standards for better performance, and (4) defining other metrics for evaluation. He also discussed the complexities and difficulties of the monitoring process and how they can drive up the cost and time involved with a monitoring project as well as confuse the results.

An example of the impact of Hunt's research was provided in the case of permeable pavements. A comprehensive, parallel monitoring study was conducted to evaluate various permeable pavement designs and the results were compared with standard asphalt. Monitoring results found permeable pavements achieve runoff reductions greater than 98%. Previous to the study, runoff reduction credit was only allowed in eastern North Carolina. Results of the study expanded the credit statewide, but soil permeability must be considered.

A second example was provided for Falls Lake, which is part of the Neuse River watershed. In North Carolina, the Neuse and the Tar-Pamlico watersheds are classified as "nutrient sensitive waters", limiting N and P discharges to comply with a TMDL. All new development must have a nutrient management strategy in order to: control and treat the first flush (defined as the first inch of rainfall); eliminate peak flow increase in a 1-year, 24-hour storm; and limit nutrient loading to 2.5 kg/ha-yr. of N, and 0.35 kg/ha-yr. of P. Two infiltrating wet ponds (clay liner omitted) were monitored using a water budget approach, which accounted for flow into the ponds, flow out of the ponds, evapotranspiration (ET), precipitation, and infiltration. Sampling methods using automated samplers, area velocity meters, weirs, tipping bucket rain gages, water levels, and an ET gage and model were utilized.

A third example described monitoring two bioretention cells and a small swale capturing water from a bridge deck. For each of these systems, the monitoring strategy was diagrammed, including the inlet and outlet of each BMP. Samplers were used to take water quality samples, and a bubbler flow module measured flows, which are set using a control weir or flume with a known stage discharge relationship. Hunt described multiple challenges that commonly occur in monitoring studies including turbulent flows, backwater conditions, and pressurized flows, which result in inaccurate flow measurements, and hence an inaccurate assessment of water quality performance of the BMP. For bioretention cells, inflow runoff volume was calculated using the initial abstraction method, and the influent peak flow rate was calculated using the rational method (Maidment 1993) . For the swale, hydrologic data were deemed unreliable, and inflow was assumed to equal outflow, since little infiltration would be expected to occur. A detailed survey of the upstream catchment bridge was conducted to verify inflow.

A fourth example was provided using two paired watersheds, one employing a low impact development (LID) design, and the other using traditional development methods. The study compared the watersheds across time and space; each watershed was about 6 acres in size. The LID watershed had 84% directly-connected impervious area (DCIA). The traditional watershed had 61% DCIA. The LID watershed contained a bioretention cell, rainwater cisterns with the water reused for toilet flushing and irrigation, and an underground detention/infiltration system. The traditional development had a pretreatment swale and a large dry detention pond. As in the previous examples, inflows and outflows were instrumented and sampled using automatic samplers, area-velocity meters, and control weirs. Water quality samples were collected and analyzed for total suspended solids (TSS), total N (TN), total Kjeldahl nitrogen (TKN), ammonium (NH_4-N), nitrate-nitrite (NO_2+3-N), total P (TP), and orthophosphate (PO_4^{3-}). Each watershed was compared with a control. A statistically significant decrease was found for removal of TSS, TP, and PO_4^{3-}, but not for NO_2+3-N, despite a large percent reduction observed. This was attributed to a significant decrease in influent NO_2+3-N concentrations. Thus, having an influent that is too clean can pose issues for a monitoring program aimed at determining the performance of a treatment device.

Hunt described designing for monitoring, including pretreatment at the inlet and periodic maintenance to remove accumulated sediment and debris. Inappropriate use of trash guards caused a 20% reduction in flow that could have otherwise passed into an inlet. Hunt also discussed residual pathogens and bacterial issues associated with stormwater, noting that entire journal articles are based upon grab samples, as opposed to composite samples, resulting in a diminished level of understanding. Hunt described evaluating residual pathogens after the storm in multiple places, such as along the surface to the manhole, down the manhole, and along the inside of a pipe to the sampling point. Hunt also mentioned the issue of accounting for all mass, including debris accumulating in drop inlets, resulting in a loss of 10-20 lb. N/impervious acre. Hunt described calibrating measurement flumes and/or weirs, appropriate use of samplers and flow monitoring, elimination of bypass flows, and periodic field maintenance of monitoring equipment. The advantages of multiple samples across a storm hydrograph versus single composite samples were discussed. Composite samples are the minimum required to capture mass flux. Within storm analysis provides verification of the presence of a "first-flush", i.e., where pollutants are concentrated in the initial portion of runoff. However, this will increase monitoring costs; often a few specific storms can be selected to minimize this effect.

5. What is the history of some of the existing and proposed MTD evaluation programs and what lessons were learned?

Kurt Marx, formerly of the TAPE program and the University of Washington, presented an overview of the Washington State TAPE program. TAPE is operated by the Washington Department of Ecology and the Washington Stormwater Center. The program approves new stormwater treatment devices (mostly manufactured devices). These treatment devices are required by the Phase I and Phase II municipal stormwater permits in the state that require treatment for new construction and re-development projects. TAPE certifies treatment devices by assessing the removal of total suspended solids, dissolved copper and zinc, total P, and hydrocarbons. A minimum percent treatment for each pollutant must be proven in a given range of concentrations.

The TAPE certification program originated in 1999, created by the American Public Works Association, Washington Chapter, Surface Water Managers Committee. In 2002 the state Department of Ecology adopted the program and drafted the first guidance manual. Revisions to the guidance document and process were made in 2004 and 2008. In May 2008, the TAPE program closed due to budget and staffing constraints. TAPE re-opened with a revised guidance document in January 2011.

Currently, the program consists of one full time equivalent (FTE) (Washington Stormwater Center); one staff person at Ecology (approx. 10-20% time), a stakeholder advisory group (municipal volunteers), and the board of reviewers (stormwater experts paid a nominal fee per review). The program is funded by Ecology grants and by fees collected from participants, paid in three installments of $2000, $4000, and $6000 throughout the process. A summary of the program accomplishments through March, 2015 is provided in Table C2.

Table C2. TAPE Actions as of March 2015.

Program metric	**Actions completed**
Technologies fully approved since TAPE re-opened in January 2011	5
Total number of technologies approved under TAPE program*	15
Technologies currently active in stages of the TAPE program • Initial application • QAPPs being developed (& site identification) • QAPPs being reviewed • Monitoring underway • Final technical reports being reviewed	~12

*Since inception

Looking back on the experience, Marx summarized the "lessons learned" as:

1. Longevity of the program and a good business plan is essential. Manufacturers will not invest in certification/verification if there is a chance that the program will not last many years.
2. Create consistent internal policies for decisions and review to be consistent for all participants. Don't rely on the knowledge of one staff person that may leave the program.
3. Have a robust system to deal with requests for public documents. Competition is fierce in this industry, and other companies will want to gain access to documents if they can.
4. Any program must have a system to approve or allow alternative configurations to an approved device. Manufacturers are always improving products and responding to customer needs. Often time, these changes do not warrant a complete re-testing or re-submittal, but should still be reviewed and approved.
5. Strive to minimize the time that it takes for certification/verification.
6. Make sure that maintenance and maintainability of the device is included in a certification/verification program.
7. Strive to achieve reciprocity and collaboration with other programs. This will make your program more robust, and will help manufacturers minimize costs.

Seth Brown, Water Environment Federation (WEF)/ Storm and Stream Solutions, LLC, presented on a WEF Project, "Exploring the Need for a National Stormwater BMP Testing and Verification Stormwater Program". A new effort has begun to investigate the feasibility of developing a national stormwater BMP testing protocol and evaluation program. Stormwater BMP pollution removal efficiency studies have increased in both frequency and complexity in recent years. However, the stormwater monitoring field is still relatively young and the approach to categorize, review, evaluate, verify and certify or approve stormwater runoff controls is less mature than that of other water monitoring sectors.

Some states and localities have independently developed BMP evaluation protocols and programs over the past two decades. This has created both programmatic and administrative inconsistencies throughout the country as well as created a landscape of water quality studies that use different monitoring techniques. This not only negatively impacts the ability of resource managers to properly address local and regional water pollution and restoration efforts, but it creates financial disincentives and burdens to private businesses that produce innovative proprietary stormwater practices.

In 2013, WEF assembled the national STEPP Workgroup. A steering committee was assembled to explore the feasibility of developing a national stormwater testing protocol, verification, and certification program. Members of the committee include federal and local regulators, environmental scientists, stormwater BMP manufacturers, and a non-profit organization, many of whom have background and experiences in stormwater BMP water quality monitoring. This effort was designed to investigate the merits of developing a testing and evaluation program of national scale to meet the needs in the stormwater sector. A white paper addressing the issue was published in February 2014 (Water Environment Federation 2014). The recommendations in this white paper addressed the central question behind the development of the document: "Is a national stormwater testing and evaluation program for products and practices needed and is it feasible?" The STEPP Steering Committee agrees that there is a need for a national program, and that the development of such a program is feasible.

Beyond addressing these questions, the steering committee developed a series of recommendations that are listed below:

1. Meaningful engagement and support is needed from USEPA.
2. The STEPP workgroup should engage with state regulatory agencies to gather input and support. Both proprietary products and public-domain practices should be included in a comprehensive stormwater national testing and evaluation program.
3. Buy-in on a national program is needed from other professional organizations, NGOs, and state and regional stormwater organizations.
4. A common protocol for testing and evaluation and programmatic/process needs to be developed.
5. The development of an implementation plan and associated business plan is needed to determine logistical and financial sustainability.
6. Additional issues, such as long-term maintenance and international ETV programs, need to be further investigated in future efforts.
7. Collaboration with non-domestic ETV programs, such as the European ETV and Toronto Regional Conservation Authority's STEPP, is needed in future efforts.
8. To maximize the impact of the development of the white paper, widespread distribution and stakeholder reaction is needed.

During the discussion, N. Goulet summarized Virginia's interim program. Development of the Virginia Program began in 2007, led through the Virginia Stormwater BMP Clearinghouse and the Virginia Department of Conservation and Recreation (DCR). During this time a draft protocol known as VTAP was developed. Development of VTAP continued after the transfer of the Virginia Stormwater Management Program (VSMP) from DCR to Virginia Department of Environmental Quality (DEQ) in July 2013. While the initial regulatory effort was begun under the DCR, the final regulation adopting the VTAP program was not completed. In July of 2013, the stormwater program and the Clearinghouse were transferred to the DEQ. It was determined that the VTAP regulatory adoption would take longer than 2 years, so an alternative, interim process was developed by DEQ in the spring of 2014 (DEQ 2014). This guidance document provided a procedure for approval of MTDs for use under Part IIB of the VSMP Regulation. This VSMP regulation [9VAC25-870] states that stormwater BMPs used to meet the new water quality design requirements [Part IIB] must be listed on the Virginia Stormwater BMP Clearinghouse website. According to this guidance document, the maximum percent TP removal that the DEQ will assign to any MTD is 50%. Field testing data from the Washington TAPE program and the now defunct TARP program originally developed by the New Jersey Department of Environmental Protection are allowed as a basis for receiving credit.

Facilitated Discussion

A facilitated discussion was held on the history of MTD evaluation programs. T. Schueler asked K. Marx, "What is the drop-out rate in the TAPE program?" According to Marx, MTDs that make it to field testing, with a unit in the ground, almost always successfully complete the program and receive certification. Since the TAPE program consists of an initial application – which are often approved on a pilot status, the next step is identifying a site, getting it approved. Some applications have stalled in the site approval process (25-33%). R. Magee clarified that NJCAT administers the TARP protocols and procedures as amended by the NJDEP, which focus upon laboratory testing and is limited to sediment. A possible complication that may lengthen the process was if monitoring is begun on an approved site, but information learned in that monitoring program leads to a shift to another sites, generating the need to restart the application. R. Magee stated that site selection and field monitoring will always be a challenge, but you learn information in the field that you can't elsewhere, especially with respect to operation and maintenance. A. Stevens asked if technical modifications of a device were ever made as a result of the monitoring program. According to K. Marx, the TAPE program is not conducive to simultaneously performing research and development on the MTDs being evaluated. Once certified under TAPE, the MTD is not required to be re-certified. Maintenance will largely be dependent on the site and its permitting status, there is no ongoing TAPE maintenance reporting required. The reasons why some other states accept TAPE, but not the other way around was discussed, it was determined that this may be due to specific Washington State criteria and rainfall. However, TAPE does accept initial TARP evaluations for pilot status (for sediment), and was prepared to accept VTAP as meeting a portion of its requirements.

6. *What are the costs of these programs?*

J. Lenhart, Chief Technology Officer, Contech Engineered Solutions, presented "Verification Programs, Setting the bar and Leveling the Playing Field, what is the Cost?" Lenhart addressed the costs of Stormwater BMP performance monitoring programs which are based on capital expense and time. However, there is also a cost involved with *not* having a monitoring program which insures BMPs are meeting performance expectation and establishing a level playing field for fair competition.

The time it takes to complete a monitoring program is dependent on a number of factors. The first step is to identify a site and go through engineering design and construction (9 months), then wait for site stabilization and a pollutant load to be generated (1 year). Next is to develop an approved QAPP and begin the monitoring, which is usually a two-year process. Once the monitoring is complete, there is a reporting phase of about 3 to 6 months. All in all, the process can take four to five years to complete.

There are actions that can be taken to speed the process, such as already having sites in the ground, retrofits, multiple sites to increase sampling success or dedicated test facilities. Obviously the best time to start on a program is now.

Monitoring is typically done by consultants or in-house. Even then, the use of independent labs and sample handling increases costs. Basic costs include labor, expenses, equipment, analytical fees and occasional fees by the reviewing body. Costs will vary depending on the protocols which govern the number of samples and the pollutant parameters being analyzed (Table C3).

Table C3. Estimated Costs (thousands) of Monitoring (assumes 20 storms captured)

Category	**Attribute**	**Cost, 10^3\$**
Labor	Skilled staff (2 x 0.25 FTE) 2.5 years	75
Expenses	Travel, setup, retrieval, maintenance, Supplies	8
Equipment	Samplers (2) Telecommunications	21
Analytical	20 Storms (TSS, SSC, TP, TVSS, Metals)	40
Total		**184**

Use of a consultant to execute the work, including reporting and QAPP development, can add another $100,000 to the cost.

There are issues that can increase costs. Sometimes the site does not generate enough pollutants (or too many) and a new site needs to be selected. Issues such as safety, odd hydraulic conditions, extreme weather, or even nuisance wildlife can set a program back in terms of cost or time.

Though these costs may seem high, the MTD industry is 20 years old, and historically these testing programs have been successfully completed by a number of smaller startup companies. In addition, some companies have spent millions of dollars over the past 20 years to verify their products. To allow other products into the marketplace without appropriate verification does not promote a level playing field. Some also want lab verification only. However, the general consensus among agencies recognizes the need for field verification, since lab conditions do not reflect the real-world conditions of the field environment.

Others will argue that verification programs are a barrier to marketplace entry and stifle innovation. Verification and testing are not new to industries where innovation is prevalent. Cell phones need an allowed frequency and battery testing to meet Federal Communications Commission (FCC) regulations. Cars are crash tested and have their emissions and mileage tested. A manufacturer of a highway guard rail product, a simple nonproprietary metal form, must test its product, even though they can say it looks and functions just like the others.

Not having a program leads to a downward spiral of sizing and performance claims. This leads to the lowest common denominator and actually stifles innovation. Programs which set the bar and level the playing field entice entrepreneurs to innovate in order to clear the bar and not have to worry about unverified claims undermining the market.

In addition, having no program leads to a general mistrust of the industry and results in lower water quality in the field. This is in effect a "lose, lose, lose" situation for the industry, the customers and, most importantly, the water.

There are ways to reduce costs and the time elements. Verification programs should allow for pilot testing and conditional approvals. Programs need to distinguish between required criteria and guidelines for the field testing protocol, as well as establish climatic regions to reduce the number of tests needed nationwide.

Agencies have costs too! These programs need to maintain the bar and level the playing field. To do otherwise leads to an entropic decay of the programs. This puts the program at risk, which increases user costs associated with uncertainty and the confusion of false claims, not to mention the decline in water quality and impacts to the receiving waters.

In conclusion, there is a need for a robust verification program. The cost is not small, but the reward is significant. Since the potential negative water quality consequences of installing hundreds or thousands of MTDs without some assurance of performance is huge, we must hold manufacturers accountable. Let the technology be used where it makes sense, especially with the economic drivers present in urbanized environment.

Facilitated Discussion

A facilitated discussion was held that focused upon verification programs. T. Schueler inquired on the proportion of participants that seek verification. According to J. Lenhart, most manufacturers seek verification and eventually perform the required monitoring. S. Comstock stated that in Maryland, very few MTDs have gone through field verification; most are permeable pavers. A discussion ensued which compared different verification processes, e.g., market-based verification and a regional program. J. Lenhart suggested a regional verification program for an area as large as the CBW should include some form of reciprocity. This could consist of a two-tiered program, with the first tier consisting of conditional approval based on criteria developed by an individual state program, then in a second tier, be evaluated for Chesapeake Bay-specific requirements, which could be developed after consulting additional programs such as TAPE, TARP, and VTAP. R. Magee commented that historically, TARP evolved due to necessity in New Jersey, and at the time, little to no input was received from other states on verification, and a real problem exists in financially sustaining such programs. Magee suggested that the constituents that the program evaluated should be carefully chosen, i.e., not use every parameter that we can think of.

Session 3: What should an MTD evaluation program look like?

7. Development of an outline, lead

This facilitated discussed addressed the question, “Is a regional approach aligned with the CBP something that we want to undertake, and what should it look like?” F. Rose commented that, while it takes time to get approval for MTDs, there are existing programs that demonstrate the feasibility of MTD evaluation. Therefore, it is important to begin using a core set of standards that can be improved over time. R. Batiuk suggested that CBTAP could be implemented at the governor’s level (Executive Council of CBP), i.e., begin with a political directive. N. Goulet suggested that we don’t need to start from scratch: TARP, TAPE, VTAP can provide a nucleus for the CBTAP, i.e., use these existing programs as cornerstones. Goulet suggested that the steps forward should include: 1) appointing a panel of 12-15 people from industry, consulting, academia, state, and local government; 2) developing a consensus protocol through the USWG; and 3) beginning implementation across the CBP. S. Comstock suggested that since local government will ultimately be held accountable for load reductions, a unified set of standards in the MS4 jurisdictions will help. J. Davis-Martin suggested that the process could be similar to Homeowner BMP efficiencies, and proposed that any MTD that passes a regional protocol, approved by the CBP, should be considered “approved” for use Bayside. Davis-Martin inquired whether MTD evaluations would be separate from the BMP panel process. Goulet commented that the MTD evaluations are difficult because they don’t have a standard, approved testing protocol across the CBW, i.e.,”, but evaluations are essential in verifying vendor claims. R. Magee inquired as to what exactly is meant by “verifying”. Why would you not want to evaluate the performance of an MTD over several different scenarios [in the lab] then scale them up?

D. Sample commented that verification of MTD performance could include laboratory or field evaluations, and that there are advantages and disadvantages of each. However, in the laboratory, you cannot replicate the physical conditions in the field. To clarify the discussion of the various protocols, Sample presented Table C4 comparing the TAPE, TARP, VTAP programs. Some of the differences between them stem from Virginia’s focus on P as an area of concern, which was later amended to include N and sediment for application in the CBW. In contrast, Washington State, which mainly focuses on western Washington and the Puget Sound, has a primary focus on metals (for endangered species), sediment, P, and oils (due to shipyard concerns).

Sample and Goulet proposed using VTAP as a starting point – modify as needed, but it should be applicable to the entire CBW. While a national program (STEPP) is under discussion, it could be a long way off. S. Crafton suggested that a regional protocol such as the CBTAP should be developed now, with the understanding that is would fold into the eventual national program, should the latter become successful. S. Brown commented that a regional program would open up the market, as well as increase reciprocity between different regions. WEF will collaborate with developing protocols. Goulet indicated this will be facilitated by inclusion of Brown and WEF as members of the MTD Expert Panel. J. Lenhart suggested that the evaluation /verification should have a defined “carrot” at the end of the stick, or a value, so that people will be incentivized to expend the time and expense to be tested. Goulet proposed that an example of a “carrot” is its inclusion in the matrix of BMPs provided credit in the CBWM, which would then provide an incentive for people to use the MTDs, while Lenhart suggested that another “carrot” would be getting credit for the existing BMPs. Goulet recommends we develop a protocol for evaluating MTDs that is applicable Bay-wide – so that VA, MD, etc. are all on the same page; levelling the playing field among manufacturers. The efficiency of the MTD would then be provided credit in the CBWM. S. Comstock suggested a distinction be made between "verification" and "certification" – they hold different meanings in the CBP. J. Hanson inquired how the MTD Expert Panel might tackle other constituents of concern such as bacteria or trash, etc. Goulet responded that we should focus on sediment, N, and P first, i.e., "crawl before walking". S. Perry commented that both the process and the protocols should allow for innovation – there are products and technology on the shelf that are engineered to help tackle some of these nutrient problems, but they may only be identified once this process is underway.

G. Snead summarized that the workshop established that there is a need for a regional program; however, there are several challenges yet to be addressed. Such a program will bring some order to currently established programs. Davis-Martin expressed a concern that whether the CBP is the right venue for it as it has much on its plate. He suggested it could be done independently by CRC/STAC or another university. G. Snead reminded the group that this could be a recommendation that comes out of the MTD Expert Panel Report. J. Frye suggested that an MTD evaluation program would be very beneficial to be under the CBP assuming there is a commitment from the states to participate. Goulet reiterated his proposal that this would work through the USWG, which has all of the key players necessary to achieve buy-in. Brown recommended the stormwater equipment manufacturers association (SWEMA) be solicited for input. Lenhart commented that developing the protocol is relatively easy, but keeping it relevant over time, i.e., adaptable, is much more difficult.

Table C4. Comparison of Evaluation Programs of Manufactured Treatment Devices (Sample et al. 2012).

Group	Parameter	TAPE[1]	TARP[2,3] (Field Tests of TSS Removal)	VTAP[4]
Applicability (States)		Washington	New Jersey (also to varying degrees, reciprocity with CA, MA, MD, PA, VA[5])	Virginia
Use Designation	**Pilot**			
	Minimum Data for Certification	Lab	---	Lab or Field
	Time Limit of Certification, Months	30	---	While performance testing is being conducted
	Maximum # of Installations (in state)	5	1	20
	Accepted Field Testing Protocol	Min.1 in NW, all WA installations monitored	TARP	VTAP, NJ TARP, TAPE or Approved Protocol
	Conditional			
	Minimum Data for Certification	1 Field (Lab Supplemented)	---	2 Field Indicative of VA Conditions
	Time Limit of Certification, Months	No limit	Assigned Expiration	No limit
	Maximum # of Installations (in state)	No limit	No limit	No limit
	Accepted Field Testing Protocol	Comparable with TAPE	TARP	VTAP, NJ TARP, TAPE or Approved Protocol

General Use

Group	Parameter	TAPE[1]	TARP[2,3] (Field Tests of TSS Removal)	VTAP[4]
Use Designation (continued)	Minimum Data for Certification	1 Field in NW (Lab Supplemented)	1 Field (Lab Supplemented)	2 Field, 1 indicative of VA Conditions
	Time Limit of Certification, Months	No Limit	Assigned expiration	No Limit
	Maximum # of Installations (in state)	No Limit	No Limit	No Limit
	Accepted Field Testing Protocol	TAPE	TARP (NJ)	VTAP
Storm Event Guidelines	Minimum Storm Depth, mm	3.8	2.5	2.5
	Minimum Preceding Dry Period, Hours (<1 mm rainfall)	6	6	6
	Minimum Post Dry Period, Hours (<1 mm rainfall)	6	NA	NA
	Minimum Storm Duration, Hours	1	NA	NA
	Minimum Rainfall Sampled, mm	NA	381 (at least 50% total annual rainfall)	381
	Minimum Testing Time Period, Years	1.5 maintenance cycles or 2 wet seasons for cycles >2 yrs.	1	1 Maintenance cycle
Sampling (Automatic)	Minimum Aliquots per Event	10 (may accept > 6)	10 (6 for storms <1 h)	10 (6 for storms < 1h)
	Event Coverage < 24 Hours	75% of Hydrograph Volume	70%	70% , as much of first 20% as practical
	Event Coverage > 24 Hours	75% of first 24 hr.	70%	70% , as much of first 20% as practical
Sampling (Automatic), (continued)	Rainfall Monitoring: Type of Monitoring During Event	Continuous	Continuous	Continuous

Group	Parameter	TAPE[1]	TARP[2,3] (Field Tests of TSS Removal)	VTAP[4]
	Max. Rainfall Time Interval, Minutes	15	5	None
	Max. Rainfall Volume increment, mm	NA	0.25	0.25
	Average Intensities, mm/Hour	50%>0.76	NA	NA
	Maximum Intensity, mm/Hour	NA	127 (1 exception allowed)	102
	Maximum Total Rainfall per Storm, mm	NA	76 (1 exception allowed)	NA
	Maximum Sampling Duration, Hours	24	NA	NA
	Minimum # of Storm Events	12, however must achieve required confidence level	20 (25 recommended)	24
	Maximum # of Storm Events	NA	NA	NA
	Minimum Sequential Events	NA	As Many as Practical	10 (5 sets of 2 sequential events)
	Maximum Inflow/Outflow Discrepancy	NA	NA	10%
Sampling (Discrete, Additional)	Required Testing of Design Loading Rate	50-125% of Rate	Min. 3 Events>75% of Rate	Min. 2 Events >75% of Rate
	Influent Concentration	Must Meet Influent Water Quality Concentration Ranges	NA	NA
	Basic TSS/Pretreatment-All Sites	TSS	TSS, SSC	NA

Group	Parameter	TAPE[1]	TARP[2,3] (Field Tests of TSS Removal)	VTAP[4]
	Basic/Pretreatment-Screening (3 Events)	PSD, pH, TP, Ortho-P, Hardness, Total and Dissolved Cu and Zn	NA	NA
	Phosphorus-All Sites	TSS, TP, Ortho-P	NA	TP, TSP, SRP (if sorption), TSS, SSC, PSD, Specific Gravity
	Phosphorus-Screening (3 Events)	PSD, pH, Hardness, Total and Dissolved Cu and Zn	NA	NA
	Nitrogen-All Sites	NA	NA	TN, TDN, Ammonia-N, Ox-N
	Dissolved Metals-All Sites	TSS, Hardness, Total and Dissolved Cu and Zn	NA	NA
	Dissolved Metal-Screening (3 Events)	PSD, pH, TP, Ortho-P	NA	NA
Sampling (Discrete, Additional) (continued)	Oil-All Sites	NWTPH-Dx (grab sample only), Visible Sheen	NA	NA
	Oil-Screening (3 Events)	pH, TP, Ortho-P, Hardness, Total and Dissolved Cu and Zn	NA	NA
	Laboratory Certification for WQ Samples	National or State Certified; WA DOE Accredited	NJELC/NJNELA (NELAC)	VELAP (NELAC)

Group	Parameter	TAPE[1]	TARP[2,3] (Field Tests of TSS Removal)	VTAP[4]
Sediment Analysis	Basic and Pretreatment	Optional: PSD, percent solids, grain size, percent volatile solids	Sediment Removed at 50% Capacity	NA
	Phosphorus	Optional: PSD, TP	NA	PSD, TP, Percent Volatile Solids
	Dissolved Metals	Optional: PSD, total Cd, Cu, Pb, and Zn	NA	NA
	Oil	Optional: PSD, NWTPH-Dx	NA	NA
Supplemental Lab Testing	% of Design Stress Test	50%, 75%, 100%, and 125% (+/-10%) of Design	NA	NA
	Specified Sediment PSD	Sil-Co-Sil 106	NA	NA
	Influent	Must Meet Influent Water Quality Concentrations	NA	NA
Sediment Analysis (continued)	TSS Min. Performance Standard:			
	Basic	TSS: 80% Removal	NA	NA
	Pretreatment	TSS: 50% Removal	NA	NA
Maintenance	General	Record All Maintenance	Record All Maintenance	Record all Maintenance
	Specified Sediment Removal	NA	Sediment Removed at 50% Capacity	NA
	Specified Filter Removal	NA	Filter Replaced Once 90% Max Flow Rate Reached	NA
Site Approval	Min. Sampling Events to Characterize	NA	3	NA
	WQ Parameters	NA		NA

Group	Parameter	TAPE[1]	TARP[2,3] (Field Tests of TSS Removal)	VTAP[4]
	Influent Concentration	NA	TSS, PSD, Continuous Water Level TSS Arithmetic Avg. < 100 mg/L TSS Weighted Avg. < 300 mg/L Arithmetic Avg. d_{50}<100 µm Weighted Median d_{50}<200 µm	NA

[1]TAPE (2011)
[2](TARP 2003)
[3]NJDEP (2009)
[4]DCR (2012)