**PRELIMINARY DRAFT**

**Quantification of BMP Impact on Chesapeake Bay Program Management Strategies**



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# Project Background and Purpose

The Chesapeake Bay Trust awarded a contract to Tetra Tech to quantify the effect the Chesapeake Bay Model’s (CBM) best management practices (BMPs) have on each of the Chesapeake Bay Program’s (CBP’s) management strategies to better enable jurisdictions, localities, and others to assess the impact of their watershed implementation plans (WIPs) on all 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 matrix that assigns each BMP (or BMP group) an impact score for each management strategy or outcome.

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.

This document has been designed for municipalities and others developing watershed restoration plans to use as a guide to understanding how their implementation activities affect the management strategies and additional goals. It is anticipated that this information will be included in the Chesapeake Assessment Scenario Tool (CAST) and the associated Maryland Assessment Scenario Tool (MAST). With these tools, users will be able to adjust the scores based on their location. For instance, if a municipality is located near brook trout habitat, they could increase those scores to highlight brook trout as a priority. At the time of this report, the best way to incorporate the BMP impact scores into CAST and MAST has not been discussed.

# 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” (CBPO 2014). Each management strategy outlines its goal, outcome(s), and baseline; relevant partners; factors influencing the success of the management strategy; 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 alternative goals that were not explicitly addressed by the existing 29 management strategies. The additional goals were identified during the Chesapeake Scientific and Technical Advisory Committee Optimization Workshop and subsequent conversations as representing issues important to local governments and capturing the co-benefits of BMPs.

Table 1 lists the original 29 management strategies Tetra Tech reviewed with Mr. Davis-Martin and the actions agreed upon (i.e., remove or keep). This review resulted in a final list of 19 management strategies for inclusion in the analysis. Table 2 lists the 10 additional goals that were analyzed for the project. 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. These are provided in appendix A. Full descriptions of the original management strategies can be found 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 MAST 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  |
| 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

# 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 because the septic technology information in CAST is 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 the BMPs. (Categories were considered for agricultural BMPs, but were later dropped to preserve the specific CPPE information associated with each practice.) 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 best professional judgement (BPJ) of experts in each BMP sector. The groupings were sent to their respective workgroups for review, but no changes were suggested. A complete list of BMPs and BMP groups is provided in appendix B.

# Narrative Impact Scoring Guidelines

## 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 were also 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 includes a description of the goal of the management strategy, a brief description of the factors influencing the success of the management strategy, and scoring criteria against which the BMPs would 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 was also 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 worsen progress toward achievement of the management strategy or additional goal. A score of 0 is intended to represent a BMP that has no positive or negative impact on achievement of the management strategy or additional goal. A score of 5 represents a BMP that makes a substantial improvement toward achievement of 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 3 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 |

## 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 the achievement of 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 achievement of a particular management strategy, but the intent of the scoring guidelines is to consider the average condition at the average site.

With few exceptions, the narrative scoring guidelines do not account for the scale (i.e., size or extent of the practice) or geographic location (e.g., installed next to a stream or in the center of town) 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 between the practice and management strategy outcome is likely to play a role in BMP planning and implementation, but is not incorporated explicitly within the scoring guidelines.

# 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) conservation practice physical effects (CPPE) data (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 without a stand-alone literature review. Agricultural BMPs were scored using a separate method based on existing NRCS CPPE data and expert BPJ.

## Literature and BMP Expert Panel Reports

### 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 using the EBSCO*host* online research database. Literature was searched using key words, including BMP types and management strategy language. Preliminary scoring was completed based on the 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 used in scoring. The documents used include three panel reports on floating treatment wetlands, urban shoreline management, and street and storm drain cleaning practices. The remaining 100 urban documents consisted of reports or manuals written by government agencies, peer-reviewed journal articles, conference presentations, guidebooks/manuals, dissertations, informational papers, and other miscellaneous documents.

### Forestry BMP Scoring

Tetra Tech’s forestry BMP review focused on available literature as well as 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 many of the 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.

## Chesapeake Bay Program and other Subject Matter Expert Input

The GITs, workgroups, and Tetra Tech subject matter experts were provided with an Excel file 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 were not to 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). They 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 input on scoring for management strategies—BPJ—that directly relate to each GIT for each BMP or BMP group. 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, by GIT, is provided below.

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 scores for BMPs/BMP groups—BPJ—that directly relate to the workgroup for each management strategy/additional goal, except for the toxic management strategy, which was scored by the Toxics Contaminants Workgroup under the WQGIT. Input was provided by the Wastewater Treatment, Forestry, and Toxic Contaminants workgroups. Additional information is provided below by workgroup.

### 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 Habitat 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 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 resource 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 scores for BMPs.

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. These principal stressors should be identified and prioritized with the highest score given to actions (e.g., BMPs) that alleviate the principal stressors. The Habitat GIT reviewer suggested that a table of forecasted principal stressors as a function of land use, impervious cover, and other factors be developed to help aid in site-specific project scoring.

### 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 Sustainable Fisheries GIT is comprised of managers and scientists who focus on improving management and recovery of oysters, blue crab, menhaden, striped bass, and alosines. The members are experts in their respective fields from multiple state and federal agencies and nongovernmental organizations.

### 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.

### 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.

### Water Quality GIT—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.

### Water Quality GIT—Forestry Workgroup

The Forestry Workgroup reviewed the BMPs classified as 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.

### Water Quality GIT—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 ten 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.

### Water Quality GIT—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/decentralized sector. The Tetra Tech staff member completing the scoring sheet is a national/international OWTS/decentralized wastewater management expert who is personally involved with OWTS planning, engineering design, and management (e.g., installation, inspection, operation and maintenance), as well as 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 informed judgements to be made for scoring practices that were more qualitative or subjective in nature.

### Water Quality GIT—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 toxics contaminants (e.g., hydrophilic organics, hydrophobic organics, and metals). For scoring, the Workgroup chose the pollutant group that was most associated with the sector that the BMP is related to and ranked the BMP for the main pollutant of concern. Table 3 provides a summary of each contaminant group, the primary sectors where 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, simazine, metolachlor, and their degradation products) and localized extent for some chlorinated insecticides (aldrin, chlordane, dieldrin, DDT/DDE, heptachlor epoxide, mirex). The chlorinated insecticides have localized severity based on risk to aquatic organisms. For many pesticides that had 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, 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 products, flame retardants, biogenic hormones  | 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 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.  |

## Agricultural Practice Scoring

Agricultural practice scoring was conducted differently than the scoring of practices 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](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/nm/technical/cp/?cid=nrcs144p2_068827) 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:

* Soil erosion
	+ Sheet and rill erosion
	+ Wind erosion
	+ Ephemeral gully erosion
	+ Classic gully erosion
	+ Excessive bank erosion from streambank, shoreline, water conveyance channels
* Soil quality degradation
	+ Organic matter depletion
	+ Compaction
	+ Subsidence
	+ Concentration of salts or other chemicals
* Excess water
	+ Seeps
	+ Runoff, flooding, or ponding
	+ Seasonal high water table
	+ Drifted snow
* Insufficient water
	+ Inefficient use of irrigation water
	+ Inefficient moisture management
* Water quality degradation
	+ Pesticides transported to surface and groundwater
	+ Excess nutrients in surface water and groundwater
	+ Salts 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
	+ Elevated water temperature
	+ Petroleum, heavy metals, and other pollutants transported to receiving surface water and groundwater
* Air quality impacts
	+ Emissions of particulate matter and particulate matter precursors
	+ Emissions of ozone precursors
	+ Emissions of greenhouse gases
	+ Objectionable odors
* Degraded plant condition
	+ Undesirable plant productivity and health
	+ Inadequate structure and composition
	+ Excessive plant pest pressure
	+ Wildfire hazard, excessive biomass accumulation
* Fish and wildlife—inadequate habitat
	+ Inadequate habitat—food
	+ Inadequate habitat—cover/ shelter
	+ Inadequate habitat—water
	+ Inadequate habitat—habitat continuity (space)
* Livestock production limitation
	+ Inadequate feed and forage
	+ Inadequate shelter
	+ Inadequate water
* Inefficient energy use
	+ Equipment and facilities
	+ Farming/ranching practices and field operations

CPPE human considerations are grouped into the following categories:

* Cost information (not used)
* Benefit information (not used)
* Cultural resources and/or historic properties (not used)
* Capital (not used)
* Profitability (not used)
* Risk (not used)
* Land
	+ Change in land use
	+ Land in production
* Labor
	+ Labor hours
	+ Change in management level

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 the physical effects and human considerations 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 to 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 were also 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. In this manner, for example, a CPPE score of 3 for excessive sediment in surface water could translate into anything from a 0 to a 5 narrative score for any given strategy or goal. In this case, it would be a positive score. 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, there were some gaps, 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 are also 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.

## 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, Tetra Tech completed a quality check, by a different person than who did the original scoring for that sector. For example, quality assurance/quality control checks were performed on the forestry scoring 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 first round of scoring was completed, 10 percent of scores were checked by a second reviewer who had scored different agricultural 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.

# Analysis and Results

## Results

The BMP scores were put into an MS Access database, where each score was associated with a source, management strategy, and BMP. 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 their understanding of the management strategies and BMP functionality. For example, while having intimate understanding of the management strategies, some GITs expressed concern with 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. 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. That is, while the scoring can be averaged, the narrative guidelines associated with each numerical score are not equal interval changes and do not result in an average narrative description of the impact on a management strategy. Tetra Tech assumed that 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.

The final scores are included in an Excel file in appendix E. This file also contains tables of the final scores and the number of individual scores used in determining the final score. In addition, the file 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 use during watershed planning.

## Considerations for Applying Scores to Specific BMP Implementation

### Adjusting Scores Based on BMP Location and Scale

BMP and BMP group effects 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 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. 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.

### Adjusting Scores Based on Management Strategy Priorities

In some cases, a locality might decide that certain management strategies take priority over others when developing a WIP. For example, a community in Virginia could decide that the blue crab abundance management strategy is a higher priority for them than other management 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 which 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 that have 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 non-priority management strategy scores, such as bacteria loads, drinking water protection/security, and property values in Table 4 would not be adjusted under the priority management strategy score weighting system.

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 |

## 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 a score. 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 BMP “connecting septics to wastewater treatment plants.” 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 owning 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 6.2.1.

While some patterns were found in the scores for small groups of agricultural BMPs and management strategies, it was concluded that the information lost in presenting these 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. This grouping was based on similarities in sources treated (e.g., animal feedlot runoff), in locations benefited (e.g., riparian protection), or in 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.

## Future Steps / Recommendations

The next step after the scoring is reviewed by the applicable GITs and workgroups 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, but the matrix of scores can be used to help evaluate secondary considerations and priorities and perhaps distinguish between BMP choices when the nutrient and sediment efficiencies are equivalent.

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.

There are two primary ways in which localities can use the scoring matrix:

* 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 encourage based on management strategy priorities.

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 their 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 better 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, there is no one overall best BMP 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 and MAST, but how and when that will be done has not yet been decided. It is recommended that this report and any associated documentation be made available on the CAST and MAST documentation pages to ensure that users understand how to use the information. Incorporating the data into CAST and MAST 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 into account local conditions, and on the limitations of the matrix should be included with any public distribution of the matrix.

# References

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 |
| 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 |
| 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 |
| Dirt & Gravel Road Erosion & Sediment Control - Driving Surface Aggregate + Raising the Roadbed | Dirt/Gravel Roads |
| Dirt & Gravel Road Erosion & Sediment Control - Outlets only |
| Dirt & Gravel Road Erosion & Sediment Control - with Outlets |
| Dry Detention Ponds and Hydrodynamic Structures | Dry Ponds |
| Dry Extended Detention Ponds |
| Erosion and Sediment Control Level 1 | Erosion and Sediment |
| Erosion and Sediment Control Level 2 |
| Erosion and Sediment Control Level 3 |
| Erosion and Sediment Control on Extractive |
| Filter Strip Runoff Reduction | Runoff Reduction |
| Filter Strip Stormwater Treatment |
| 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 |
| Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain |
| MS4 Permit-Required Stormwater Retrofit | N/A - Could include multiple practices |
| Nutrient Management Maryland Commercial Applicators | Nutrient Management Plan |
| Nutrient Management Maryland DIY |
| Nutrient Management Plan |
| Nutrient Management Plan High Risk Lawn |
| Nutrient Management Plan Low Risk Lawn |
| Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain | Permeable Pavement |
| 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 |
| Shoreline Management | Shoreline Management |
| Stormwater Management by Era 1985 to 2002 MD | N/A - Could include multiple practices |
| Stormwater Management by Era 2002 to 2010 MD |
| Stormwater Performance Standard-Runoff Reduction |
| Stormwater Performance Standard-Stormwater Treatment |
| Stream Restoration | Stream Restoration |
| Street Sweeping 25 times a year-acres | Street Sweeping |
| Street Sweeping 25 times a year-lbs |
| Street Sweeping Pounds |
| Tree Planting | Tree Planting |
| 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. |
| **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. |   |   |   |   |   |
| **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).  |
| **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. |
| **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. |
| **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 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 |
| **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 that their respective management strategies would be affected by BMPs or how their respective BMPs would affect management strategies. The Toxics Contaminant 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, Ag Report)
* The water quality impacts of greater herbicide applications associated with conservation tillage remain unclear. (Schueler and Youngk, Ag report)

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](http://www.chesapeakebay.net/publications/title/toxic_contaminants_memo_urban_sector)
* [Potential Benefits of Nutrient and Sediment Practices to Reduce Toxic Contaminants in the Chesapeake Bay Watershed: Agriculture and Wastewater Sectors](http://www.chesapeakebay.net/publications/title/toxic_contaminants_memo_agriculture_and_wastewater_sector)
* <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](http://www.chesapeakebay.net/publications/title/street_sweeping_and_storm_drain_cleaning_expert_panel_report)

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

**Literature**

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