Estimation of BMP Impact on Chesapeake Bay Program Management Strategies

Photo by Lynda Richardson, USDA Natural Resources Conservation Service

PREPARED BY:
Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030-2201
Phone: 703-385-6000
www.tetratech.com

TETRA TECH

PREPARED FOR:
Chesapeake Bay Trust
60 West Street, Suite 405
Annapolis, MD 21401
Phone: 410-974-2941
www.cbtrust.org

April 28, 2017

Contents

Tables

1 Project Background and Purpose

The Chesapeake Bay Trust awarded a contract to Tetra Tech to quantify the effects the Chesapeake Bay Model's (CBM's) best management practices (BMPs) have on each of the Chesapeake Bay Program's (CBP's) management strategies. The results of the project will enable jurisdictions, localities, and others to assess the impact the BMPs contained in their watershed implementation plans (WIPs) will have on CBP's management strategies. This analysis is intended to capture both the co-benefits and unintended consequences, if applicable, for each BMP. The objective of the project is to create a simple matrix that assigns an impact score to each BMP (or BMP group) for each management strategy or outcome. These values are not a quantification of results, but show the BMP's relative impact. The matrix is not intended as a method to evaluate WIPs or other restoration plans and is not a requirement for WIP development, nor is it a quantitative tool for performing rigorous evaluations of BMPs.

The matrix can be used by jurisdictions to help them decide on which BMPs to include in their WIP or other restoration plan if other BMP selection criteria (e.g., nutrient and sediment load reductions, cost, implementability) are equally satisfied by the candidate BMPs. It should help them develop WIPs that achieve the primary goal of reducing nutrient and sediment loads to the Chesapeake Bay, while also achieving additional goals that are important to them. The matrix considers a typical BMP's potential for affecting those additional goals; however, its actual impact could be affected by many factors, which are not explored in this document. For instance, matrix values could be different for BMPs near the Bay and upstream in the watershed.

This document has been designed for jurisdictions and others developing WIPs to use as a guide to understanding how their implementation activities affect the management strategies and additional goals. It does not look at economic benefits or considerations, except where noted (e.g., the property value goal). It is anticipated that this information will be included in the Chesapeake Assessment Scenario Tool (CAST). This document describes the management strategies and additional goals; the BMPs/BMP groups that Tetra Tech evaluated; the impact scoring guidelines for each management strategy and additional goal; and the results of BMP scoring for the individual management strategies.

2 Management Strategies

Management strategies are specific focus areas developed by the CBP goal implementation teams (GITs) to describe what is necessary to achieve the Chesapeake Bay Watershed Agreement vision:

> …an environmentally and economically sustainable Chesapeake Bay watershed with clean water, abundant life, conserved lands, and access to the water, a vibrant cultural heritage, and a diversity of engaged citizens and stakeholders" (CBP 2014)

Each management strategy outlines its goal, outcome(s), and baseline; relevant partners; factors influencing its success; current efforts and gaps in action, resources, or data; management approaches that are being used or will be used to achieve the outcome(s) of the strategy; and how progress will be monitored and assessed.

Tetra Tech reviewed the 29 management strategies with James Davis-Martin of the Virginia Department of Environmental Quality, the project technical lead for this project and the chair of the Water Quality Goal Implementation Team (WQGIT). Based on those discussions, 10 management strategies were removed from the project because they are not applicable (e.g., some management strategies are policy-oriented and could not be addressed through BMPs). The inapplicable management strategies were replaced with 10 additional goals not explicitly addressed by the existing management strategies. The additional goals were identified as representing issues important to local governments and capturing the co-benefits of BMPs during the Chesapeake Scientific and Technical Advisory Committee Optimization Workshop and subsequent conversations.

Table 1 lists the original 29 management strategies Tetra Tech reviewed with Mr. Davis-Martin and the actions agreed upon for each one (i.e., remove or keep). This review resulted in a final list of 19 management strategies and goals for inclusion in the analysis. To aid in understanding the additional goals, Tetra Tech drafted goal descriptions to mirror the management strategies. Mr. Davis-Martin reviewed the descriptions, as did Ms. Mary Gattis, who is the coordinator for the Local Government Advisory Committee. Each description includes a definition, goals, outcomes, and factors influencing success and is provided in appendix A. Full descriptions of the original management strategies are available at http://www.chesapeakebay.net/managementstrategies. The Urban Workgroup also suggested including cost-effectiveness as a category for BMP scoring. Tetra Tech and Mr. Davis-Martin agreed that cost-effectiveness information already is available in CAST and did not fit the description of a management strategy or an additional goal/co-benefit.

Table 1. Original Management Strategies and Status in BMP Impact Scoring Project

Goal	Strategy	Action
Sustainable Fisheries Goal	Blue Crab Abundance and Management	Kept abundance only
Sustainable Fisheries Goal	Oysters	Kept
Sustainable Fisheries Goal	Fish Habitat	Kept

Goal	Strategy	Action
Sustainable Fisheries Goal	Forage Fish	Kept
Vital Habitats Goal	Wetlands	Kept
Vital Habitats Goal	Black Ducks	Kept
Vital Habitats Goal	Stream Health	Kept
Vital Habitats Goal	Brook Trout	Kept
Vital Habitats Goal	Fish Passage	Kept
Vital Habitats Goal	Submerged Aquatic Vegetation	Kept
Vital Habitats Goal	Forest Buffers	Kept
Vital Habitats Goal	Tree Canopy	Kept
Water Quality Goal	2017 and 2025 WIPs	Removed
Water Quality Goal	Water Quality Standards Attainment and Monitoring	Removed
Toxic Contaminants Goal	Toxic Contaminants Research	Removed
Toxic Contaminants Goal	Toxic Contaminants Policy and Prevention	Kept
Healthy Watersheds Goal	Healthy Watersheds	Kept
Stewardship Goal	Citizen Stewardship	Kept
Stewardship Goal	Local Leadership	Removed
Stewardship Goal	Diversity	Removed
Land Conservation Goal	Protected Lands	Kept
Land Conservation Goal	Land Use Methods and Metrics Development	Kept
Land Conservation Goal	Land Use Options Evaluation	Removed
Public Access Goal	Public Access Site Development	Kept
Environmental Literacy Goal	Students	Removed
Environmental Literacy Goal	Sustainable Schools	Removed
Environmental Literacy Goal	Environmental Literacy Planning	Removed
Climate Resiliency Goal	Climate Monitoring and Assessment	Removed
Climate Resiliency Goal	Climate Adaptation	Kept

The additional goals included in the BMP impact scoring project are:

- Air Quality
- Bacteria Loads
- Biodiversity and Habitat
- Drinking Water Protection/Security
- Economic Development/Jobs
- Energy Efficiency
- Flood Control/Mitigation
- Groundwater Recharge/Infiltration
- Property Values
- Recreation

3 Best Management Practices

The CBM incorporates a substantial number of different BMP types spread across the agriculture, forestry, wastewater, and urban sectors. The overall current list of BMPs was obtained from CAST, with the exception of the list of on-site wastewater, or *septic system*, technology BMPs. That information was obtained from the National Environmental Information Exchange Network (NEIEN) because the septic technology information in CAST was considered too general. For this project, only the septic technology BMPs were reviewed in the wastewater sector; treatment plant technologies were not reviewed because it was assumed that the overriding factors in treatment plant upgrades are cost and pollutant removal.

The BMPs were grouped into generalized categories for each sector that represent the essential functions of the practices in the group to minimize redundancy in scoring them. For example, the *bioretention/raingardens—A/B soils, no underdrain*; *bioretention/raingardens—A/B soils, underdrain*; and *bioretention/raingardens—C/D soils, underdrain* BMPs were combined into the *bioretention* BMP group. The BMP groupings were developed based on the best professional judgment (BPJ) of experts in each BMP sector. The groupings were sent to their respective workgroups for review, but no changes were suggested. Some BMPs are represented in multiple sectors. For example, both the agriculture and urban sectors have sector-specific BMPs for stream restoration and tree planting. In those cases, the BMPs were scored and reported on separately. A complete list of BMPs and BMP groups is provided in appendix B.

Categories were considered for agricultural BMPs, but were later dropped to preserve the specific conservation practice physical effects (CPPE) information associated with each practice. While some patterns were identified for small groups of agricultural BMPs and management strategies, it was concluded that the information lost in presenting those scores by BMP group or groups of management strategies and goals in simplified tables or charts would render the information far less useful. For example, groups were created for agricultural BMPs prior to scoring. These groupings were based on similarities in sources treated (e.g., animal feedlot runoff), locations benefited (e.g., riparian protection), or pollutants addressed (e.g., nutrient management). Some groups included only one BMP (e.g., *commodity cover crops, drainage control*), while others included several BMPs (e.g., *soil stabilization measures*). In the end, the function and effect of the BMPs included in some groups were not sufficiently similar to result in equivalent scores for those BMPs in the same groups. Similarly, many agricultural BMPs have multiple impacts that were similar across groups (e.g., nutrient loss reduction), further diminishing the differences among groups. For this reason, agricultural BMPs were scored individually and were not grouped after scoring.

4 Narrative Impact Scoring Guidelines

4.1 Development

Tetra Tech developed narrative guidelines for assigning impact scores to foster consistency in scoring across multiple evaluators. The narrative guidelines were used to evaluate the impact of each BMP on the individual management strategies (and goals). Tetra Tech reviewed each management strategy, focusing on the *Factors Influencing Success* section, to help identify and assess the factors for which BMP impacts are of greatest concern. Narrative guidelines also were developed for the additional goals, using the information provided in the additional goal descriptions in appendix A.

Tetra Tech completed a draft impact score document for each of the selected management strategies and additional goals that describes the goal of the management strategy and the factors influencing the success of the management strategy, and includes scoring criteria against which the BMPs were to be evaluated. The draft impact scoring guidelines were based on available information obtained from management strategies, management strategy team members, GIT members, BMP panel reports, scientific literature, the previously funded toxic contaminants study, and BPJ. Tetra Tech also sought input from the relevant GITs, sector workgroups, and other experts.

Each GIT and workgroup was given the opportunity to comment on the corresponding draft scoring guidelines. Tetra Tech requested input on whether the scoring guidelines were consistent with the management strategies and accurately captured the elements that make a BMP relevant to a management strategy. Relevant literature to support or refine the scoring guidelines also was requested. After receiving input from GIT and workgroup members, Tetra Tech refined the scoring guidelines to reflect relevant comments from the experts. After the scoring guidelines were final, the project moved to the BMP scoring phase.

The impact scoring narrative for each management strategy and additional goal was developed with a parallel structure to provide an *apples-to-apples* comparison. Each narrative has a range of scores from 5 to −5, where −5 indicates that implementation of the BMP would substantially limit progress toward achieving the management strategy or additional goal. A score of 0 is intended to represent a BMP that has no positive or negative impact on achieving the management strategy or additional goal. A score of 5 is the preferred score and represents a BMP that would substantially enhance achieving the management strategy or additional goal. For each scoring guideline, management strategy-specific narratives were developed for scores −1, − 3, −5, 1, 3, and 5. The scores −2, −4, 2, and 4 were used as in-between scores reserved for BPJ. Table 2 provides an example narrative scoring guideline. Final narrative scoring guidelines are included in appendix C.

Table 2. Example Narrative Scoring Guideline for Blue Crab Abundance Management Strategy

Value	Score	Scoring Narrative for Blue Crab Abundance
5	Substantial Improvement	Practice directly improves submerged aquatic vegetation (SAV) or other habitat or water quality conditions in localized area to the benefit of blue crab abundance
4	Moderate-to-Substantial Improvement	Somewhere between 3 and 5 → BPJ
3	Moderate Improvement	Practice decreases nutrient loads from tributaries
2	Slight-to-Moderate Improvement	Somewhere between 1 and 3 → BPJ
1	Slight Improvement	Practice decreases thermal load from tributaries and/or contributes to optimal salinity contributions from tributaries
0	No Effect	Practice has no impact on blue crab abundance
-1	Slight Worsening	Practice increases thermal load from tributaries and/or contributes to undesirable salinity contributions from tributaries
-2	Slight-to-Moderate Worsening	Somewhere between −1 and −3 → BPJ
-3	Moderate Worsening	Practice increases nutrient loads from tributaries
-4	Moderate-to-Substantial Worsening	Somewhere between −3 and −5 → BPJ
-5	Substantial Worsening	Practice directly worsens SAV or other habitat or water quality conditions in localized area to the detriment of blue crab abundance

4.2 Considerations

The narrative impact scoring guidelines were designed to provide consistency across management strategies and additional goals, with no consideration given to whether BMPs could achieve the maximum/minimum scores for a specific strategy. In other words, the maximum impact scores (−5 and 5) represent the greatest possible negative or positive impact on achieving goals regardless of the ability of BMPs to have that effect.

The impact scoring guidelines also were designed to be applied conceptually to a particular BMP. This is not an evaluation of a BMP in a specific location or under specific conditions, but more broadly of whether the BMP would typically have an impact on the management strategy in question. BMPs were assumed to be correctly installed, and existing vegetation (e.g., trees) was assumed to have been disturbed during construction as appropriate.

The scoring represents the average or typical application/implementation of a specific BMP, assuming no knowledge of site-specific information that could alter an application/implementation. In many cases, there are site-specific modifications or practice features that could cause a BMP to have more or less of an impact on achieving a particular management strategy, but the intent of the scoring guidelines is to consider the average condition at the average site.

Some management strategies or additional goals are more relevant on a larger regional scale, while others are more relevant on a local scale. With few exceptions, the narrative scoring guidelines do not account for the scale (i.e., size or extent of the practice), general location (e.g., installed next to a stream or in the center of town), or watershed location (e.g., upstream or downstream) of the BMP. Exceptions include drinking water protection/security, riparian forest buffers, submerged aquatic vegetation (SAV), and wetlands, for which geographic location is directly relevant to the management strategy and is incorporated explicitly within the scoring guidelines. There are other management strategies such as *black duck*, *blue crab abundance*, *brook trout*, and *oysters* for which proximity of the practice to the management strategy outcome is likely to play a role in BMP planning and implementation, but is not incorporated explicitly within the scoring guidelines.

Management strategies and goals encompass a broad range of subject areas, some of which are impacted by nutrient and sediment loads (e.g., stream health, fish habitat). BMPs selected to achieve load reduction targets for nutrients and sediments will have an impact on the achievement of these management strategies and goals. Where nutrients and sediments have been identified as factors influencing the success of a management strategy or goal, those pollutants appear in the scoring narrative. The impact that BMPs designed for nutrient and sediment reduction have on management strategies and goals, however, also is dependent on the impact they have on other factors listed in the scoring narratives. For that reason, the scoring of BMPs versus management strategies and goals is often not aligned directly with the performance of BMPs in reducing sediment and nutrient loads.

5 Individual Management Strategy / BMP Scoring

Three main methods were used to derive BMP scores: (1) reviewing literature and CBP BMP Expert Panel reports; (2) obtaining BPJ from GIT, workgroup, and other subject matter experts; and (3) using U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) CPPE data (for agriculture BMPs only). The urban and forestry BMPs were scored based on both literature review findings and expert BPJ. Other sectors such as wastewater and toxics were scored based on BPJ and input from GITs and workgroups, without a stand-alone literature review. Agricultural BMPs were scored using a separate method based on existing NRCS CPPE data, along with expert BPJ and input from GITs and workgroups.

The relationship between an individual BMP and each management strategy or goal is framed by the narrative statement. The experts scoring each BMP applied BPJ and knowledge of available literature when determining the best relationship between BMPs and narrative statements. In nearly all cases, experts scored the BMPs through a qualitative analysis that took into consideration how and to what extent the BMP affects specific pollutants and pollutant pathways, and whether the BMP has direct or indirect impacts on biological and habitat parameters specified in the narrative statements.

5.1 Literature and BMP Expert Panel Reports

5.1.1 Urban BMP Scoring

Tetra Tech's urban BMP review, including urban forestry, focused on available literature as well as the CBP's urban BMP Expert Panel reports. Literature was found through online searches as well as through the EBSCO*host* online research database using key words that included BMP types and management strategy language. Information found in the literature was applied to the impact scoring guidelines for each management strategy or additional goal. Preliminary impact scoring was based on an initial literature search. After the preliminary scoring was completed, a targeted literature search was conducted for urban BMPs and management strategies that were not found in the initial search. Tetra Tech reviewed 158 documents relating to the effects of urban BMPs (see appendix D). Of those documents, 103 were found to be useful and were applied to BMP impact scoring. The documents used consisted of reports and manuals written by government agencies, peer-reviewed journal articles, conference presentations, guidebooks/manuals, dissertations, informational papers, expert panel reports, and other miscellaneous documents.

5.1.2 Forestry BMP Scoring

Tetra Tech's forestry BMP review focused on available literature and the CBP's Riparian Buffer Expert Panel report. Literature was identified through the EBSCO*host* online research database and online searches using key words that included BMP types and management strategy language, especially defining factors in the narrative scoring guidelines.

There was significant overlap in the literature reviews between the urban and forestry BMPs because several practices apply to both sectors. In addition to the sources identified in the urban BMP literature review, 21 other documents were identified, not all of which were found to be relevant (see appendix D). The additional sources focused on forest buffers, forest harvesting practices, and dirt/gravel roads. They were a combination of journal articles and guidebooks/manuals from state agencies. Each BMP was scored against each management strategy using the accumulated information from all literature reviewed. Many of the findings overlapped significantly across literature sources.

5.2 CBP and other Subject Matter Expert Input

The GITs, workgroups, and Tetra Tech subject matter experts were provided with an Excel spreadsheet on which to score the BMPs. Each customized spreadsheet included only the relevant management strategies or BMPs the specific group was asked to score. Tetra Tech provided narrative scoring guidelines and instructions on how to score and use the scoring spreadsheet. Members of the GITs and workgroups were asked to review the full management strategy/additional goals guideline documents prior to scoring. Scorers were reminded that scale and location of a BMP should not be considered in the scoring. The exception was for a few narratives that included language regarding BMP location (e.g., riparian buffer, drinking water protection area, SAV area). Scorers also were asked to consider the BMP to be in working order and in a general, nonspecific location.

Input from GIT members was important to developing BMP scores. Tetra Tech solicited their BPJ on scoring for each BMP or BMP group for management strategies directly related to their GIT. They were asked to leave the score blank for any BMP they did not feel comfortable scoring. Input was provided by the Habitat, Sustainable Fisheries, and Fostering Chesapeake Stewardship GITs. Additional discussion is provided below by GIT.

Tetra Tech also sought input from the sector workgroups under the WQGIT because they have in-depth knowledge of the BMPs in their sector. Each workgroup was asked to provide their BPJ on scoring for BMPs or BMP groups for each management strategy and additional goal directly related to their workgroup, except for Toxic Contaminants Workgroup which only scored the toxic management strategy. Input was provided by the Wastewater Treatment, Forestry, and Toxic Contaminants workgroups. Additional information is provided below by workgroup.

5.2.1 Protect and Restore Vital Habitats GIT (Habitat GIT)

The Habitat GIT reviewed and provided scores for the *SAV*, *wetlands*, *stream health*, *black duck*, *fish passage*, and *brook trout* management strategies using BPJ for BMPs with which they felt comfortable providing scores, while leaving others blank. The GIT is comprised of members of the Fish Passage, Stream Health, SAV, and Wetlands workgroups who are experts in their respective fields and come from multiple state and federal agencies and nongovernmental organizations.

The Habitat GIT provided notations on and explanations of the scores they assigned to each BMP. An overarching comment from the reviewers was their discomfort with setting scores for BMPs in a general context because the effectiveness of a BMP will vary with both site-specific conditions and the presence of associated other BMPs. GIT members cautioned that one size does not fit all and that care should be taken to ensure that the scoring results do not influence higher level BMP selection and funding decisions at the expense of site-specific suitability.

In some instances, BMPs were assigned negative scores for consistency with the Maryland Department of the Environment acknowledgment that there might be tradeoffs associated with water quality projects. In other instances, the GIT found BMP impacts to be so variable that a single score could not be assigned. Because the underlying assumptions could not be fully quantified, Tetra Tech excluded the scores given as ranges from the analysis and final BMP scores.

Regarding stream health, one reviewer from the Habitat GIT suggested that site-specific project scores should be based on site-specific principal stressors, which vary by stream or watershed. Those principal stressors should be identified and prioritized, with the highest score given to actions (e.g., BMPs) that alleviate them. The Habitat GIT reviewer suggested that a table be developed of forecasted principal stressors as a function of land use, impervious cover, and other factors to help aid in site-specific project scoring. Principal stressors of a habitat and secondary considerations for stream health or wetlands are outside the scope of this analysis and were not addressed in this project.

5.2.2 Sustainable Fisheries GIT

The Sustainable Fisheries GIT reviewed and used BPJ to provide BMP scores for the *blue crab abundance*, *fish habitat*, *forage fish*, and *oysters* management strategies. The GIT is comprised of managers and scientists who discuss fishery management issues that cross state and jurisdictional boundaries in the Chesapeake Bay and connect science to management decisions. The members are experts in their respective fields from multiple state and federal agencies and nongovernmental organizations.

5.2.3 Fostering Chesapeake Stewardship GIT

The Fostering Chesapeake Stewardship GIT reviewed and used BPJ to provide BMP scores for the *citizen stewardship* and *protected lands* management strategies. This GIT’s charge is to increase citizen action; support environmental education for all ages; and assist citizens, communities, and local governments in undertaking initiatives to conserve treasured landscapes. The members are experts in their respective fields from multiple state and federal agencies and nongovernmental organizations.

5.2.4 Maintain Healthy Watersheds GIT

The Maintain Healthy Watersheds GIT was contacted to provide input into scoring BMPs for the *healthy watersheds* and *land use methods and metrics development* management strategies. The GIT, however, did not provide any feedback.

5.2.5 WQGIT—Agriculture Workgroup

Tetra Tech staff communicated with Mark Dubin, lead on this task for the Agriculture Workgroup, regarding the preferred approach for scoring agriculture BMPs (section 5.3). Mr. Dubin agreed that the preferred approach of using CPPE data was reasonable. Tetra Tech provided the Agriculture Workgroup with the initial scoring documentation for review, but did not receive any feedback.

5.2.6 WQGIT—Forestry Workgroup

The Forestry Workgroup reviewed the BMPs classified under forestry sector or forestry/urban sector and scored them for all the management strategies. Scoring for forestry BMPs (including forest- or tree-related BMPs under agriculture and urban sector BMPs) was completed with input provided by members participating in a Forestry Workgroup meeting.

5.2.7 WQGIT—Urban Stormwater Workgroup

The Urban Stormwater Workgroup was not able to provide initial BMP scoring for the management strategies and additional goals. Tetra Tech relied on an internal subject matter expert to provide scores based on BPJ. The staff member has more than 30 years of experience in the evaluation, development, and application of innovative stormwater management technology. He has provided training for more than 10 years on various aspects of stormwater management, including low impact development / environmental site design (LID/ESD), and has authored numerous publications related to LID/ESD, including book chapters, manuals of practice, and technical papers.

5.2.8 WQGIT—Wastewater Treatment Workgroup

For the wastewater sector, only on-site wastewater treatment systems (OWTSs) were scored. After discussion with Mr. Davis-Martin, it was decided that wastewater treatment plant upgrades are determined mainly by permit conditions, cost, and other factors, so management strategies would not play a role in upgrade decisions. Scoring for OWTS technologies was completed by the Wastewater Treatment Workgroup and a Tetra Tech staff member using BPJ. For the septic scoring using BPJ, it was assumed that a new advanced system (i.e., BMP) is replacing an existing standard treatment system, not a new system. Thus, the scoring is for the enhanced technology of the systems.

The Tetra Tech staff member used a combination of BPJ, Tetra Tech experience coordinating and supporting three BMP Expert Panels related to OWTS BMPs over the past 4 years, and Tetra Tech's ongoing routine collection and review of literature related to nutrient reduction and other direct and secondary impacts of OWTS and decentralized systems. The Expert Panel reports supported by Tetra Tech required extensive literature reviews as well as the collection and synthesis of subjective information provided by panelists on typical practices in their jurisdictions. Tetra Tech routinely scans the relevant literature related to OWTS performance by monitoring a Google Scholar query on a weekly basis. This routine scan of the recent literature is supplemented by focused literature reviews for projects as well as participation in wastewater conferences and symposia, including those specific to the OWTS and decentralized systems sector. The Tetra Tech staff member completing the scoring sheet is a national and international OWTS and decentralized system wastewater management expert who is personally involved with OWTS planning, engineering design, and management (e.g., installation, inspection, and operation and maintenance) as well as with decentralized and centralized treatment systems. In addition to being the Chesapeake Bay OWTS BMP Expert Panel coordinator, the staff member also completed a guide to decentralized wastewater research and capacity development products for the Water Environment Research Foundation several years ago. Familiarity with the literature and state of knowledge allowed him to score OWTS BMPs accurately for the various quantitative management strategies (e.g., *bacterial loads*), while a deep understanding of the implications of OWTS BMPs and centralized systems enabled him to make informed judgments on scoring practices that were more qualitative or subjective in nature.

5.2.9 WQGIT—Toxic Contaminants Workgroup

The Toxic Contaminants Workgroup scored all BMPs for the *toxic contaminants policy and prevention* management strategy. There are several different groups of toxic contaminants (e.g., hydrophilic organics, hydrophobic organics, and metals). For scoring, the workgroup chose the pollutant group most closely associated with the sector to which the BMP is related and ranked the BMP for the main pollutant of concern. Table 3 provides a summary of each contaminant group; the primary sectors in which it is a concern; and its likely extent, severity, and sources.

Table 3. Summary of Contaminant Group Concerns

Contaminant Group	Sector	Extent, Severity, and Sources
Polychlorinated biphenyls (PCBs)	Urban	Widespread extent and severity. The severity was based on risk to human health through consumption of contaminated fish with impairments identified in all of the watershed jurisdictions. Some primary sources are contaminated soils, leaks from transformers, and atmospheric deposition.
Mercury	Atmospheric	Widespread extent and severity. The severity was based on risk to human health through consumption of contaminated fish. The primary source is air emissions from coal-fired power plants.
Polycyclic aromatic hydrocarbons (PAHs)	Urban	Widespread extent throughout the Bay watershed. The severity was localized based on impairments for risk to aquatic organisms in a limited number of areas in the watershed. The primary sources are contaminated soils, road sealants, atmospheric deposition, and combustion.
Pesticides	Ag, Urban	Widespread extent of selected herbicides (primarily atrazine, metolachlor, and simazine, and their degradation products) and localized extent for some chlorinated insecticides (aldrin, chlordane, DDT/DDE, dieldrin, heptachlor epoxide, and mirex). The chlorinated insecticides have localized severity based on risk to aquatic organisms. For many pesticides that have widespread occurrence, water quality standards were not available to determine impairments. Research shows sublethal effects for some compounds at environmentally relevant concentrations. Primary sources are applications on agricultural and urban lands and legacy residue in soils.
Petroleum hydrocarbons	Urban	Localized extent and severity (to aquatic organisms) in a limited number of areas in the watershed.
Dioxins and furans	Industrial	Localized extent and severity (to aquatic organisms) in a limited number of areas in the watershed. The primary sources are spills, contaminated soils, and atmospheric deposition.
Metals and metalloids	Urban	Localized extent and severity (to aquatic organisms) of some metals (aluminum, chromium, iron, lead, manganese, and zinc) in a limited number of areas in the watershed. The primary sources are spills, industrial processes, and atmospheric deposition.
Pharmaceuticals, household and personal care	Urban, Wastewater, Ag Septics	Information was not adequate to determine extent or severity. Their use in the watershed, however, suggests widespread extent is possible. Severity was not accessed but research shows sublethal effects to selected aquatic organisms for some compounds at environmentally relevant

Contaminant Group	Sector	Extent, Severity, and Sources
products, flame retardants, biogenic hormones		concentrations. Range of sources from wastewater treatment and septic tanks to animal feeding operations. Biogenic hormones assessment was focused on naturally occurring compounds from humans or animals.

5.3 NRCS CPPE Data (Agriculture BMPs Only)

Agricultural BMP scoring was conducted differently than the scoring of BMPs from other sectors. Tetra Tech staff communicated with Mark Dubin, lead on this task for the Agriculture Workgroup, regarding the preferred approach. Mr. Dubin agreed that using the NRCS CPPE data was a reasonable approach to developing scores for agricultural BMPs. Tetra Tech used values from a national CPPE spreadsheet dated September 14, 2015.

The CPPE data detail in subjective language the physical effects that conservation practices have on problems for soil, water, air, plant, animal, and human resources. The estimation of physical effects is based on the professional experience of NRCS staff and available technical information. The primary purpose of CPPE data is to allow conservation planners to compare the projected physical effects of individual conservation practices on resource concerns and then assemble a system of practices that addresses producer needs and minimizes adverse effects of treatment.

CPPE physical effects are grouped into the following categories:

- Air Quality Impacts
  - Emissions of greenhouse gases
  - Emissions of ozone precursors
  - Emissions of particulate matter and particulate matter precursors
  - Objectionable odors
- Degraded Plant Condition
  - Excessive plant pest pressure
  - Inadequate structure and composition
  - Undesirable plant productivity and health
  - Wildfire hazard, excessive biomass accumulation
- Excess Water
  - Drifted snow
  - Runoff, flooding, or ponding
  - Seasonal high-water table
  - Seeps
- Fish and Wildlife—Inadequate Habitat
  - Inadequate habitat—cover/shelter
  - Inadequate habitat—food
  - Inadequate habitat—habitat continuity (space)
  - Inadequate habitat—water
- Inefficient Energy Use
  - Equipment and facilities
  - Farming/ranching practices and field operations
- Insufficient Water
  - Inefficient moisture management
  - Inefficient use of irrigation water
- Livestock Production Limitation
  - Inadequate feed and forage
  - Inadequate shelter
  - Inadequate water

- Soil Erosion
  - Classic gully erosion
  - Ephemeral gully erosion
  - Excessive bank erosion from streambank, shoreline, water conveyance channels
  - Sheet and rill erosion
  - Wind erosion
- Soil Quality Degradation
  - Compaction
  - Concentration of salts or other chemicals
  - Organic matter depletion
  - Subsidence
- Water Quality Degradation
  - Elevated water temperature
  - Excess nutrients in surface water and groundwater
  - Excess pathogens and chemicals from manure, biosolids, or compost applications in surface water and groundwater
  - Excessive sediment in surface water
  - Pesticides transported to surface and groundwater
  - Petroleum, heavy metals, and other pollutants transported to receiving surface water and groundwater
  - Salts in surface water and groundwater

CPPE human considerations are grouped into the following categories:

- Cost Information (not used)
- Benefit Information (not used)
- Capital (not used)
- Cultural Resources and/or Historic Properties (not used)
- Land
  - Change in land use
  - Land in production
- Labor
  - Change in management level
  - Labor hours
- Profitability (not used)

  Risk (not used)

CPPE scores range from −5 to 5, with 0 indicating that the practice does not impact the particular physical effect or human consideration. Each score is accompanied by at least one rationale.

Tetra Tech linked CPPE information with the management strategies and additional goals by first identifying all Chesapeake Bay physical effects and human considerations contained in the narrative scoring guidelines for the strategies and goals. This set of physical effects and human considerations was compared against those in the CPPE spreadsheet, with all CPPE physical effects and human considerations that matched or related strongly to those in the management strategies and additional goals retained for scoring purposes. Tetra Tech also linked the Chesapeake Bay BMPs with NRCS conservation practices by practice definitions and resource targets.

The crosswalks between CBP BMPs and NRCS conservation practices were used to determine which conservation practices to retain for scoring purposes. At this point, Tetra Tech had retained a subset of

NRCS conservation practices and a subset of CPPE physical effects and human considerations relevant to those practices. Those practices and physical effects constitute the CPPE data used to determine scores for each agricultural BMP reported in the CBM.

Tetra Tech created links between the set of CPPE physical effects and human considerations and the set of CBP management strategies and additional goals. The crosswalks between CBP BMPs and NRCS conservation practices also were built into the scoring spreadsheet. With these linkages, a CBP BMP could be selected from a drop-down list and the matching NRCS conservation practice(s), the associated physical effects and human considerations and their NRCS scores, and a list of applicable management strategies and additional goals revealed.

While both the CPPE matrix and scoring for management strategies and additional goals used a scale from −5 to 5, Tetra Tech did not simply apply the CPPE scores to the strategies and goals. Instead, Tetra Tech used both the CPPE scores and associated rationale to determine the best match with language in the strategy and goal narrative impact scoring guidelines. For example, a CPPE score of 3 for excessive sediment in surface water could translate into a narrative score from 0 to 5. Tetra Tech achieved consistency in translating CPPE scores to impact scores by noting in comment fields the CPPE scores applied to determine the impact score for each BMP-strategy/goal combination.

While the CPPE matrix contained sufficient information to score nearly all BMPs for nearly all strategies and goals, some gaps were observed, most notably with regard to the new phase 6 manure technology BMPs. In those cases, Tetra Tech obtained information from Expert Panel reports and a limited review of available literature. The Tetra Tech staff scoring the agricultural BMPs also are supporting development of BMP Expert Panel reports for certain agricultural BMPs (e.g., conservation tillage, nutrient management, cropland irrigation) and, therefore, incorporated knowledge of those panel reports into BPJ-based scoring for relevant BMPs.

5.4 Quality Assurance/Quality Control of Scores from Literature and Expert Panel Reports

After the literature review and scoring for forestry and urban BMPs was completed, a quality check was performed by a Tetra Tech staff member who had done the original scoring for different sector. For example, quality assurance/quality control checks on the forestry scoring were performed by the staff member who scored the urban BMPs. Five percent of literature-scored results were reviewed by a second staff member to determine if that person produced similar scoring values. Results were found to be substantially similar between reviewers.

For agricultural BMPs, after the scoring was completed, 10 percent of scores were checked by a second reviewer who had scored different BMPs. Major differences and patterns in those differences were identified and resolved, with updated scores recorded as appropriate. Using this approach, substantial agreement in scoring was considered acceptable (i.e., perfect matches were not required). Final Tetra Tech scores were delivered to Mark Dubin of the Agriculture Workgroup for his review.

6 Analysis and Results

6.1 Results

The BMP scores were put into an Access database, where each score was associated with a source, management strategy, and BMP. Once in the database, the scores were reviewed, processed, and finalized.

6.1.1 Score Review and Processing

Tetra Tech reviewed results of BMP scoring from BPJ, CBP GITs and workgroups, and literature searches. Several BMP scores differed by greater than 3 points due to different interpretations of the narrative impact scoring guidelines and understanding of BMP functionality and implementation. During the final score calculation, individual scores were weighted based on the reviewer's understanding of the management strategies and BMP functionality. For example, while having intimate understanding of the management strategies, some GITs expressed concern about their lack of understanding of specific BMPs and how they are implemented to reduce pollutants. Those scores were weighted lower than scores by sector workgroups or subject matter experts. The final scores were developed by averaging the weighted scores to account for the different assumptions and interpretations, and then rounded to the nearest 0.5. The minimum and maximum scores as well as the number of scores were determined for each BMP/management strategy combination.

6.1.2 Final Scores

The final average scores are recorded in an Excel file provided in appendix E, along with the range and number of scores for each BMP/management strategy combination. This file also contains the original scores and the reasoning or assumptions made on a specific score by the individual who provided the score. The final scores are arranged in a matrix to facilitate their use by jurisdictions during watershed planning. The BMP impact scores were not added or averaged across management strategies, as that would imply that the 29 management strategies and additional goals have equal importance to every municipality and jurisdiction across the watershed. Some communities might be looking at only certain management strategies. Averaging or adding scores across all strategies could lead to the misconception that certain BMPs are being recommended by using strategies of no concern to them.

Because the average weighted BMP scoring was used, the final score for each BMP should be considered relative to the scores for other BMPs being evaluated against the same management strategy and not necessarily against the original scoring guidelines. The final users of the data might not have the same in-depth knowledge of BMP functionality or management strategy goals and limiting factors as the original scorers, so the relative scoring between BMPs is likely to be sufficiently informative in local prioritization efforts. When looking at scores, a user can accept that a BMP with a score of 4 is better than a BMP with a score of 2, but should not interpret it to be twice as effective as the BMP with a score of 2; simply that it is *more* effective.

6.2 Considerations for Applying Scores to Specific BMP Implementation

6.2.1 Aggregating Scores

As discussed in section 1, the matrix generated by this project is designed to assign each BMP an impact score for each management strategy or additional goal. Scores were assigned using available information and some general assumptions described in section 4 to provide a *general or qualitative* indication of the relative impacts of BMPs on the various management strategies and goals. These scores do not factor in the size or treatment area of any individual BMP and scores should not be considered additive. For example, a swale treating 2 acres should not be interpreted to have a score twice that of a BMP treating 1 acre. Application of a BMP will have varying levels of impact depending on its location and specific design parameters. Thus, the magnitude of the impact will be unique to the specific application. The matrix scores are provided only to indicate the typical relative impacts of BMPs as applied *in general* to assist planners in selecting the suite of BMPs to be included in WIPs. There is insufficient information in the matrix to support aggregation of BMP scores for determining overall impact or to support comparison of various implementation scenarios with different types and numbers of BMPs. Such applications are beyond the scope of this project and are unlikely to be supported by current scientific knowledge or the scoring protocol used in this document.

6.2.2 Comparing Scores across Sectors and Management Strategies

Users of the matrix should be mindful that the scores for each BMP are relative within each source category and each management strategy or goal. Comparing scores across sectors or across management strategies is discouraged. While attempts were made to standardize scoring across all sectors and management strategies and goals, that standardization was not fully achieved. For example, scores for BMPs in the urban sector should not be compared with scores for BMPs in the agriculture sector. Similarly, scores for a specific urban BMP for two different management strategies (e.g., *black duck* and *tree canopy*) should not be compared.

6.2.3 Adjusting Scores Based on BMP Location and Scale

BMP and BMP group effect scores should be considered within the context of the placement and scale of the BMP. For example, a practice handling a relatively small quantity of runoff (e.g., a 10-car parking lot) or influencing environmental conditions over a small geographic area (e.g., a homeowner's rain garden) would not be expected to have the same impacts (positive or negative) as practices handling large runoff volumes (e.g., a large church parking lot) or impacting large geographic areas (e.g., a 200-acre farm under cover crops). Similarly, a forested riparian buffer adjacent to an SAV restoration area would be expected to have a greater impact on SAVs than the same buffer placed 2 miles upstream on a tributary to the bay. Finally, some BMPs have varying levels of performance under different soil and other site-specific conditions. The impact of these BMPs on management strategies and additional goals also can vary based on site-specific conditions. Users should consider this and adjust scores as appropriate.

For some management strategies, location or scale considerations already are factored into the scoring (e.g., the SAV management strategy refers to *directly* affecting SAV habitat and water quality). In other cases, users should consider altering scores to reflect differences in anticipated BMP effects based on the scale and placement of the BMP. Following are a few examples:

- **Drinking Water Protection/Security Management Strategy:** This management strategy is based on a goal of protecting designated drinking water supply sources, so scores apply only if the BMP is located in a designated drinking water supply area. Otherwise, at the site-specific level, the score is 0.
- **Oyster Restoration Management Strategy:** This management strategy is based on a goal of increasing oyster habitat and populations, so scores apply only if the BMP is targeted to oyster restoration tributaries. Otherwise, at the site-specific level, the score is 0.
- **Wetlands Management Strategy:** This management strategy is based on a goal of increasing wetland acres and improving the function of degraded wetlands, so scores apply only if the BMP is in proximity to an existing wetland or will create a wetland. Otherwise, at the site-specific level, the score is 0.

In addition, as suggested by members of the Habitat GIT, in some site-specific instances when evaluating BMP impact on the *stream health* management strategy, a lower score might be warranted because the stressor being alleviated is a low priority or has only a minor impact on the stream. Similar comparisons could be made to BMPs addressing other management strategies, such as *fish passage*.

6.2.4 Adjusting Scores Based on Management Strategy Priorities

Not all management strategies and additional goals are relevant to all parts of the watershed. In some cases, a locality might decide that certain management strategies take priority over others in developing their WIP. What a municipality in Pennsylvania might be interested in is not the same as a town in Maryland, located along the Bay. These communities have different priorities and goals, so they will be interested in difference additional benefits. For example, a community in Virginia could decide that the *blue crab abundance* management strategy is a higher priority for them than other strategies. This can be addressed in two ways. First, the community could decide to focus on BMPs that score highly for only the *blue crab abundance* management strategy and not consider BMP effects on other management strategies that are not a priority for them.

Alternatively, the scoring system can be weighted in favor of a specific management strategy or suite of management strategies. If the Virginia community decides that they want to consider all management strategies, but *blue crab abundance, fish habitat, forage fish, climate adaptation,* and *flood control/mitigation* are the most important, all BMP scores for those strategies can be weighted more strongly. For instance, the magnitude of scores can be increased by 1 for each BMP under the management strategies with the highest priority. In this example, all the BMPs under those strategies with a positive score would be increased by 1, while leaving the scoring for other management strategies unchanged. Similarly, if there are any BMPs that negatively impact the *sustainable fisheries* management strategies, their scores would be reduced by 1, reflecting an increased negative impact on the priority management strategies to discourage their use. For example, under the standard scoring system, the *constructed wetland, gravity dispersal* BMP receives a 1.5, 2, −0.5, 0.5, and −1 for *blue crab abundance*, *fish habitat*, *forage fish*, *climate adaptation*, and *flood control/mitigation*, respectively (Table 4). Under a prioritized scoring system, they would receive scores of 2.5, 3, −1.5, 1.5 and −2, respectively, based on their positive or negative original score. The weighted scoring does not represent a change in the functional impact of a BMP, but instead reflects a change in the relative priority of that BMP. Note that the nonpriority management strategy scores, such as *bacteria loads*, *drinking water protection/security*, and *property values* in Table 4 would not be adjusted under the weighted scoring system for priority management strategies.

Table 4. Priority Management Strategy Score Weighting Example

Constructed Wetland, Gravity Dispersal	Original Score	Priority Adjustment	Priority Score
Blue Crab Abundance	1.5	1	2.5
Fish Habitat	2.0	1	3.0
Forage Fish	-0.5	-1	-1.5
Climate Adaptation	0.5	1	1.5
Flood Control/Mitigation	-1.0	-1	-2.0
Bacteria Loads	3.5	0	3.5
Drinking Water Protection/Security	2.5	0	2.5
Property Values	0.0	0	0.0

6.3 Discussion

As previously stated, different reviewers provided different BMP scores. The narrative impact scoring guidelines were intended to remove the potential for different assumptions and interpretations of the management strategies and additional goals, but were not completely successful in accomplishing that objective. Some groups and individuals applied different interpretations and assumptions to the guidelines, in many cases because of a difference in the level of knowledge and expertise regarding the BMP or the management strategy. While some reviewers might have made reasonable assumptions about BMPs, other more expert reviewers had specific facts to support their scoring. In aggregating the scores, Tetra Tech did not have *a priori* information on how each reviewer came to a scoring decision.

As an example, a septic expert and a wastewater treatment plant expert both evaluated the *connecting septics to wastewater treatment plants* BMP. Each had a different set of assumptions and level of knowledge. The septic expert assumed the impact would be less water for immediate infiltration from septic drain fields and the excess water eventually entering a stream or river system through wastewater treatment plant discharge to surface water, potentially increasing the nutrient load to a stream and decreasing infiltration around the septic system. In addition, there could be secondary effects of the connections through increased sewers or infrastructure and the potential for new areas of growth. That logic led to a negative score for the BMP's impact on the *stream health* management strategy. Conversely, the wastewater treatment expert did not extend the impacts of a septic connection to a treatment plant to that level, but assumed that the BMP would have a positive impact on the water quality in the stream proximate to the septic connection location and assigned a positive score to the *stream health* management strategy. Neither interpretation is necessarily wrong; they simply are based on different assumptions and interpretations. Another example involves the *citizen stewardship* management strategy. In scoring agriculture practices, the "citizen" was interpreted to be someone who did not own the land. For the other sectors, the "citizen" was interpreted as the person who owned the land on which a BMP or practice would be implemented.

The most frequent comment from BMP scorers pertained to BMP locations and the inherent differences in scores due to the potential location of a BMP. Scorers were asked to disregard the location of the BMP during scoring unless location was incorporated into the scoring narrative. A discussion of how to interpret the scoring with regard to BMP location is provided in section 6.2.3.

6.4 Future Steps / Recommendations

After the scoring has been reviewed by the applicable GITs and workgroups, the next step is to make the information available at the local level. The primary objective of selecting BMPs for an implementation strategy should be to reduce nutrients and sediment to meet Chesapeake Bay and other total maximum daily load (TMDL) reduction goals. The matrix of scores, however, can be used to help evaluate secondary considerations and priorities (co-benefits) and perhaps distinguish between BMP choices when the nutrient and sediment efficiencies are equivalent. Ranges have been provided in the matrix of scores (appendix E) to illustrate how the assessment of secondary impacts and co-benefits varied among scorers.

The matrix evaluates a wide range of BMP impacts and can show where mutual benefits can be achieved depending on priorities. Localities should involve a diverse group of stakeholders in creating a BMP implementation strategy. The matrix can be used to aid discussion of stakeholder goals.

Localities can use the scoring matrix in multiple ways:

- To characterize the additional benefits of their BMP strategy beyond nutrient and sediment reductions. They can use the matrix either to select priority BMPs or to identify the additional benefits of a BMP strategy, especially for BMPs that provide similar nutrient and sediment reductions.
- To make decisions about which BMPs to adopt based on management strategy priorities.
- To help sell a restoration plan to local watershed groups and government officials by presenting the additional benefits that can be derived from allocating resources for BMP implementation to reduce nutrient and sediment loads.

Because the scores are generalized and not based on site-specific characteristics, it will be important to convey to local users the ability to refine the scoring system to address their local conditions. The following points should be included with any distribution of the matrix:

- Some BMPs might not be relevant to the user's predominant land uses and should be excluded from consideration. Similarly, some management strategies might not be relevant to some communities.
- The communities might want to weight the scores or management strategies to more accurately reflect their local circumstances and priorities. Users should understand that this is an option and that they can include site-specific details about BMPs in the scoring to allow for a more customizable matrix.
- It is important to minimize unintended consequences of the matrix. It is possible that the scoring system will be taken as a final recommendation of the *best*, or recommended, BMPs. That is not the intent of the matrix. Users should not be overly reliant on the results of the scoring in determining their BMP funding priorities. Because local conditions vary throughout the Chesapeake Bay watershed, no single BMP is the one overall best practice that fits all circumstances. For example, some BMPs are more suited to one land use or soil type than to another. This matrix does not provide that type of information.

The BMP scores will be incorporated into CAST, but the method and timing for that effort have not yet been determined. It is recommended that this report and any associated documentation be made available on the CAST documentation pages to ensure that users understand how to use the information. Incorporating the data into CAST will make available one-stop shopping for localities evaluating nutrient and sediment reductions, cost, and the additional benefits or impacts of BMPs as they are building or evaluating potential implementation strategies. Sufficient documentation, especially on the above points, on how to use the matrix to take local conditions into account, and on the limitations of the matrix, should be included with any public distribution of the matrix.

As new BMPs are approved or existing BMPs are altered, their impact on management strategies and additional goals should be determined using the procedure specified in this document (i.e., impact scoring guidelines). Secondary impacts of BMPs already are being considered by Expert Panels, but the procedure used for this document has not been considered by those groups. It could, however, be added to an Expert Panel charge in the future.

If municipalities wish to review additional tools and documents on co-benefits, the following additional resources are available:

- The Center for Neighborhood Technology prepared a report on the value of green infrastructure. This document reviews urban green infrastructure BMPs in relation to their economic, social, and environmental benefits. The report is available on their website at http://www.cnt.org/sites/default/files/publications/CNT_Value-of-Green-Infrastructure.pdf.

- The U.S. Department of Agriculture Forest Service developed i-Tree, which provides a method to conduct urban and rural forestry analysis and benefits assessment. The tool is available at https://www.itreetools.org/.
- The InVEST (integrated valuation of ecosystem services and tradeoffs) model developed by the Natural Capital Project is a more complex tool that looks at ecosystems services such as carbon storage, pollinator abundance, water yield, and nutrient/sediment retention. Documentation and additional information are available on their website at http://www.naturalcapitalproject.org/invest/.

7 References

CBP (Chesapeake Bay Program). 2014. Chesapeake Bay Watershed Agreement. Annapolis, MD. http://www.chesapeakebay.net/documents/FINAL_Ches_Bay_Watershed_Agreement.withsignatures-HIres.pdf.

Appendix A: Descriptions of Additional Goals

Air Quality

Air quality is the degree to which the ambient air is pollution-free, assessed by measuring a number of indicators of pollution.

Goal

Protect or enhance local air quality.

Factors Influencing Success

- Available information on air quality impacts of BMPs will affect both the selection and expected air quality effects. Planning for air quality improvements will require reliable information on BMP performance.
- The Chesapeake Bay airshed is significantly larger than its watershed, with air pollution coming from as far away as Cincinnati, Ohio. Impacts of local BMPs can be shrouded by this contribution.
- Many sources of air pollution will not be addressed by nutrient and sediment BMPs, so the potential overall impact of these BMPs on air quality may be severely limited.

Bacteria Loads

The load of bacteria that passes a particular point of a river (such as a monitoring station on a watershed outlet) in a specified amount of time (e.g., daily, annually). Mathematically, load is essentially the product of water discharge and the concentration of a substance in the water. Implementation of BMPs to meet TMDL requirements will also reduce bacteria loads to local waterbodies. In some cases, additional BMPs directed at bacteria will be implemented alongside nutrient and sediment practices. Some practices may have unintended consequence of increasing bacteria loads, such as riparian buffers increasing wildlife presence in stream corridors.

Goal

Implement BMPs that will reduce bacteria loads to local waterbodies while at the same time reducing nutrient and sediment loads.

Factors Influencing Success

- Available information on bacteria reductions achievable with BMPs will affect both the selection and expected bacteria load reductions. Planning for bacteria load reductions will require reliable information on BMP performance.
- Unmanaged or unmanageable sources of bacteria such as waterfowl can contribute significant bacteria loads. These sources may be increased in some cases because of BMP implementation.
- Bacteria pathways are complicated by the potential for regeneration of bacteria from “seed” bacteria down-gradient from BMPs. In addition, in-stream sources of bacteria can shroud impacts of land-based BMPs.

Biodiversity and Habitat

Diversity is the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems. Habitat is the natural home or environment of an animal, plant, or other organism.

Goal

Protect or enhance upland wildlife habitat to enhance or preserve biodiversity. Habitat goals and outcomes for wetlands, black ducks, brook trout, fish passage, SAV, riparian forest, and tree canopy are already addressed under established management strategies.

Factors Influencing Success

- Both the quantity and quality of habitat will need to be adequate to achieve the goal.
- The ability to stitch together sufficient stretches of habitat will affect the overall impact on wildlife. Isolated areas may have significantly less beneficial impact.
- The connectivity of different habitats will affect the overall biodiversity and habitat benefits of practices.
- The presence of nonnative plants (e.g., ornamental trees) and animals, as well as expansive areas of turf, will have an adverse effect on biodiversity.
- Crop prices will influence willingness to install and maintain practices that take land out of production. Property values and development pressures will limit opportunities in urban areas and areas adjacent to urban areas.

Drinking Water Protection/Security

Drinking water protection involves a range of steps including delineation and assessment of source waters; assessment of potential contaminant sources; implementation of management measures to prevent, reduce, or eliminate risks to the drinking water supply; and plans to address emergencies.

Goal

Implement BMPs that protect designated drinking water supply sources, both surface and groundwater sources, in areas with state approved source water protection plans.

Factors Influencing Success

- Location of BMPs relative to the drinking water supply and drainage area will impact the selection and effects of the BMPs.
- The degree to which drinking water protection resonates among landowners will impact their willingness to install and maintain protective practices.
- Geological conditions and land uses in the drinking water supply watershed will have a large impact on the potential for BMPs to achieve local goals source protection.

Economic Development/Job Creation

Economic development refers to efforts that seek to improve the economic well-being and quality of life for a community by creating and/or retaining jobs and supporting or growing incomes and the tax base. Economic development includes activities that stabilize local economies, create long-term employment, contribute to the health of the natural environment, build on local resources and capacity, and increase community control and ownership. A job is a paid position of regular employment or a task or piece of work, especially one that is paid.

Goal

Generate new jobs and stimulate local economy through practice implementation, operation and maintenance, or other means.

Factors Influencing Success

- Adequate training to support job growth may not be available.
- BMP prioritization and selection at the site level will have an impact on capital and maintenance costs, as well as indirect costs due to any associated changes that may be required at the site to accommodate implementation of the BMPs. For example, changes in farm management to adapt to implementation of a new animal waste management system could result in changes in job opportunities. The extent and frequency of street sweeping will also have an impact on overall costs and job opportunities.
- The current availability of local businesses, labor and supplies will impact the degree of success. High unemployment rates may result in abundant, low-cost labor, whereas low unemployment rates may restrict available labor. The mechanisms through which BMPs are paid for, implemented, and maintained may also have a direct impact on costs and job opportunities.
- The type of BMPs to be implemented will depend on land uses and the current level of BMP implementation at the sites. The degree of automation versus manual labor required both before and after the BMPs are implemented will affect job opportunities.

Energy Efficiency

Energy efficiency is the act of providing the same service while reducing energy consumption through altered processes or conditions. Part of these processes could include the act of generating energy or reducing the cooling needs in urban heat islands.

Goal

Reduce energy consumption or generate energy. Implementation of BMPs will have a neutral or net positive impact on energy efficiency in areas where they are implemented.

Factors Influencing Success

- Many BMPs require maintenance. BMP maintenance requires site visits and thus energy consumption. For example, grass swales require mowing and certain septic technologies require electric pumps to operate. Other practices could remove the need for mowing or other energy consumption.
- Certain practices can help mitigate the *heat island* effect in urban areas. For example, impervious cover reduction can reduce the amount of asphalt that absorbs the sun’s energy.

- Urban tree canopy can create shade, and thus reduce the amount of energy needed to cool buildings during the summer months.
- The number and type of passes required for tillage, nutrient management, and pesticide management operations will affect energy consumption. For example, deep tillage is more energy intensive than disking operations. Equipment choices for harvesting also affect energy consumption.
- Commercial and organic fertilizers have different energy footprints, an important factor in determining the overall energy efficiency of alternative combinations of nutrient sources. Methane generation at animal operations may also improve overall farm energy efficiency.
- The type and use patterns of irrigation systems (e.g., center pivot vs. furrow) can affect energy consumption. The design and management of bird houses can have significant impacts on energy consumption (e.g., ventilation). Manure and litter hauling strategies and distances can also affect energy consumption on a larger geographic scale.
- The availability of shade trees and structures can affect agriculture animal health and the need to consume energy for cooling mechanisms or herd management.

Flood Control/Mitigation

Flood control refers to all methods used to reduce or prevent the detrimental effects of floodwaters. Flood mitigation involves the management and control of flood water movement, such as redirecting flood runoff through the use of floodwalls and flood gates, rather than trying to prevent floods altogether.

Goal

Improve flood control and mitigation to protect properties while also maintaining natural cycles to the extent needed to protect water quality and biological communities.

Factors Influencing Success

- Location and types of BMP opportunities will have an impact on success. For example, upland BMPs may have a greater impact in an urban setting than in an agricultural setting due to differing runoff coefficients and pathways.
- Soils, topography, and land cover will impact both the selection and performance of BMPs on the landscape scale. The type and coverage of BMPs (e.g., farm system vs. stand-alone urban practices) will affect the potential for BMPs to have an impact on flood control and mitigation.
- Practice design standards and specifications, if not updated to accommodate climate change, will also affect the potential for BMPs to be effective.
- The municipality has a Hazard Mitigation Plan that includes specific flood control/mitigation practices, such as green infrastructure or living shorelines. Additional elements of the Plan could include policy or building staff capacity. Specific actions could include: Drainage system maintenance, floodplain protection, watershed management, riparian buffers, wetland preservation/restoration, slope stabilization, channel modification, storm sewers.

Groundwater Recharge/Infiltration

Groundwater recharge or deep drainage or deep percolation is a hydrologic process where water moves downward from surface water to groundwater. Recharge is the primary method through which water enters an aquifer. Infiltration is the process by which water on the ground surface enters the soil.

Goal

Maintain groundwater recharge rates at levels sufficient to sustain aquifer water levels. Implementation of BMPs will have a neutral or net positive impact on groundwater recharge rates where they are implemented.

Factors Influencing Success

- Geological conditions (e.g., soils) will have a large impact on current recharge rates and the potential for BMPs to achieve local goals for infiltration/recharge.
- Pumping rates for various uses of groundwater (e.g., drinking water, irrigation) have the potential to overwhelm any impact due to BMP implementation. Droughts can cause major changes in aquifer levels. Urbanization can drive up water demand for groundwater use.
- The presence of irrigation systems will impact options on farmland.
- Availability of land for recharge areas will impact BMP options in urban settings.
- Climate change could have an effect through reduced precipitation to an area and other factors.

Property Values

Property value is an estimate of what a home or a piece of land is actually worth.

Goal

Preserve or enhance property values through enhanced water quality and related benefits associated with BMP implementation.

Factors Influencing Success

- The incremental impact of BMPs on property values might not be measurable. Properties adjacent to those receiving BMPs might have a greater impact on property value than the BMPs.
- Site conditions may limit the set of BMPs available, thereby impacting the potential for selecting BMPs that will reduce nutrient and sediment loads while also protecting property values. For example, land availability can limit the choices for runoff retention in urban settings (e.g., a wet pond or wetland could not be installed in an ultra-urban setting.) BMPs that require significant operations/maintenance costs could negatively affect property values.

Recreation

Recreation can take many forms including swimming, wading, fishing, boating. picnics, wildlife viewing, hiking, birdwatching.

Goal

Increase recreational value of land and waters within the watershed.

Factors Influencing Success

- BMP's ability to reduce nutrients that might cause algal blooms and reduce sediment deposition that in turn affects benthic organisms and the fish that consume them.
- Accessibility for disabled, aging, and lower-income residents is also important, and BMPs on public properties can have an impact on this factor (e.g., wetland treatment systems in urban areas could provide birding opportunities).
- Partnerships, volunteerism, and public outreach can also be essential to the maintenance and preservation of recreational opportunities, but BMPs might have no impact on these factors.
- Land acquisition is often important to enhance park facilities and services; BMPs involving land use change or retirement (e.g., forest buffers) may be helpful in this regard when implemented on lands adjacent to parklands.

Appendix B: List of BMPs and Groupings

Agriculture

Chesapeake Bay Model BMP Type
Ag Shoreline Management (incl. Nonvegetated and Vegetated)
Agricultural Ditch BMPs
Agricultural Stormwater Structures / Nursery and Greenhouse Runoff Capture and Reuse
Alternative Crops and Alternative Crop/Switchgrass (RI)
Alternative Water System (Off Stream Watering Without Fencing)
Amendments for the Treatment of Agricultural Waste
Animal Compost Structure RI (Resource Improvement)
Animal Mortality Facility (Mortality Composters)
Animal Waste Management Systems (All Types-not including lagoon covers or end use)
Annual Legume, Annual Legume and Grass, Annual Ryegrass, Cover Crop Barley, Cover Crop Forage Radish, Cover Crop Forage Radish and Grass, Cover Crop Oats, Cover Crop Rye, Cover Crop Triticale, Cover Crop Wheat, Cover Crop Winter Hardy Brassica (ALL) - No additions for Phase 6
Barnyard Clean Water Diversion (RI [Resource Improvement])
Barnyard Runoff Controls
Biofilters
Commodity Cover Crop Barley, Rye, Wheat (ALL); No additions for Phase 6
Conservation Tillage (incl. from MAST: conservation till without nutrients, additional acres, and total acres)
Continuous High Residue Till
Conversion to Hayland (RI)
Conversion to Pasture (RI)
Cropland Irrigation Management
Dairy Precision Feeding and/or Forage Management
Dirt & Gravel Road E&SC-Driving Surface Aggregate + Raising the Roadbed
Dirt & Gravel Road E&SC-Outlets Only
Dirt & Gravel Road E&SC-with Outlets
Dry Waste Storage Structure (RI)
Forest Buffers
Grass Buffer on Watercourse (RI)
Grass Buffers
Grass Nutrient Exclusion Area on Watercourse (RI)
Heavy Use Poultry Area Concrete Pads
Horse Pasture Management
Irrigation Water Capture Reuse
Lagoon Covers
Land Retirement to Hay without nutrients (HEL)
Land Retirement to Pasture (HEL)
Loafing Lot Management
Manure Injection/Manure Incorporation
Manure Technology: Chemical Treatments (Dry and Wet Manure)
Manure Technology: Composting

Chesapeake Bay Model BMP Type
Manure Technology: Microbial Digestion (anaerobic digester)
Manure Technology: Solid-Liquid Separation
Manure Technology: Thermal (or Thermochemical) Treatment
Manure Transport (ALL Animal Types and all manure forms)
Narrow Forest Buffer
Narrow Grass Buffer
Phase 5.3.2 Nutrient Management Tier 2 N
Phase 5.3.2 Nutrient Management Tier 2 N and P
Phase 5.3.2 Nutrient Management Tier 2 P
Phase 5.3.2 Nutrient Management Tier 3 N
Phase 6 Conservation Tillage
Phase 6 High Residue Tillage
Phase 6 Nutrient Management-N Core
Phase 6 Nutrient Management-N Supplemental
Phase 6 Nutrient Management-P Core
Phase 6 Nutrient Management-P Supplemental
Poultry Litter Treatment (e.g., alum)
Poultry Phytase
Precision Intensive Rotational/Prescribed Grazing
Rotational Grazing (RI)
Sorbing Materials in Ag Ditches
Stream Access Control with Fencing
Stream Restoration Ag
Streamside Forest Buffers
Streamside Grass Buffers
Swine Phytase
Tree Planting
Vegetative Environmental Buffer for Poultry-Grass (RI)
Vegetative Environmental Buffer for Poultry-Trees (RI)
Water Control Structure (ALL including RI)
Watercourse Access Control - Narrow Grass and Grass (RI)
Watercourse Access Control - Narrow Trees and Trees (RI)
Wetland Restoration and Streamside Wetland Restoration

Forestry

Sector	Chesapeake Bay Model BMP Type	Scoring Group
Forestry	Dirt & Gravel Road Erosion & Sediment Control - Driving Surface Aggregate + Raising the Roadbed	Dirt/Gravel Roads
Forestry	Dirt & Gravel Road Erosion & Sediment Control - Outlets only	
Forestry	Dirt & Gravel Road Erosion & Sediment Control - with Outlets	
Forestry	Forest Harvesting Practices	Forest Harvesting Practices
Forestry	Shoreline Management	Shoreline Management

Sector	Chesapeake Bay Model BMP Type	Scoring Group
Forestry	Stream Restoration	Stream Restoration
Agriculture	Forest Buffers	Forest Buffers
Agriculture	Narrow Forest Buffer	
Agriculture	Streamside Forest Buffers	
Urban	Forest Buffers	
Urban	Forest Conservation	Forest Conservation
Agriculture	Tree Planting	Tree Planting
Urban	Tree Planting	

On-site Wastewater Systems

Chesapeake Bay Model BMP Type	Scoring Group
Constructed Wetland Septic	Constructed Wetland, Gravity Dispersal
Constructed Wetland Elevated Mound	Constructed Wetland, Pumped Dispersal
Constructed Wetland Shallow Pressure	
IFAS	IFAS, Gravity Dispersal
IFAS Elevated Mound	IFAS, Pump Dispersal
IFAS Shallow Pressure	
IMF	Intermittent Media Filter, Gravity Dispersal
IMF Elevated Mound	Intermittent Media Filter, Pump Dispersal
IMF Shallow Pressure	
Septic Effluent Elevated Mound	Pumped Dispersal
Septic Effluent Shallow Pressure	
RMF	Recirculating Media Filter, Gravity Dispersal
RMF Elevated Mound	Recirculating Media Filter, Pump Dispersal
RMF Shallow Pressure	
Septic Connections	Septic Connections
Septic Tank Pumpout	Septic Tank Pumpout
NSF 40	Unspecified Advanced Treatment
NSF 40 Elevated Mound	
NSF 40 Shallow Pressure	
Proprietary Ex Situ Elevated Mound	
Proprietary Ex Situ	
Proprietary Ex Situ Shallow Pressure	
Septic Denitrification	
Septic Tank Advanced Treatment	

Urban

Chesapeake Bay Model BMP Type	Scoring Group
Abandoned Mine Reclamation	Abandoned Mine Reclamation
Advanced Grey Infrastructure Nutrient Discovery Program	Advanced Grey Infrastructure Nutrient Discovery Program
Bioretention/raingardens - A/B soils, no underdrain	Bioretention
Bioretention/raingardens - A/B soils, underdrain	
Bioretention/raingardens - C/D soils, underdrain	
Bioswale	

Chesapeake Bay Model BMP Type	Scoring Group
Dirt & Gravel Road Erosion & Sediment Control - Driving Surface Aggregate + Raising the Roadbed	
Dirt & Gravel Road Erosion & Sediment Control - Outlets only	
Dirt & Gravel Road Erosion & Sediment Control - with Outlets	Dirt/Gravel Roads
Dry Detention Ponds and Hydrodynamic Structures	
Dry Extended Detention Ponds	Dry Ponds
Erosion and Sediment Control Level 1	
Erosion and Sediment Control Level 2	
Erosion and Sediment Control Level 3	
Erosion and Sediment Control on Extractive	Erosion and Sediment
Filter Strip Runoff Reduction	
Filter Strip Stormwater Treatment	Runoff Reduction
Filtering Practices	Filtering Practices
Forest Buffers	Forest Buffers
Forest Conservation	Forest Conservation
Grass Buffers	Grass Buffers
Impervious Surface Reduction	Impervious Surface Reduction
Infiltration Practices w/ Sand, Veg. - A/B soils, no underdrain	
Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain	Infiltration Practices
MS4 Permit-Required Stormwater Retrofit	N/A - Could include multiple practices
Nutrient Management Maryland Commercial Applicators	
Nutrient Management Maryland DIY	
Nutrient Management Plan	
Nutrient Management Plan High Risk Lawn	
Nutrient Management Plan Low Risk Lawn	Nutrient Management Plan
Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain	
Permeable Pavement w/ Sand, Veg. - A/B soils, underdrain	
Permeable Pavement w/ Sand, Veg. - C/D soils, underdrain	
Permeable Pavement w/o Sand, Veg. - A/B soils, no underdrain	
Permeable Pavement w/o Sand, Veg. - A/B soils, underdrain	
Permeable Pavement w/o Sand, Veg. - C/D soils, underdrain	Permeable Pavement
Shoreline Management	Shoreline Management
Stormwater Management by Era 1985 to 2002 MD	
Stormwater Management by Era 2002 to 2010 MD	
Stormwater Performance Standard-Runoff Reduction	
Stormwater Performance Standard-Stormwater Treatment	N/A - Could include multiple practices
Stream Restoration	Stream Restoration
Street Sweeping 25 times a year-acres	
Street Sweeping 25 times a year-lbs	
Street Sweeping Pounds	Street Sweeping
Tree Planting	Tree Planting

Chesapeake Bay Model BMP Type	Scoring Group
Urban Growth Reduction	Urban Growth Reduction
Vegetated Open Channels - A/B soils, no underdrain	Infiltration Practices
Vegetated Open Channels - C/D soils, no underdrain	
Wet Ponds and Wetlands	Wet Ponds
Wet Ponds and Wetlands	Wetlands

Appendix C: Narrative Scoring Guidelines

Mgmt Strat. / Add. Goals	5: Substantial Improvement	4: Moderate-to-Substantial Improvement	3: Moderate Improvement	2: Slight-to-Moderate Improvement	1: Slight Improvement	0: No Effect	-1: Slight Worsening	-2: Slight-to-Moderate Worsening	-3: Moderate Worsening	-4: Moderate-to-Substantial Worsening	-5: Substantial Worsening
Air Quality	Practice continuously improves the air1 quality in the surrounding area by either removing pollutants (e.g., ammonia, odors, or particulates) or preventing them from becoming airborne.	Somewhere between 3 and 5 → BPJ	Practice continuously improves the air quality at the site by either removing pollutants or preventing them from becoming airborne.	Somewhere between 1 and 3 → BPJ	Practice slightly improves the air quality at the site during limited periods (e.g., maintenance) by either removing pollutants or preventing them from becoming airborne.	Practice has no impact on Air Quality.	Practice slightly decreases the local air quality at the site during limited periods (e.g., maintenance).	Somewhere between -1 and -3 → BPJ	Practice continuously decreases the local air quality at the site.	Somewhere between -3 and -5 → BPJ	Practice consistently decreases the local air quality in the surrounding area.
Bacteria Loads	Practice results in greater than 90 percent decrease of the bacteria load in BMP effluent, in site runoff, or to a waterbody, or excludes livestock from waterbodies.	Somewhere between 3 and 5 → BPJ	Practice results in between 30–90 percent decrease of the bacteria load in BMP effluent, in site runoff, or to a waterbody, or limits livestock access to waterbodies.	Somewhere between 1 and 3 → BPJ	Practice results in less than 30 percent decrease of the bacteria load in BMP effluent, in site runoff, or to a waterbody, or provides alternative water supply or riparian buffer with no fencing to reduce livestock access to waterbodies.	Practice has no impact on bacteria loads	Practice results in less than 30 percent increase of the bacteria load in BMP effluent, in site runoff, or to a waterbody, or increases livestock access to riparian zone without direct access to waterbodies.	Somewhere between -1 and -3 → BPJ	Practice results in 30–90 percent increase of the bacteria load in BMP effluent, in site runoff, or to a waterbody, or provides additional limited livestock access to waterbodies.	Somewhere between -3 and -5 → BPJ	Practice results in greater than 90 percent increase of the bacteria load in BMP effluent, in site runoff, or to a waterbody, or provides unlimited livestock access to waterbodies.
Biodiversity and Habitat	Practice creates (or restores) a permanent area that allows for a diverse selection of beneficial native plants, which provide food and habitat for pollinators and other species.	Somewhere between 3 and 5 → BPJ	Practice improves the quality of a permanent area of land that allows for a diverse selection of beneficial native plants, which provide food and habitat for pollinators and other species.	Somewhere between 1 and 3 → BPJ	Practice improves the quality of small, isolated areas of land that allows for a diverse selection of beneficial native plants, which provide food and habitat for pollinators and other species. May also apply to areas of habitat improvement that are not necessarily permanent.	Practice has no impact on Biodiversity and Habitat.	Practice degrades low quality areas of viable habitat, thus reducing the overall biodiversity of the area	Somewhere between -1 and -3 → BPJ	Practice permanently degrades an area of viable habitat, thus reducing the overall biodiversity of that area.	Somewhere between -3 and -5 → BPJ	Practice permanently removes areas of viable habitat, thus reducing the overall biodiversity of an area and potentially surrounding areas.

Mgmt Strat. / Add. Goals	5: Substantial Improvement	4: Moderate-to-Substantial Improvement	3: Moderate Improvement	2: Slight-to-Moderate Improvement	1: Slight Improvement	0: No Effect	-1: Slight Worsening	-2: Slight-to-Moderate Worsening	-3: Moderate Worsening	-4: Moderate-to-Substantial Worsening	-5: Substantial Worsening
Black Duck	Practice directly creates, enhances, or restores wetland habitats or increases or enhances connectivity of breeding, foraging, migrating, and wintering habitats (upland areas; lowland salt marshes; nontidal marshes; fresh/brackish emergent, forested, or scrub/shrub wetlands; mudflats; SAV; large bodies of open water) for black ducks.	Somewhere between 3 and 5 → BPJ	Practice protects against (e.g., conservation easements, buffers) or reverses shoreline disturbance (e.g., dredging, marina/housing development) adjacent to wetlands, or increases cover or food sources in areas adjacent to wetlands.	Somewhere between 1 and 3 → BPJ	Practice restores, enhances, or preserves native species in or near wetlands or other black duck habitat types, or reduces impacts of climate change (e.g., large storm events, flooding, sea level rise, salinity changes).	Practice has no impact on wetlands	Practice reduces native species in or near wetlands or other black duck habitat types, or increases impacts of climate change (e.g., large storm events, flooding, sea level rise, salinity changes).	Somewhere between -1 and -3 → BPJ	Practice increases shoreline disturbance (e.g., dredging, marina/housing development) adjacent to wetlands, or decreases cover or food sources in areas adjacent to wetlands.	Somewhere between -3 and -5 → BPJ	Practice directly removes wetlands or increases black duck habitat fragmentation.
Blue Crab Abundance	Practice directly improves SAV or other nearshore habitat or water quality conditions in localized area to the benefit of blue crab abundance	Somewhere between 3 and 5 → BPJ	Practice decreases nutrient loads from tributaries	Somewhere between 1 and 3 → BPJ	Practice decreases thermal load from tributaries and/or contributes to optimal water quality contributions from tributaries	Practice has no impact on blue crab abundance	Practice increases thermal load from tributaries and/or contributes to undesirable water quality contributions from tributaries	Somewhere between -1 and -3 → BPJ	Practice increases nutrient loads from tributaries	Somewhere between -3 and -5 → BPJ	Practice directly worsens SAV or other nearshore habitat or water quality conditions in localized area to the detriment of blue crab abundance
Brook Trout	Practice creates riparian shade where there was none previously, removes a high temperature direct discharge source or removes invasive/nonnative species that directly impacts native brook trout.	Somewhere between 3 and 5 → BPJ	Practice improves riparian shade conditions, decreases a high temperature direct discharge source or improves access to spawning or seasonally important habitat.	Somewhere between 1 and 3 → BPJ	Practice reduces impervious surface or increases other nonriparian practices to reduce runoff temperature/quantity or improve runoff quality.	Practice has no impact on brook trout.	Practice increases impervious surface or otherwise increases runoff temperature/quantity or degrades runoff quality.	Somewhere between -1 and -3 → BPJ	Practice decreases riparian shade conditions, increases a high temperature direct discharge source or creates a barrier to spawning or seasonally important habitat.	Somewhere between -3 and -5 → BPJ	Practice removes riparian shade, introduces a high temperature direct discharge source or introduces invasive/nonnative species that directly impact native brook trout.
Citizen Stewardship	Practice and required O&M is fully implementable by citizens [Citizens do not include government agencies, nonprofit organizations, or professionals (business or individual)] without assistance (technical or financial).	Somewhere between 3 and 5 → BPJ	Practice is fully implementable by citizens [Citizens do not include government agencies, nonprofit organizations, or professionals (business or individual)], but O&M requires assistance (technical or financial).	Somewhere between 1 and 3 → BPJ	Practice can be implemented by citizens [Citizens do not include government agencies, nonprofit organizations, or professionals (business or individual)] with assistance (technical or financial) from local governments or organizations.	Practice has no impact on citizen stewardship or not applicable to citizen stewardship.					

Mgmt Strat. / Add. Goals	5: Substantial Improvement	4: Moderate-to-Substantial Improvement	3: Moderate Improvement	2: Slight-to-Moderate Improvement	1: Slight Improvement	0: No Effect	-1: Slight Worsening	-2: Slight-to-Moderate Worsening	-3: Moderate Worsening	-4: Moderate-to-Substantial Worsening	-5: Substantial Worsening
Climate Adaptation	Practice directly increases the protection of living resources and habitats from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea level rise.	Somewhere between 3 and 5 → BPJ	Practice directly increases the protection of public infrastructure and communities from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea level rise.	Somewhere between 1 and 3 → BPJ	Practice indirectly increases the protection of living resources, habitats, public infrastructure, or communities from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea level rise.	Practice has no impact on climate adaptation.	Practice indirectly decreases the protection of living resources, habitats, public infrastructure, or communities from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea level rise.	Somewhere between -1 and -3 → BPJ	Practice directly decreases the protection of public infrastructure and communities from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea level rise.	Somewhere between -3 and -5 → BPJ	Practice directly decreases the protection of living resources and habitats from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea level rise.
Drinking Water Protection/ Security	Practice eliminates toxic contaminants from entering drinking water supplies.	Somewhere between 3 and 5 → BPJ	Practice eliminates traditional pollutants (e.g., nutrients, metals, sediment) from entering drinking water supplies.	Somewhere between 1 and 3 → BPJ	Practice reduces traditional pollutants (e.g., nutrients, metals, sediment) from entering drinking water supplies.	Practice has no impact on Drinking Water Protection/ Security.	Practice introduces small amounts of traditional pollutants into drinking water supplies.	Somewhere between -1 and -3 → BPJ	Practice introduces large amounts of traditional pollutants into drinking water supplies.	Somewhere between -3 and -5 → BPJ	Practice introduces toxic contaminants into drinking water supplies.
Economic Development/ Job Creation	Practice gives rise to a new business to aid in practice implementation/maintenance or creates full-time permanent staff positions. OR Practice stimulates local economy.	Somewhere between 3 and 5 → BPJ	Practice increases demand for existing businesses that support practice implementation/maintenance OR creates a new part-time permanent staff positions.	Somewhere between 1 and 3 → BPJ	Practice creates temporary jobs for practice installation/implementation or O&M.	Practice has no impact on Economic Development/ Job Creation.	Practice removes the need for temporary jobs for practice installation/ implementation or O&M.	Somewhere between -1 and -3 → BPJ	Practice decreases demand for existing businesses that support practice implementation/maintenance OR removes a new part-time permanent staff positions.	Somewhere between -3 and -5 → BPJ	Practice causes closing of a new business or removes a full-time permanent staff positions. OR Practice inhibits local economy.
Energy Efficiency	Practice creates natural shade from newly planted trees (e.g., tree planting) in a developed area creating shade to reduce energy needed for cooling. OR creates a positive net production of energy over its design lifetime (implementation and post-implementation); energy is captured and used.	Somewhere between 3 and 5 → BPJ	Practice actively enhances natural shade from existing trees in a developed area increasing shade to reduce energy needed for cooling. OR increases productivity (e.g., crop yield) with no net increase in energy consumption versus baseline (i.e., previous surface or no practice) over its design lifetime (implementation and post-implementation). OR Practice eliminates existing need for energy spent on O&M.	Somewhere between 1 and 3 → BPJ	Practice passively protects or preserves natural shade from existing trees in a developed area to prevent increase in energy needed for cooling. OR Practice reduces existing need for energy spent on O&M.	Practice has no impact on energy efficiency.	Practice has potential to harm existing trees in a developed area which increases energy needed for cooling. OR Practice increasing existing need for energy spent on O&M.	Somewhere between -1 and -3 → BPJ	Practice harms trees providing natural shade. OR decreases productivity (e.g., crop yield) with no net increase in energy consumption versus baseline (i.e., previous surface or no practice) over its design lifetime. OR Practice creates need for energy spent on O&M.	Somewhere between -3 and -5 → BPJ	Practice reduces natural shade by removing trees. OR either increases energy consumption or reduces energy efficiency versus baseline over its design lifetime (e.g., pumped dispersals for septic systems).

Mgmt Strat. / Add. Goals	5: Substantial Improvement	4: Moderate-to-Substantial Improvement	3: Moderate Improvement	2: Slight-to-Moderate Improvement	1: Slight Improvement	0: No Effect	-1: Slight Worsening	-2: Slight-to-Moderate Worsening	-3: Moderate Worsening	-4: Moderate-to-Substantial Worsening	-5: Substantial Worsening
Fish Habitat	Practice creates riparian shade, wetlands or SAV where there was none previously; removes a high temperature direct discharge source; or removes hardened shoreline.	Somewhere between 3 and 5 → BPJ	Practice improves riparian shade conditions, wetlands or SAV; decreases a high temperature direct discharge source or otherwise directly improves stream water quality (e.g., DO, nutrients, turbidity); or directly prevents sea level rise.	Somewhere between 1 and 3 → BPJ	Practice reduces impervious surface or increases other nonriparian practices to reduce runoff temperature/quantity or improve runoff quality.	Practice has no impact on fish habitat.	Practice increases impervious surface or otherwise increases runoff temperature/quantity or degrades runoff quality.	Somewhere between -1 and -3 → BPJ	Practice decreases riparian shade, wetlands or SAV; increases a high temperature direct discharge source or otherwise directly worsens stream water quality (e.g., DO, nutrients, turbidity); or directly contributes to sea level rise.	Somewhere between -3 and -5 → BPJ	Practice removes riparian shade, wetlands or SAV; introduces a high temperature direct discharge source; or creates a hardened shoreline.
Fish Passage	Practice directly removes barriers, retrofits culverts, or installs passage structures	Somewhere between 3 and 5 → BPJ	Practice improves fish habitat for target fish species (e.g., Alewife, Brook Trout)	Somewhere between 1 and 3 → BPJ	Practice reduces the need for privately owned dams (e.g., reduces flooding probability, increases water supply or use efficiency)	Practice has no impact on fish passage	Practice increases the need for privately owned dams (e.g., increases flooding probability, decreases water supply or use efficiency)	Somewhere between -1 and -3 → BPJ	Practice worsens fish habitat for target fish species (e.g., Alewife, Brook Trout)	Somewhere between -3 and -5 → BPJ	Practice directly creates barriers or hinders fish passage
Flood Control/ Mitigation	Practice prevents runoff to streams. OR improves stormwater drainage or channel condition to prevent flooding.	Somewhere between 3 and 5 → BPJ	Practice increases the floodplain, delays peak flow, and/or reduces flashiness. OR replaces flood prone impervious areas with pervious cover.	Somewhere between 1 and 3 → BPJ	Practice slightly reduces runoff to streams.	Practice has no impact on Flood Control/ Mitigation	Practice slightly increases runoff to streams.	Somewhere between -1 and -3 → BPJ	Practice reduces the floodplain, expedites peak flow, and/or increases flashiness. OR replaces flood prone pervious areas with impervious cover.	Somewhere between -3 and -5 → BPJ	Practice diverts all runoff to streams. OR degrades stormwater drainage or channel condition to prevent flooding.
Forage Fish	Practice directly improves fish habitat quality or amount (including through removal of shoreline modifications, protection/establishment of SAV, or directly improving the production of benthic organisms or the distribution and productivity of plankton) or improves access to upriver spawning areas.	Somewhere between 3 and 5 → BPJ	Practice directly improves water quality (e.g., removes or reduces direct discharges, in-stream sources, etc.) or protects shorelines.	Somewhere between 1 and 3 → BPJ	Practice improves water quality through watershed BMPs, reducing impervious surfaces, etc.	Practice has no impact on forage fish.	Practice worsens water quality through watershed land use and development.	Somewhere between -1 and -3 → BPJ	Practice directly worsens water quality (e.g., adds or increases direct discharges, in-stream sources, etc.) or develops shorelines.	Somewhere between -3 and -5 → BPJ	Practice directly worsens fish habitat quality or amount (including shoreline hardening or other modifications, removal of SAV, or directly worsening the production of benthic organisms or the distribution and productivity of plankton), or worsens access to upriver spawning areas.

Mgmt Strat. / Add. Goals	5: Substantial Improvement	4: Moderate-to-Substantial Improvement	3: Moderate Improvement	2: Slight-to-Moderate Improvement	1: Slight Improvement	0: No Effect	-1: Slight Worsening	-2: Slight-to-Moderate Worsening	-3: Moderate Worsening	-4: Moderate-to-Substantial Worsening	-5: Substantial Worsening
Groundwater Recharge/ Infiltration	Practice maximizes infiltration at a hardened site (e.g., replaces impervious surface area with pervious surface or captures and infiltrates runoff from urban or hardened sites).	Somewhere between 3 and 5 → BPJ	Practice increases infiltration at a hardened site (e.g., replaces impervious surfaces with semi-pervious surfaces).	Somewhere between 1 and 3 → BPJ	Practice reduces runoff and increases infiltration at an unhardened site (e.g., change in tillage that increases infiltration).	Practice has no impact on groundwater recharge/ infiltration than without the practice.	Practice increases runoff and decreases infiltration at an unhardened site (e.g., change in tillage that decreases infiltration).	Somewhere between -1 and -3 → BPJ	Practice directly decreases infiltration at a = hardened site (e.g., replaces pervious surfaces with semi-pervious surfaces).	Somewhere between -3 and -5 → BPJ	Practice prevents infiltration at a hardened site (e.g., adds impervious surface area without runoff capture and infiltration) or uses/removes groundwater.
Healthy Watersheds	Practice directly restores or conserves nonurban lands	Somewhere between 3 and 5 → BPJ	Practice protects or improves stream flow regimes or channel stability	Somewhere between 1 and 3 → BPJ	Practice improves water quality or reduces impervious surfaces	Practice has no impact on healthy watersheds	Practice worsens water quality or increases impervious surfaces	Somewhere between -1 and -3 → BPJ	Practice worsens stream flow regimes or channel stability	Somewhere between -3 and -5 → BPJ	Practice directly increases urbanization
Land Use Methods and Metrics Development	Practice creates wetlands or forest areas.	Somewhere between 3 and 5 → BPJ	Practice conserves existing forest, wetlands., or agriculture land or converts crop land to pasture, forage production, perennial grass, etc.	Somewhere between 1 and 3 → BPJ	Practice creates limited area (<0.5 acre) of vegetation or trees.	Practice has no impact on land use methods and metrics development	Practices removes existing vegetation (<0.5 acres) and replaces with impervious surface or turf.	Somewhere between -1 and -3 → BPJ	Practice removes agriculture fields.	Somewhere between -3 and -5 → BPJ	Practice removes wetlands of forested areas.
Oyster Restoration	Practice directly restores and/or protects native oyster habitat or populations	Somewhere between 3 and 5 → BPJ	Practice improves water quality (e.g., decreases nutrient loads and/or reduces sediment) in targeted oyster restoration tributaries	Somewhere between 1 and 3 → BPJ	Practice reduces runoff that would decrease salinity in targeted oyster restoration tributaries	Practice has no impact on oyster restoration	Practice increases runoff that would decrease salinity in targeted oyster restoration tributaries	Somewhere between -1 and -3 → BPJ	Practice worsens water quality (e.g., increases nutrient loads and/or increases sediment) in targeted oyster restoration tributaries	Somewhere between -3 and -5 → BPJ	Practice directly reduces and/or harms native oyster habitat or populations
Property Values	Practice has potential to significantly improve the property value of the surrounding properties/neighborhood by reducing a threat (e.g. flood reduction) and providing an amenity to the community (e.g. recreational opportunities).	Somewhere between 3 and 5 → BPJ	Practice has potential to slightly improve the property value of the surrounding properties/neighborhood through aesthetic improvement and/or the reduction in a threat. OR practice increases property value through improved soil health/increased crop yields.	Somewhere between 1 and 3 → BPJ	Practice has potential to improve the property value of the land it is situated on.	Practice has no impact on Property Values.	Practice has potential to reduce the property value of the land it is situated on.	Somewhere between -1 and -3 → BPJ	Practice has potential to slightly reduce the property value of the surrounding properties/neighborhood by degrading the aesthetics and/or increasing or causing a threat. OR practice decreases property value through degraded soil health/decreased crop yields.	Somewhere between -3 and -5 → BPJ	Practice has potential to significantly reduce the property value of the surrounding properties/neighborhood by increasing a threat and removing an amenity.
Protected Lands	Practice directly protects/creates highest value wetlands and forestland for maintaining water quality.	Somewhere between 3 and 5 → BPJ	Practice reduces new development pressures, including transportation and energy infrastructure, new housing, and commercial development.	Somewhere between 1 and 3 → BPJ	Practice creates area with native vegetation or removes nonnative vegetation.	Practice has no impact on protected lands	Practice removes area of native vegetation or introduces nonnative vegetation.	Somewhere between -1 and -3 → BPJ	Practice increases new development pressures, including transportation and energy infrastructure, new housing, and commercial development.	Somewhere between -3 and -5 → BPJ	Practice directly degrades or removes highest value wetlands and forestland that maintained water quality.

Mgmt Strat. / Add. Goals	5: Substantial Improvement	4: Moderate-to-Substantial Improvement	3: Moderate Improvement	2: Slight-to-Moderate Improvement	1: Slight Improvement	0: No Effect	-1: Slight Worsening	-2: Slight-to-Moderate Worsening	-3: Moderate Worsening	-4: Moderate-to-Substantial Worsening	-5: Substantial Worsening
Recreation	Practice creates addition opportunities for recreational use of the water. Practice removes water pollution to waterbodies that have direct-contact recreation (e.g., wading, swimming). Practices eliminate reduce harmful algal blooms.	Somewhere between 3 and 5 → BPJ	Practice creates opportunities for recreational use of the adjacent land or improves the conditions for existing water recreation. Practice reduces water pollution to waterbodies that have direct-contact recreation (e.g., wading, swimming). Practices helps reduce harmful algal blooms.	Somewhere between 1 and 3 → BPJ	Practice enhances a neighborhood by providing opportunities for passive recreation (e.g., wildlife viewing, walking, biking).	Practice has no impact on Recreation.	Practice creates an environment that discourages passive recreational use to surrounding area.	Somewhere between -1 and -3 → BPJ	Practice creates an environment that discourages direct contact recreation in the waterbody.	Somewhere between -3 and -5 → BPJ	Practice removes or prevents all opportunities for recreational use of the water. Practice increases likelihood of algal blooms.
Riparian Forest Buffer	Directly improves the practice, protection, and/or maintenance of riparian forest buffers (35' or wider).	Somewhere between 3 and 5 → BPJ	Facilitates the practice, protection, and/or maintenance of riparian forest buffers.	Somewhere between 1 and 3 → BPJ	Potential to directly improve the restoration, maintenance, or conservation of riparian forest buffers, or their functionality.	Practice has no impact on riparian forest buffers.	Potential to directly impact the restoration, maintenance, or conservation of riparian forest buffers, or their functionality.	Somewhere between -1 and -3 → BPJ	Indirectly impacts the restoration, maintenance, or conservation of riparian forest buffers, or their functionality.	Somewhere between -3 and -5 → BPJ	Practice directly impacts the restoration, maintenance, or conservation of riparian forest buffers, or their functionality.
Stream Health	Practice directly improves within the stream channel and floodplain factors that impact stream health (e.g., in-stream sediment and nutrients, channel alterations/pipes, riparian areas) OR restores natural flow conditions (e.g., improves baseflow)	Somewhere between 3 and 5 → BPJ	Practice directly improves watershed-based factors that reduce the volume and rate of stormwater entering streams (e.g., impervious cover, hydrology, flow alteration).	Somewhere between 1 and 3 → BPJ	Practice improves watershed-based factors that reduce pollutant loads to streams (e.g., nutrients, salt, thermal, toxic).	Practice has no impact on stream health.	Practice worsens watershed-based factors that reduce pollutant loads to streams (e.g., nutrients, salt, thermal, toxic).	Somewhere between -1 and -3 → BPJ	Practice directly worsens watershed-based factors that reduce the volume and rate of stormwater entering streams (e.g., impervious cover, hydrology, flow alteration).	Somewhere between -3 and -5 → BPJ	Practice directly worsens within the stream channel and floodplain factors that impact stream health (e.g., in-stream sediment and nutrients, channel alterations/pipes, riparian areas) OR removes natural flow conditions (e.g., reduces baseflow)
Submerged Aquatic Vegetation		Somewhere between 3 and 5 → BPJ		Somewhere between 1 and 3 → BPJ		Practice has no impact on SAV		Somewhere between -1 and -3 → BPJ		Somewhere between -3 and -5 → BPJ	
Toxic Contaminants Policy and Prevention	Practice has potential to substantially decrease the delivery of toxic contaminants to waterbodies.	Somewhere between 3 and the 5 → BPJ	Practice has potential to moderately decrease the delivery of toxic contaminants to waterbodies.	Somewhere between 1 and 3 → BPJ	Practice has potential to slightly decrease the delivery of toxic contaminants to waterbodies.	Practice has no impact on toxic contaminants policy and prevention.	Practice has potential to slightly increase the delivery of toxic contaminants to waterbodies.	Somewhere between -1 and -3 → BPJ	Practice has the potential to moderately increase the delivery of toxic contaminants to waterbodies.	Somewhere between -3 and -5 → BPJ	Practice has the potential to significantly increase the delivery of toxic contaminants to waterbodies

Mgmt Strat. / Add. Goals	5: Substantial Improvement	4: Moderate-to-Substantial Improvement	3: Moderate Improvement	2: Slight-to-Moderate Improvement	1: Slight Improvement	0: No Effect	-1: Slight Worsening	-2: Slight-to-Moderate Worsening	-3: Moderate Worsening	-4: Moderate-to-Substantial Worsening	-5: Substantial Worsening
Tree Canopy	Directly restores or conserves tree canopy, or leads directly to establishment of policies, regulations, ordinances, or program priorities that will result in increased tree canopy.	Somewhere between 3 and 5 → BPJ	Likely to directly or indirectly restore or conserve tree canopy, or leads to establishment of policies, regulations, ordinances, or program priorities that will likely result in increased tree canopy.	Somewhere between 1 and 3 → BPJ	May indirectly result in more tree canopy.	Practice has no impact on tree canopy	May indirectly result in less tree canopy.	Somewhere between -1 and -3 → BPJ	Likely to directly or indirectly impact tree canopy (restoration or conservation), or leads to establishment of policies, regulations, ordinances, or program priorities that will likely result in decreased tree canopy.	Somewhere between -3 and -5 → BPJ	Directly removes trees or hampers restoration or conservation of tree canopy.
Wetlands	Practice directly creates or re-establishes tidal or nontidal wetlands	Somewhere between 3 and 5 → BPJ	Practice directly enhances both the water quality *and* habitat functions of wetlands	Somewhere between 1 and 3 → BPJ	Practice directly prevents degradation through enhancing either the water quality or habitat functions of wetlands OR practice reduces sediment delivery to the wetland	Practice has no impact on wetlands	Practice directly degrades either the water quality or habitat functions of wetlands OR practice increases sedimentation of the wetland	Somewhere between -1 and -3 → BPJ	Practice directly degrades both the water quality *and* habitat functions of wetlands	Somewhere between -3 and -5 → BPJ	Practice directly removes tidal or nontidal wetlands

Appendix D: Literature Listing

This appendix is a separate Excel file (*Appendix D-Literature List.xlsx*).

Appendix E: Final Impact Scores

This appendix is a separate Excel file (*Appendix E-Final Impact Scores.xlsx*).

Appendix F: Responses to GIT and Workgroup Information Request

In a May 2016 introductory email, each goal implementation team and workgroup was asked how they felt their respective management strategies would be affected by BMPs or how their respective BMPs would affect management strategies. The Toxic Contaminants Workgroup was the only group to respond. Their responses are provided below for additional information to the reader.

Toxic Contaminants Workgroup

Which specific BMP (or BMP groups) do you feel would have the greatest impact (positive or negative) on management strategy goals?

- Urban:
  - Positive (greatest to least): Infiltration, Filter Systems, Bioretention, Permeable Pavers, ponds/wetlands (with caveat that PCBs accumulate in sediment), street sweeping, IDDE
  - Neutral: Tree planting, green roofs
  - Negative: N/A
- Agriculture:
  - Positive: Land retirement, buffers, wetlands, biofilters
  - Neutral: AWMS, exclusion fencing, feed BMPs, MTT
  - Negative: cover crops, conservation tillage

What do you think their impacts might be?

- The use of partition coefficients to link nontraditional pollutants to TSS is a common approach in water quality modeling. PCB partition coefficient = 0.0224L/mg (Chapra 1989 (used value for Arochlor 1248)).
- Practices such as bioretention which have aerobic media conditions may also promote the growth of PCB-reducing bacteria (Leigh et al. 2006).
- PCBs behaved very much like a sediment particle, and effective settling of moderate to larger sediment particles was capable of achieving a minimum 50% PCB removal (Yee and McKee 2012).
- One study has investigated whether PCBs accumulate in BMP sediments. Parker et al. (2009) evaluated PCB levels in stormwater pond sediments in Arizona, and concluded many of them exceeded preliminary sediment remediation guidelines, which would require special sediment handling and disposal techniques.
- Given the high level of toxic contaminants found in street solids and sweeper wastes, street cleaning may be an excellent strategy to reduce the toxic inputs from urban portions of the Chesapeake Bay watershed (0.2 to 0.4 mg/kg of PCBs/Street Sweeper waste mass) (Street Sweeping Panel Report).
- Limited monitoring data suggest that vegetated buffers, constructed wetlands, biofilters and ponds all have a moderate to high capability to remove and degrade glyphosate and AMPA (Schueler and Youngk 2016).
- The water quality impacts of greater herbicide applications associated with conservation tillage remain unclear (Schueler and Youngk 2016).

What are the top impacts that concern you?

- Cover crop usage and conservation tillage are both of greatest potential concern because of possible association with higher herbicide application.

Do you have any information sources that you can provide us or direct us to for this project?

- Potential Benefits of Nutrient and Sediment Practices to Reduce Toxic Contaminants in the Chesapeake Bay Watershed: Urban Toxic Contaminants
- Potential Benefits of Nutrient and Sediment Practices to Reduce Toxic Contaminants in the Chesapeake Bay Watershed: Agriculture and Wastewater Sectors
- http://dcstormwaterplan.org/wp-content/uploads/Final_Comp_Baseline_Analysis_2015-with-Appendices.pdf (appendix F)
- Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices

Are there specific individuals on the GIT or management strategy team we should contact for assistance?

Literature

Leigh, M., P. Prouzova, M. Mackova, T. Macek, D. Nagle, and J. Fletcher. 2006. Polychlorinated biphenyl (PCB)-degrading bacteria associated with trees in a PCB contaminated site. *Applied and Environmental Microbiology* 72(4):2331–2342.

Parker, J., K. Fossum, and T. Ingersoll. 2000. Chemical characteristics of urban stormwater sediments and implications for environmental management, Maricopa County, Arizona. *Environmental Management* 26:99–115.

Schueler, T., and A. Youngk. 2015. *Potential Benefits of Nutrient and Sediment Practices to Reduce Toxic Contaminants in the Chesapeake Bay Watershed Part 1: Removal of Urban Toxic Contaminants*. Prepared for Chesapeake Bay Partnership, Toxics Workgroup by Chesapeake Stormwater Network, Ellicott City, MD.

Schueler, T., and A. Youngk. 2016. *Potential Benefits of Nutrient and Sediment Practices to Reduce Toxic Contaminants in the Chesapeake Bay Watershed Report 2: Removal of Toxic Contaminants from the Agriculture and Wastewater Sectors*. Prepared for Chesapeake Bay Partnership, Toxics Workgroup by Chesapeake Stormwater Network, Ellicott City, MD.

Schueler, T., E. Giese, J. Hanson, and D. Wood. 2016. *Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices - Final Report*. Chesapeake Stormwater Network, Ellicott City, MD.

Yee, D., and L.J. McKee. 2010. *Task 3.5: Concentrations of PCBs and Hg in Soils, Sediments and Water in the Urbanized Bay Area: Implications for Best Management. A Technical Report of the Watershed Program*. SFEI Contribution 608. San Francisco Estuary Institute, Oakland, CA.