Quick Reference Guide for Best Management Practices

Nonpoint Source BMPs to Reduce Nitrogen, Phosphorus and Sediment Loads to the Chesapeake Bay and its Local Waters

Chesapeake Bay Program
Science. Restoration. Partnership.

CBP/TRS-323-18

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For individual BMP reference sheets:

Chesapeake Bay Program. Title of specific BMP reference sheet. *Chesapeake Bay Program Quick Reference Guide for Best Management Practices (BMPs): Nonpoint Source BMPs to Reduce Nitrogen, Phosphorus and Sediment Loads to the Chesapeake Bay and its Local Waters,* version date of the specific BMP reference sheet.

Example:

Chesapeake Bay Program. A-3: Conservation Tillage. *Chesapeake Bay Program Quick Reference Guide for Best Management Practices (BMPs): Nonpoint Source BMPs to Reduce Nitrogen, Phosphorus and Sediment Loads to the Chesapeake Bay and its Local Waters,* MONTH DD, YYYY.

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Additional Notes:

The best management practices (BMPs) included in this reference guide represent practices approved by the Chesapeake Bay Program partnership to simulate estimated nitrogen, phosphorus, or sediment loads. The practices included in this guide do not represent a comprehensive list of BMPs available for use in the Watershed Model/Chesapeake Assessment Scenario Tool (CAST). BMPs that focus on a range of other pollution control or restoration objectives, in contrast to nutrient and sediment reductions, are not included in this reference guide.

Please note that BMPs are organized into Reference Sheets based on the editors' decisions, which can lump multiple practices into a single reference sheet.

*Sheets marked TBA have not yet been written but will be available in future editions of this guide.

IMPORTANT: Updates to the practices below were approved by the Chesapeake Bay Program partnership for inclusion in CAST-2023 and the following information included in the Second Edition of this Reference Guide reflects these changes*. Incorporation of these updates within CAST are contingent upon release of CAST-2023.

For a comprehensive list of updates included in the Second Edition of this Reference Guide, please refer to Appendix B.

CAST-2023 BMP Reference Guide Updates

- A-12: Forest Buffers and Grass Buffers
    - Credit duration for Forest Buffers changed from 10 to 15 years.
- A-13: Forest Buffers and Grass Buffers with Stream Exclusion Fencing
    - Credit duration for Forest Buffers changed from 10 to 15 years.
- A-18: Animal Mortality Management
- A-21: Agricultural Ditch Management
    - Updates to crediting for existing practices.
    - New practices added.
- A-22: Tree Planting (Agricultural)
    - Credit duration changed from 10 to 15 years.
- A-24: Nontidal Wetland Restoration, Creation, and Rehabilitation
    - Creation and rehabilitation credits updated.
    - Wetland enhancement removed.
- D-5: Urban Stream Restoration
    - Protocol 5 added.
    - Default rate removed for new reporting after 6/30/2022.
    - New and clarified qualifying conditions.
- D-7: Urban Tree Planting
    - Credit duration changed from 10 to 15 years.
- D-8: Reducing Nutrients from Grey Infrastructure
    - Nutrient Discovery Program cannot be reported after 6/30/2021.
    - Eight new Grey Infrastructure Discharge Elimination BMPs added.
- N-7: Oyster Reef Restoration
- N-8: Licensed Oyster Harvest

Introduction

About the Chesapeake Bay Program

The Chesapeake Bay Program (CBP) is a regional partnership that leads and directs Chesapeake Bay restoration and protection. CBP partners include federal and state agencies, local governments, non-profit organizations and academic institutions.

The CBP has a number of goal teams, advisory committees and workgroups to facilitate its partners' coordinated efforts (Figure 1). The Water Quality Goal Implementation Team (WQGIT) works to evaluate, focus and accelerate the implementation of practices, policies and programs that will restore water quality in the Chesapeake Bay and its tributaries. Those involved in the WQGIT and its numerous workgroups are among the individuals most deeply involved with implementation, tracking and reporting of best management practices (BMPs) to reduce nitrogen, phosphorus and sediment loads to the Chesapeake Bay.

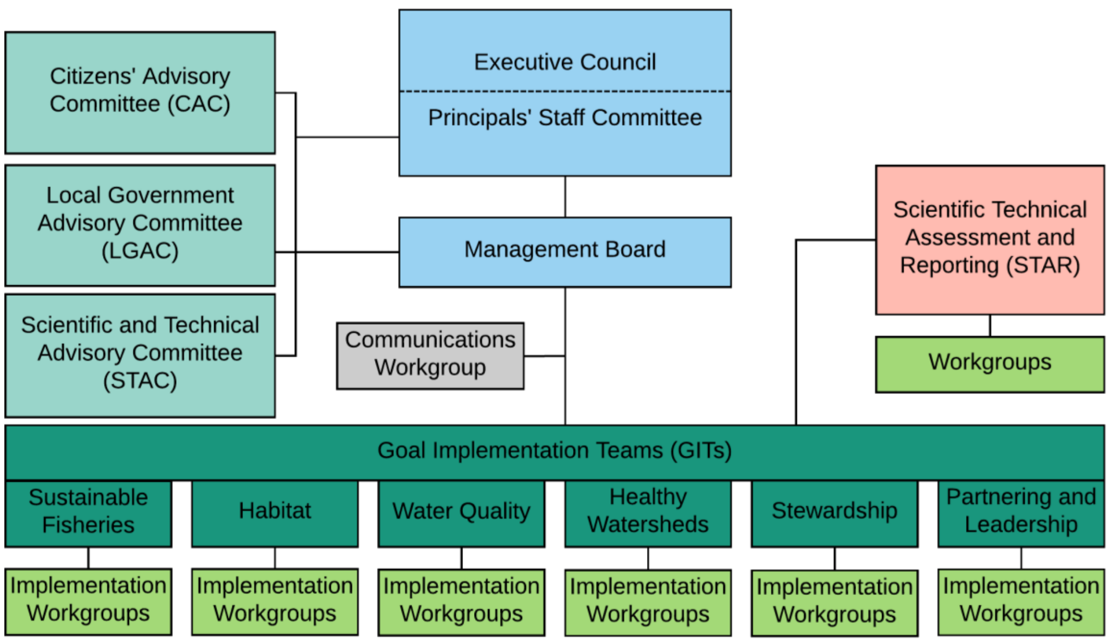


Figure 1 - Chesapeake Bay Program organizational structure

About this Guide

Across the watershed, there are countless individuals involved at some stage of the BMP implementation, tracking and reporting process. Many of these individuals are responsible for a wide range of tasks related to their jurisdiction, and Bay-related activities and BMPs may only be a small piece of their work. As such, they may rarely or never interact directly with the CBP groups depicted in Figure 1 and this exacerbates the challenge of understanding the modeling tools and practices available to reduce nutrient and sediment loads to the Bay.

As of fall 2017, the CBP partnership has over 200 best management practices (BMPs) available for nitrogen, phosphorus, and/or sediment reduction credit in the Phase 6 Chesapeake Bay Watershed Model (Watershed Model). Some of these BMPs are reportable under a variety of management strategies allowing for more nuanced reporting and crediting options, providing partners with an array of options to consider in their BMP implementation planning.

Coordination, planning and implementation by state, regional and local partners is strengthened when all parties have a consistent understanding of CBP-approved BMPs that are eligible for nitrogen, phosphorus, and sediment reductions. However, basic key information about these BMPs and how they fit within the Watershed Model – while publicly available online – is scattered among lengthy reports, appendices, and dense spreadsheets. This adds further confusion to already complex processes for Phase III WIP development, two-year milestone development and annual BMP reporting.

There are examples of explanatory materials that are more accessible to those who want a clearer sense of the basic elements of specific CBP-approved BMPs, e.g., Chesapeake Stormwater Network fact sheets. Unfortunately, this kind of accessible information does not exist for all sectors and all BMPs, particularly BMPs reviewed and approved prior to 2012. Therefore, CBP partners expressed interest in the development of a guide with basic information for each CBP-approved BMP summarized in a brief and consistent format.

The main purpose of this guide is to provide summarized profiles for each CBP-approved BMP in the Watershed Model. Each profile—or reference sheet—includes:

- General information about a BMP;
- How a BMP functions within the Watershed Model;
- What's needed for the BMP to be reported for annual progress submissions; and
- Links to additional information for readers who want more detailed information about the practice.

Other aspects of a BMP such as cost, potential ecosystem benefits or impacts, maintenance or funding sources are not discussed in the reference sheets because they vary by region, state or local area.

The reference sheets are grouped according to their affiliated source sector in the Watershed Model (A = agriculture, D = developed, N = natural, S = septic). Some BMPs, such as stream restoration, may appear in multiple sections. The overall document is organized to allow for the addition of new BMPs, as well as for revisions to existing BMPs in the Watershed Model.

Understanding Best Management Practices and the Phase 6 Chesapeake Bay Watershed Model

The focus of this guide is how BMPs fit within the overall watershed model framework. This overview offers context needed to understand technical elements in each BMP reference sheet. The description of how BMPs are simulated intends to be almost comprehensive when it comes to important concepts, but it does not explain certain details covered in the Watershed Model documentation. Readers interested in detailed technical documentation should consult the online resources in Table 1, particularly the Phase 6 Model Documentation and Chesapeake Assessment Scenario Tool (CAST).

Table 1 - List of online tools and resources for additional information or detailed documentation

Resource	Brief description of what the resource includes	URL
Phase 6 Watershed Model documentation	Complete documentation and appendices about the Phase 6 Chesapeake Bay Watershed Model.	http://cast.chesapeakebay.net/Documentation/ModelDocumentation
Chesapeake Assessment	This online tool can be used for planning purposes. Users can create and evaluate	http://cast.chesapeakebay.net/

Scenario Assessment Tool (CAST)	scenarios of various BMPs to estimate loads and load reductions for a geographic area of interest. The CAST website also provides extensive documentation for users and is updated periodically.	
BMP expert panel reports	BMP expert panel reports approved since 2012 are posted as "publications" on the Chesapeake Bay Program website. A "BMP Expert Panels" group page compiles these together under "Publications." Links to individual reports are provided in the corresponding BMP reference sheet.	http://www.chesapeakebay.net/groups/group/bmp_expert_panels
Simpson and (Weammert) Lane (2009)	This report was developed by Tom Simpson and Sarah (Weammert) Lane of the Mid-Atlantic Water Program. The report and process served as a model for the current BMP Protocol and expert panel process. Many current BMP definitions and effectiveness values are included in this report.	http://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

What is the Watershed Model?

The CBP and its partners have worked together since the 1980s to improve computer modeling tools that simulate the Chesapeake Bay and its 64,000 square mile watershed. The watershed has a land-to-water ratio of 17 to 1, higher than any estuary in North America, which illustrates that water quality in the Bay itself is greatly influenced by actions on the land and the condition of its watershed. The CBP uses the Watershed Model to understand and simulate changes in loads of nitrogen, phosphorus, and sediment to the Chesapeake Bay due to management actions implemented in the watershed.

The Phase 6 Watershed Model represents the latest iteration in the partnership's efforts to improve the modeling tools used to track progress toward water quality goals. Since the release of the Chesapeake Bay Total Maximum Daily Load (Bay TMDL) in 2010—which established nutrient and sediment targets for each Bay jurisdiction— the Watershed Model has been instrumental in evaluating progress toward pollution reduction targets.[1]

Watershed Implementation Plans (WIPs) are plans for how the Bay jurisdictions, in partnership with federal and local governments, will achieve the Bay TMDL allocations and planning targets. Phase I WIPs were developed in 2010 to inform the Bay TMDL allocations. Phase II WIPs were developed in 2012 to meet nitrogen, phosphorus and sediment planning targets based on updated information in the Phase 5.3.2 Watershed Model. Phase III WIPs were developed in 2018-2019 using the Phase 6 Watershed Model.

[1] For more information on the Watershed Model's use in the TMDL, refer to the TMDL documentation, particularly Section 4 for the modeling of the inputs, Section 5 for the modeling of the physical setting, and Section 6 for the specifics on how they were used to set the TMDL. Available online at: https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-tmdl-document

What does the Phase 6 Watershed Model do?

The Watershed Model has been designed through extensive, long-term collaboration by the CBP partnership. The history of the partnership's efforts, modeling philosophy and purposes of the Watershed Model are described in Section 1 of the Watershed Model documentation.

A primary use of the Watershed Model is to predict changes in loads entering the Chesapeake Bay due to management actions in the watershed. The model simulates loads from a range of source sectors, including agriculture, wastewater, developed and natural areas. To do this, the model uses a large amount of data to simulate the application, fate and transport of nitrogen, phosphorus and sediment in their journey from the field, lawn or forest to the stream, river and ultimately to the Chesapeake Bay (Figure 2).

The Phase 6 Watershed Model at a glance

A simplified conceptual understanding of the overall model structure makes it is easier to understand how BMPs function within the model. Figure 2 shows the basic structure of the watershed model. The processes represented correspond to separate domains that exist across the landscape of the watershed as pollutants move from a field to stream, stream to river, and from river to the Bay's tidal waters.

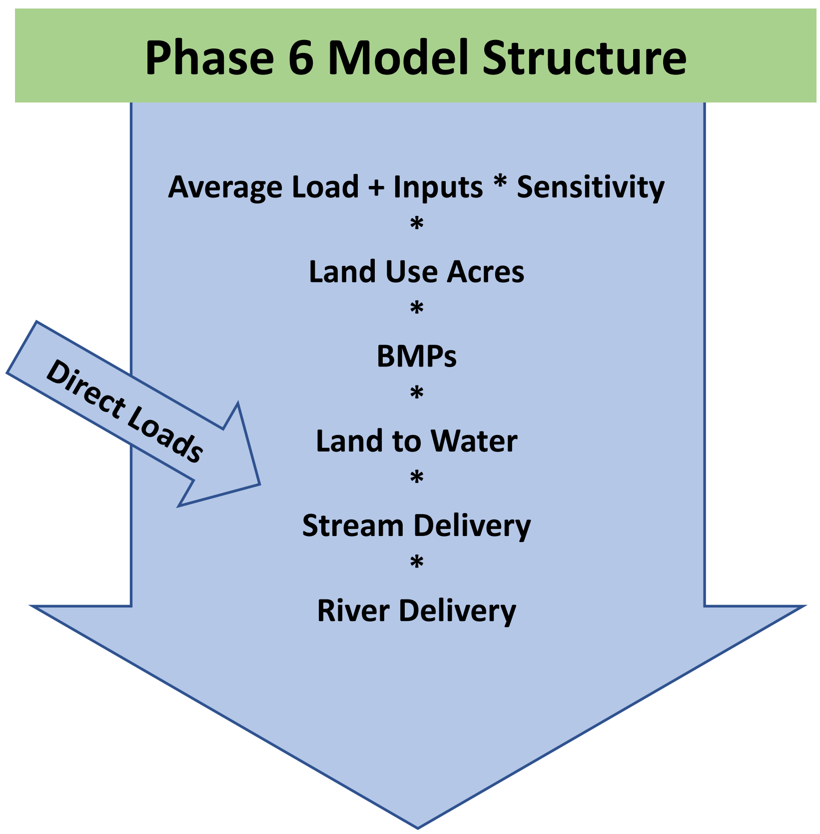
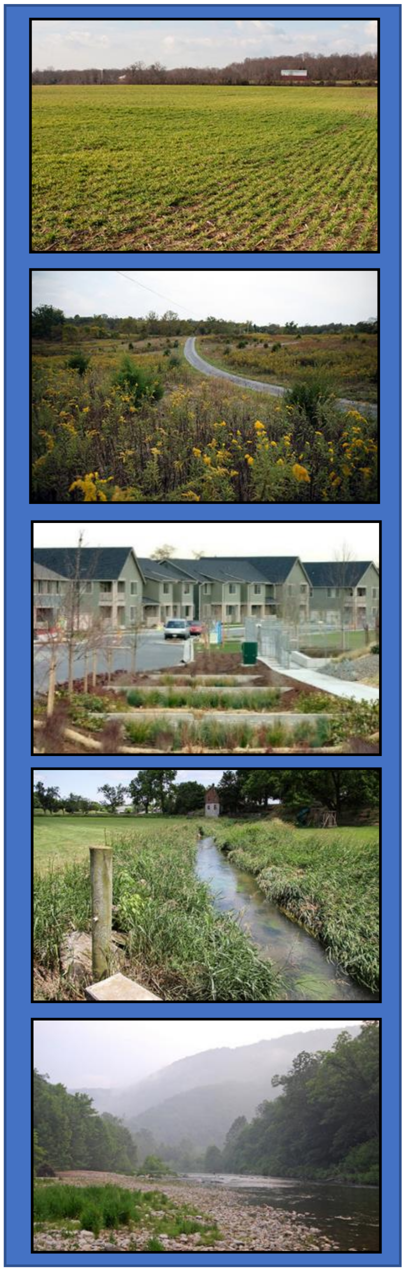


Figure 2 - Phase 6 Watershed Model Structure: If the model is considered as a single equation, each step above is a coefficient determined using the available information.



Average Loads are loads per acre for each land use averaged across the entire Chesapeake Bay watershed. Average loads are not true edge-of-field loads, but average for what would reach a small stream.

Inputs are the applications to the landscape of nutrients from atmospheric deposition, fertilizer, manure and biosolids. *Delta inputs* are the difference between the inputs to the land use in the local area and the Chesapeake Bay-wide average input.

Sensitivities are the Chesapeake Bay-wide average change in export load to a stream for each unit change for an input load.

Export loads are the net loads of nitrogen, phosphorus and sediment for a land use once the average loads, inputs and sensitivities are factored in.

The top line in Figure 2 therefore represents the loads exported from a land use to a stream in a land segment taking into account local applications, but not local watershed conditions. Those loads are then multiplied by the area of the land use in the segment (**Land Use Acres**); the effect of local **BMPs,** which act to decrease the loads; and local **Land to Water** factors.

Land to Water factors account for spatial differences in loads due to physical watershed characteristics, such as the available water capacity of soil and groundwater recharge. Land to Water factors do not add or subtract to the loads over the Chesapeake Bay watershed, but instead add spatial variance for nutrient transmission.

The application of the above factors results in an estimate of loads delivered to a stream or waterbody in a land-river segment.

Next, **Stream to River** factors are applied to account for nutrient and sediment processes in streams with average flow less than 100 cubic feet per second. These factors allow for reduction (i.e., attenuation) of nutrient delivery in the small, non-modeled streams as the loads move to the boundary of the larger modeled river reaches.

Similar to Stream to River above, **River Delivery** factors account for nutrient attenuation processes in the larger, modeled rivers as loads move to the estuary.

Direct Loads are loads that do not come from the land surface or subsurface. Point sources (e.g., wastewater treatment plants) and livestock manure deposition directly into the stream fall under this category. Direct loads may enter the conceptual model either before or after application of Stream or River Delivery Factors, depending on their physical location. Figure 2 is simplified to only show the direct loads preceding Stream Delivery.

For an increased understanding of the individual modeling factors see the Phase 6 Watershed Model documentation.

How to use the BMP Quick Reference Sheets

Each BMP reference sheet is comprised of elements intended to provide key “bottom-line” information about the practice as currently defined and understood by the CBP partnership. This section outlines each element listed in the BMP reference sheets and provides a brief statement of what information is provided by that element.

Practice Description

This is a brief narrative description of the practice(s). It is not the CBP-approved definition for modeling and reporting purposes.

CBP Definition(s)

These are the most recent BMP definitions adopted by the CBP partnership for purposes of tracking progress toward nutrient and sediment goals under the TMDL. Some reference sheets have more than one BMP definition in cases where there is more than one category. Sometimes within a specific BMP or BMP category (e.g., see A-4: Cover Crops – Traditional) there are numerous variations of specific practices that fall within the definitions. The reference sheets may provide the definitions of other terms that are not BMPs to help further understanding. For example, A-3: Conservation Tillage provides a definition of “conventional tillage” to help gain knowledge of conservation tillage BMPs.

> *Watershed Model BMP Name:* Current CBP definition of the practice (or related term) as determined by the most recent BMP expert panel or partnership decision.

The general format is better understood with an example (from A-3: Conservation Tillage):

> *Conventional Tillage:* Any tillage routine that does not achieve 15 percent crop residue coverage immediately after planting is considered conventional tillage and does not qualify as a BMP.
>
> *Low Residue Tillage:* A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 15 to 29 percent crop residue coverage immediately after planting each crop.
>
> *Conservation Tillage*: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 30 to 59 percent crop residue coverage immediately after planting each crop.
>
> *High Residue, Minimum Soil Disturbance Tillage*: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain at least 60 percent crop residue coverage immediately after planting each crop.

Specifications or Key Qualifying Conditions

Qualifying conditions are parameters necessary to meet the definition or intent of the BMP. When a BMP expert panel defines a practice and its ability to reduce nutrients and sediment, those expected reductions assume that the practice functions or performs as intended. This means the practice must meet criteria or qualifying conditions recommended by the panel as a part of the practice definition, if any. For example, a 15 to 29 percent residue coverage is a qualifying condition for the Low Residue Tillage BMP described in A-3: Conservation Tillage.

For each reference sheet, this brief paragraph notes key qualifying conditions described by BMP panels but is not a comprehensive list of what may be described in the full BMP panel report, existing state practice standards or other sources of reference. Ultimately, the jurisdictions determine their own expectations, standards and specifications for BMPs that are implemented to meet their TMDL goals. For example, each state has its own Stormwater BMP Manual that explains specific engineering standards and specifications for stormwater practices.

Nitrogen, Phosphorus and Sediment Reductions

A summary of the nutrient and sediment reductions attributed to the BMP in the Watershed Model is provided here, in narrative or tabular format, or both.

Applicable Land Use Types (or other load sources) Treated by the BMP

Every BMP is applied to specific land uses or attributed to another load source in the Watershed Model. This element notes which land uses or other sources the practice can treat.

Brief Description of BMP Simulation in the Model

This provides a brief narrative description of what BMP type the given practice is simulated as in the Watershed Model (e.g., effectiveness value, land use change, etc.). More information about BMPs and the various types of BMPs simulated in the Watershed Model is available in Appendix A.

- *Can this practice be combined with other BMPs?* The answer to this question specifies whether or not the BMP is considered “stackable.” A stackable BMP can reduce loads from the same land use or load source as other BMPs in the Watershed Model, which means it is not mutually exclusive of other practices and can therefore overlap with other practices or that other practices can subsequently apply (see Appendix A for more information).

Key Elements for State BMP Reporting through the National Environmental Information Exchange Network (NEIEN)

Each reference sheet summarizes the specific information needed to report the practice through NEIEN. This is intended to help jurisdictional partners that manage data for eventual submission to NEIEN. This same information about NEIEN reporting elements is found in the Technical Appendix of recent BMP panel reports.

- *BMP Name:* The specific BMPs available in NEIEN are listed here. Many BMPs are split in NEIEN according to the various animal types, land sources or hydrogeomorphic regions to which they can be applied. This sometimes makes it impossible to list every variation of the BMP available in NEIEN, but the most common or default practices will be listed as those are the most useful to the average reader.
- *Measurement name:* Each BMP is associated with certain units of measurement that should be reported (i.e., acres, feet, pounds, tons, number of animals, number of animal units, etc.). The units needed for the given BMP are listed here.
- *Load Source:* Load sources on which the BMP can be reported, if applicable. Not applicable for animal BMPs.
- *Geographic location:* Scales at which the BMP can be reported, e.g., hydrologic unit code (HUC), county, etc.
- *Date of implementation:* Date associated with installation or observation of the BMP.

Synonymous BMP names for Watershed Model, NEIEN and other sources

Each reference sheet includes a table that compares synonymous BMP names used by the CBP for the Watershed Model, in NEIEN and from other common sources such as NRCS Conservation Practice

Standards. It is important to remember that definitions of nonpoint source BMPs in the reference sheets are used by the CBP to track progress toward water quality goals under the TMDL. The terminology and definitions used for this purpose are described by expert panels and agreed to by the CBP so that the partnership's definitions are consistent across the jurisdictions for BMP tracking and reporting. However, there are often programs at a national, regional, state or local level that use similar terminology in slightly different contexts or with subtle differences in definitions. It is not possible to clarify every possible term or name used for practices in various contexts, but the table should provide at least some clarity for readers attempting to understand how the CBP's name for a BMP might relate to terminology or an NRCS Conservation Practice Code they are more familiar with. See example in Table 2.

Table 2 – Example Table of Synonymous BMP names for Watershed Model, NEIEN and other sources. Modified from Reference Sheet A-3: Conservation Tillage for this example.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Low Residue Tillage	Reduced Tillage	Residue and Tillage Management, No-Till (NRCS 329)*
Conservation Tillage	Conservation Tillage Mulch Tillage No Tillage Ridge Tillage	Residue and Tillage Management, No-Till (NRCS 329)* Residue and Tillage Management, Reduced Till (NRCS 345)*
High Residue, Minimum Soil Disturbance Tillage	High Residue Tillage Management	Residue and Tillage Management, No-Till (NRCS 329)*

**Sometimes a practice that is cost-shared and implemented using a NRCS Conservation Practice Standard meets the BMP definition and conditions of the CBP. However, there are cases when a NRCS Conservation Practice Code can potentially meet the CBP definition but does not automatically fulfill the definition. In this example, NRCS 329 (Residue and Tillage Management, No Till) can potentially meet any of the three BMP definitions used by the CBP, but the jurisdiction needs to verify how many acres meet which definition, if any. Similarly, NRCS 345 (Residue and Tillage Management, Reduced Till) does not automatically fulfill the CBP's definition of Conservation Tillage, but the jurisdiction can verify how many acres meet the definition.*

Additional Information

This section provides links to more detailed information relevant to the practice, such as the latest BMP expert panel report, fact sheets, webpages or other resources. The number of links provided on a given reference sheet may vary based on suggestions from workgroups, space limitations and the long-term usefulness of the information.

Version and History Statement

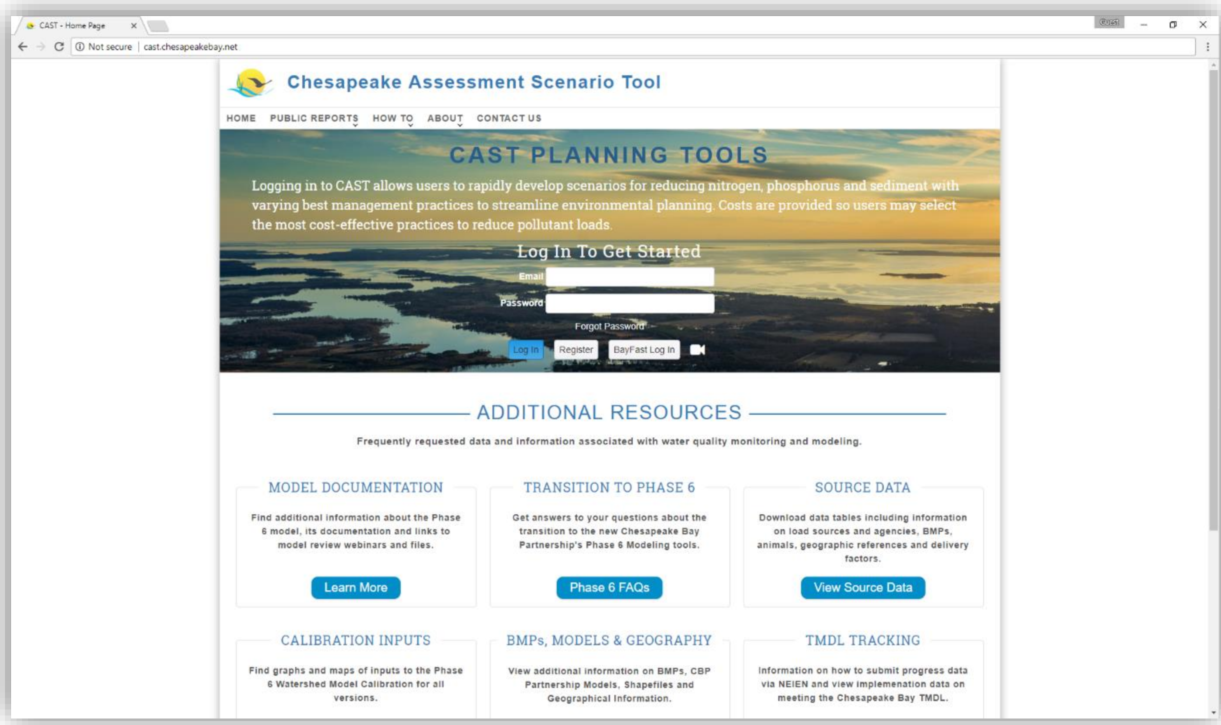
The CBP has a long history of evaluating the effectiveness of BMPs to reduce nitrogen, phosphorus and sediment loads. The partnership may revisit existing BMPs and also evaluates new, innovative BMPs when new science and research is available to determine what reductions are scientifically reasonable and defensible. A statement at the end of each reference sheet will inform the reader when the BMP was most recently evaluated and approved by the partnership, followed by a short statement that all BMP definitions and effectiveness estimates are subject to potential future reviews in accordance with the BMP Protocol (see Appendix A).

> This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in MONTH YEAR.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

Chesapeake Assessment Scenario Tool (CAST)

http://cast.chesapeakebay.net/



What is CAST?

The Chesapeake Assessment Scenario Tool (CAST) is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning. It is identical to the Watershed Model.

Users specify a geographical area and then select BMPs to apply on that area. CAST builds the user's scenarios—or sets of planned or implemented BMPs—and provides estimates of nitrogen, phosphorus and sediment load reductions. The estimated cost of a scenario is also provided so that users may select the most cost-effective practices to reduce pollutant loads.

Would CAST help me?

Local jurisdictions and states use CAST for their WIPs, two-year milestones and even local TMDLs. Any user may see the source of the data that was used in developing the TMDL and the state's most recent annual progress scenario, milestone and WIP. This allows involvement of the counties and other local planners in the Bay TMDL.

How do I sign up and learn to use it?

CAST is easily accessible online at http://cast.chesapeakebay.net/. It is free to register and create an account to create and run scenarios, and users can view model documentation, download public loads or BMP reports or source data without an account. Archived training webinars and other instructive materials are available on the website to teach new users how to use the tool. Learn more about CAST here: http://cast.chesapeakebay.net/about

The National Environmental Information Exchange Network

The National Environmental Information Exchange Network (NEIEN) is a state-federal data-sharing partnership by which environmental information can be shared, integrated, analyzed and reported without having to take possession of the data. Within the CBP, NEIEN is an internet- and standards-based tool for securely exchanging non-point source BMP information between jurisdictional partners and EPA through a system of "nodes" that communicate and handle requests.

A designated agency within each jurisdiction handles BMP submissions into NEIEN, including annual submissions to track progress toward TMDL targets. Any implementation within a jurisdiction should be submitted to the state NEIEN lead. This includes federal or other partners whose implementation may not be directly tracked through state funding or other tracking programs. So while only a small number of individuals directly interact with NEIEN, it helps to understand its role in receiving and validating BMP data to then translate the data for use and processing in the Watershed Model (**Error! Reference source not found.**).

BMP data from the jurisdictions is submitted to NEIEN in the form of an XML file which allows multiple data elements to be associated with each BMP record. Those elements depend on the BMP, but can include: implementation date, maintenance date, inspection date, reporting agency, funding source, geographic coordinates, etc. This detailed BMP information is then processed into the Watershed Model based on rules developed in consultation with the state and documented in the appropriate jurisdiction's Quality Assurance Project Plan (QAPP).

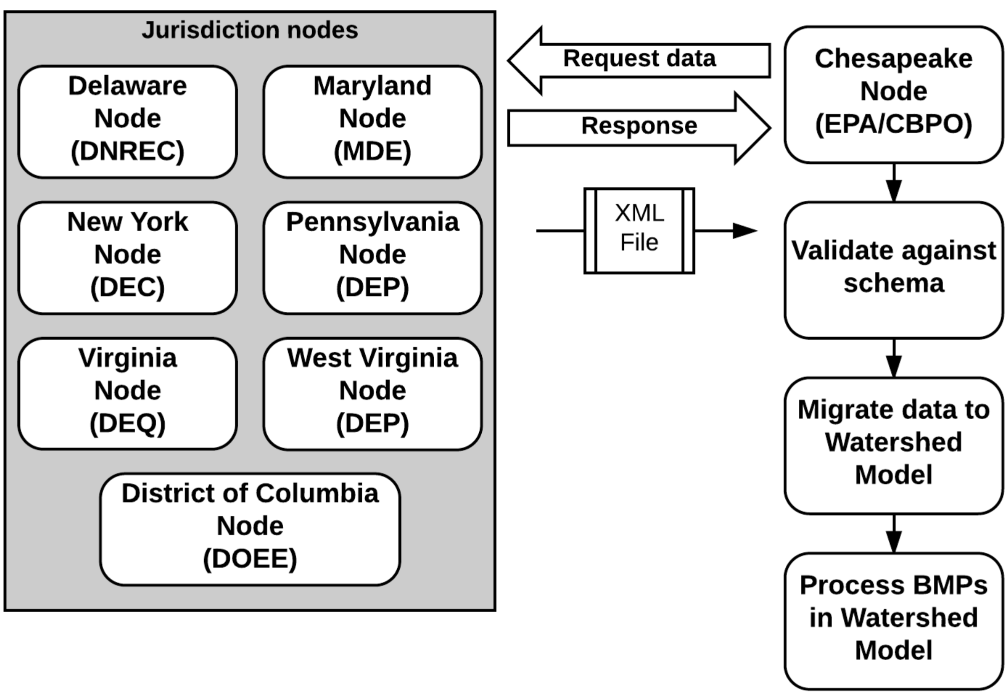


Figure 3 - Illustration of National Environmental Information Exchange Network (NEIEN) process.

Appendix A – Understanding Best Management Practices in the Phase 6 Watershed Model

This section is primarily adapted from Section 6 of the Phase 6 Watershed Model Documentation. Less technical detail is provided here than the Watershed Model documentation, so what follows should be considered an abridged version for the reader and should not be cited in lieu of the Watershed Model Documentation for any purpose.

1. What is the process for adding new BMPs or modifying existing BMPs in the modeling tools?

The BMPs available for credit in annual progress runs are approved by the partnership according to the CBP's Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model (more commonly called BMP Protocol – 2015 version). Since the definitions and values used for both loading and effectiveness estimates have important implications for the CBP and various partners, it is critical that such estimates be developed in a process that is consistent, transparent and scientifically defensible. To this end, the Water Quality Goal Implementation Team (WQGIT) established the BMP Protocol and has amended it over time.

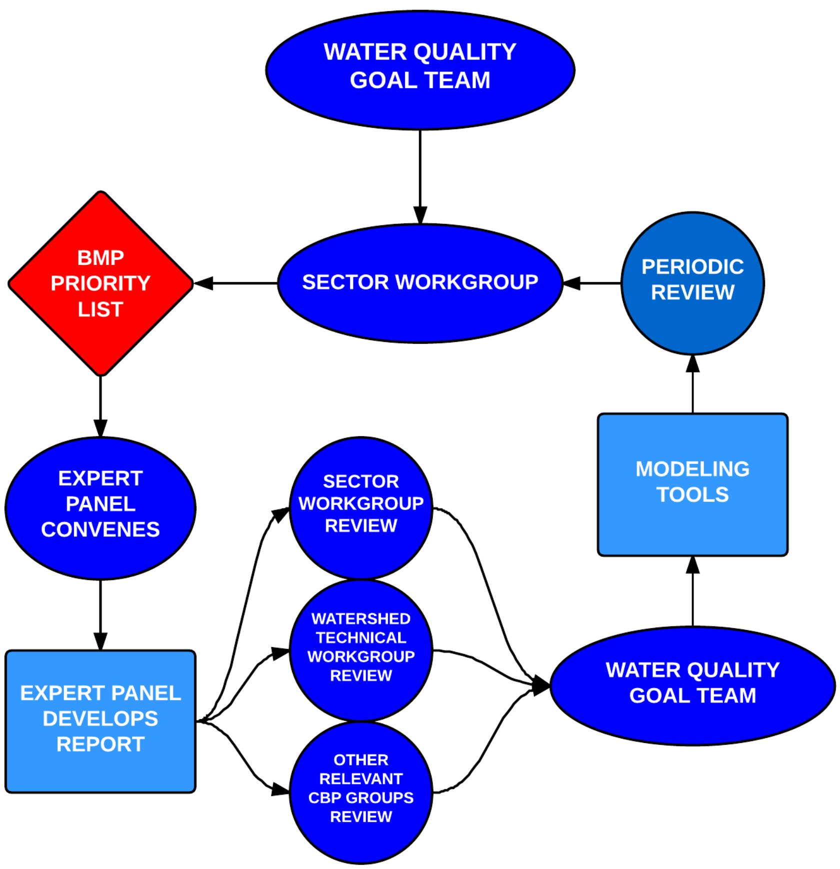


Figure 4 - Diagram of the CBP process for BMP expert panels and WQGIT to add/modify BMPs

Figure 4 illustrates the process for BMP expert panels and the WQGIT to add/modify BMPs. Each expert panel consists of six or more scientific and technical experts whose relevant research or field experience allow them to deliberate available science and deliver a report detailing their recommendations. Most BMPs approved prior to when the BMP Protocol was first adopted in 2010 were reviewed as a part of the Mid-Atlantic Water Program's BMP Assessment report (Simpson and Weammert 2009), which followed a similar process for convening experts and reaching science-based recommendations based on consensus. All BMP Expert Panel reports can be found here.

2. What types of BMPs does the Watershed Model simulate?

The Watershed Model simulates BMPs in a number of ways. The categories below describe how the effectiveness of the six common types of BMPs is calculated, although some exceptions to these categories exist. The full Model Documentation and CAST user documentation explain those exceptions.

2.1 Efficiency values

This is the most common type of BMP. An efficiency value is the percentage of a pollutant that is removed when the BMP is applied. For example, dry extended detention ponds remove 20 percent of the nitrogen that would have been delivered without the detention ponds. The pass-through value for the BMP is 100 percent minus the efficiency value. In this case, the pass-through value for dry extended detention ponds is 80 percent. For some BMPs, efficiency values can vary across different hydrogeomorphic regions and load sources (for example, cover crops would have varying effects depending on the type of land where they are planted).

2.2 Load source change

Load source change practices shift a previous load source to a new load source. For example, tree planting can shift an acre of pasture to an acre of forest. By changing acreage from a higher-loading load source to a lower-loading one (from pasture to forest), nutrients are automatically reduced on that acre of land. Each additional unit of load source change typically results in a lower load for a given geographic area. However, too much land conversion could potentially result in higher loads if the conversion results in other inputs, such as manure, being applied to an increasingly small number of acres. A full list of load sources and their definitions is available on the CAST website (See: CAST source data – Load source definitions worksheet).

2.3 Load source change with efficiency values

Some BMPs work as both a load source change and an efficiency BMP, since the land conversion also reduces the amount of nutrients delivered from upland acres. In these cases, the load source change is calculated first. An efficiency is then applied to a certain number of upland acres to account for the full benefits of the practice. Load source change BMPs that also have an efficiency value include grass buffers, grass buffer-streamside with exclusion fencing, forest buffers, forest buffer-streamside with exclusion fencing, wetland creation and wetland restoration.

Figure 5 illustrates an example of a forest buffer applied to agricultural land. If an agricultural forest buffer is applied to 10 acres of land, those 10 acres are converted to forest land (a load source change). However, forest buffers also help trap pollutants running off of surrounding land, so efficiency values apply to some of those upland acres. For forest buffers, four times the number of acres converted (4 x 10 = 40 acres) qualify for an efficiency nitrogen pollution reduction from the forest buffer BMP. There would also be an efficiency reduction applied to two times the number of acres converted (2 x 10 = 20 acres) for both phosphorous and sediment. If this forest buffer was instead located on urban land, the upland acres receiving the efficiency are a one to one ratio with the acres converted (instead of 4:1 for nitrogen and 2:1 for phosphorus and sediment).

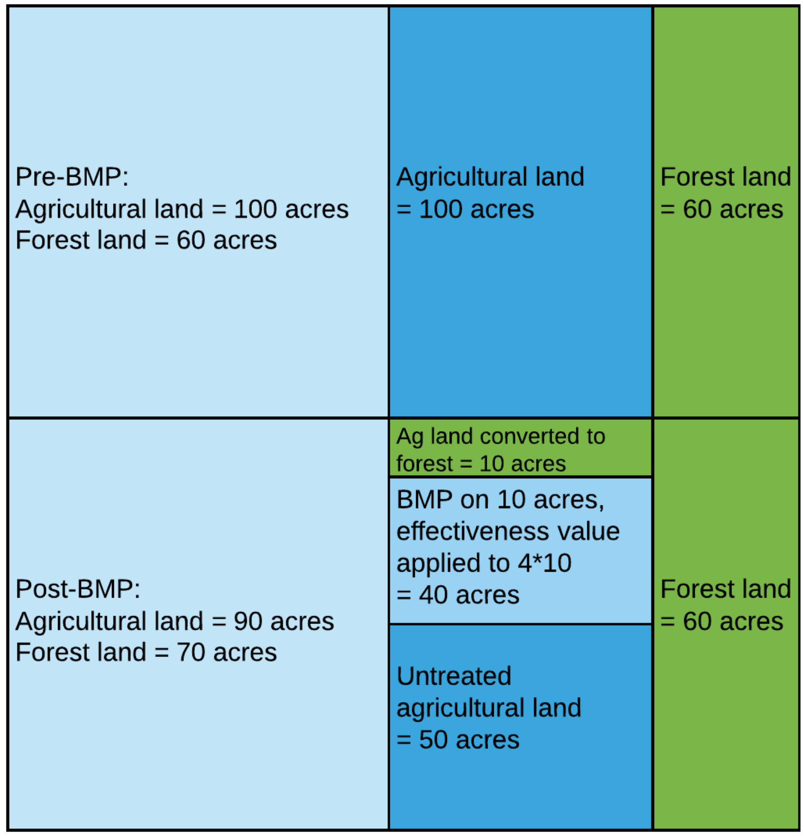


Figure 5 - Load source change with effectiveness example

2.4 Load source input reduction practices

Some BMPs directly reduce the amount of nutrients applied to each acre of land. For example, if a jurisdiction indicated that manure was transported out of a county, the total application of manure to a load source within that county/jurisdiction could be reduced. The reduced input application rate is taken into account *before* applying efficiency BMPs or load reduction practices.

2.5 Load reduction BMPs

Load reduction BMPs are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment from the edge of a stream, river or tide load. For every unit (e.g., feet) of BMP submitted, a certain amount of nitrogen, phosphorus or sediment is removed. In some cases, the submitted unit is the pounds of nitrogen, phosphorus and/or sediment removed. Load reduction BMPs include algal flow-way, oyster aquaculture, stream restoration, shoreline management, dirt and gravel roads and storm drain cleaning.

2.6 Animal BMPs

Animal BMPs are applied to animal manure for specific animal types. The fate of manure nutrients depends on natural processes and management actions. Some animal BMPs (e.g., feeding management

BMPs) directly reduce the concentration of nitrogen or phosphorus per ton of manure. Other animal BMPs relocate the manure from one load source to another; for example, animal waste management systems (AWMS) reduce the amount of nitrogen deposited on the feeding space load source and increase the amount of nitrogen available for field application or transport. Figure 6 provides a simple schematic of how manure nutrients are accounted for in the Watershed Model.

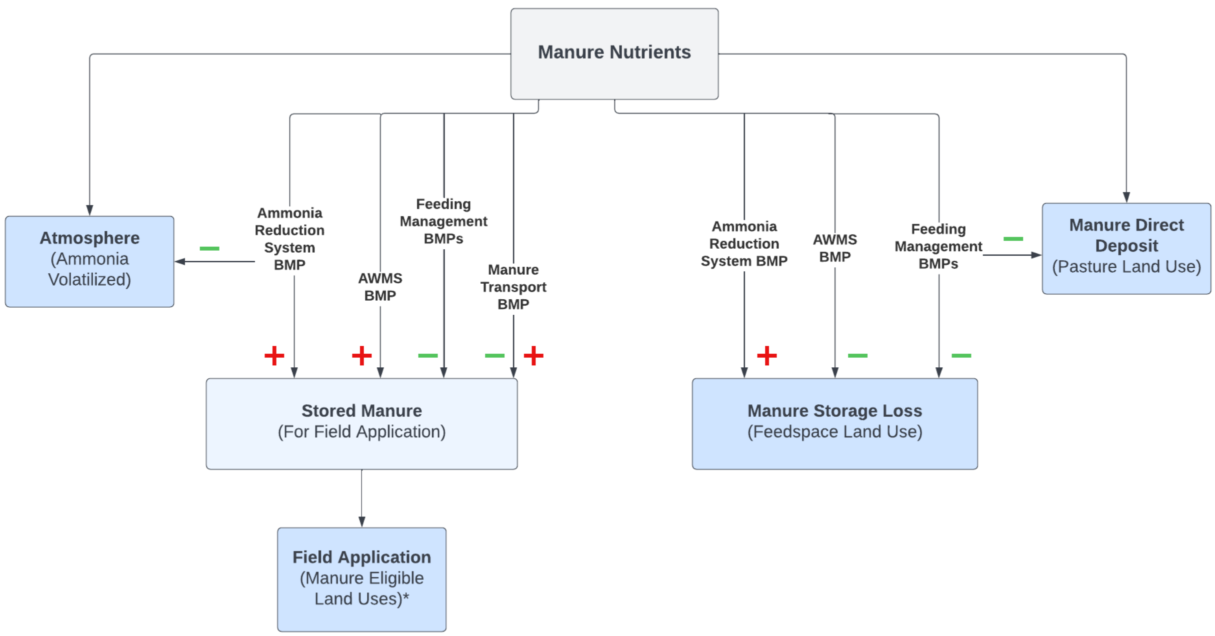


Figure 6 - Impact of Animal BMPs on agricultural nutrient load sources*. The fate of manure nutrients depends on both natural processes and management actions. Animal BMPs will not eliminate nutrients, but rather, shift them somewhere else. Green subtraction symbols indicate that the receiving load source (when appropriate labeled "land use") will have a decrease in total nitrogen and/or phosphorus. Red addition symbols indicate that the receiving load source will have an increase in total nitrogen and/or phosphorus. The impact of animal BMPs on agricultural nutrient loads in the Watershed Model is complex and dependent on several factors. Changes in manure management can result*
**Load Source Change BMPs may reduce available acres for manure application.*

The impact of animal BMPs on agricultural nutrient loads in the Watershed Model is complex and dependent on several factors. Changes in manure management can result in unanticipated changes in modeled loads. For example, when manure storage is improved to reduce manure loss (via animal waste management BMPs), more manure is available to spread on crops. In terms of the Watershed Model this means that the nutrient load on feeding space acres will be smaller, while the manure nutrients available to be applied on crop land will be greater. In situations where crop application goals are satisfied by available manure, the model assumes any excess manure will be spread on crop and pasture land to maintain the total manure mass balance.

Changes in land use can impact where manure is applied. Reduction of agricultural land use acres will reduce available acres for manure application. Development of rural areas and load source change BMPs (e.g., grass and forest buffers, agricultural land retirement) reduce the acres of land available to receive manure. The manure application rate per acre may increase because of the reduction of acres where the manure can be applied.

2.7 Exceptions

There are some BMPs that do not fit among the previous six categories. Among these exceptions are the two Stormwater Performance Standard BMPs (runoff reduction and stormwater treatment). The efficiency of each project or group of projects is determined by the number of impervious acres and the total volume of water treated. Regression equations describing these relationships were developed by the Stormwater Performance Standards Expert Panel. All the BMP type exceptions are discussed in Section 6.6 of the Watershed Model Documentation, including other notable cases such as agricultural Nutrient Management Core.

3. How is the effectiveness of BMPs calculated in the Watershed Model?

Just as each acre of land on the landscape may be impacted by multiple practices which reduce nutrient runoff, each acre in the BMP calculations can have multiple practices applied to it, contributing to what is referred to as a "pass-through factor" in the Watershed Model documentation.

BMPs that cannot physically occupy the same acre of land – two separate types of cover crop, for example – are known as mutually exclusive BMPs. All other BMPs in the Watershed Model are assumed to be randomly distributed in an area so that the probability of overlapping BMPs increases as the implementation level of each BMP increases.

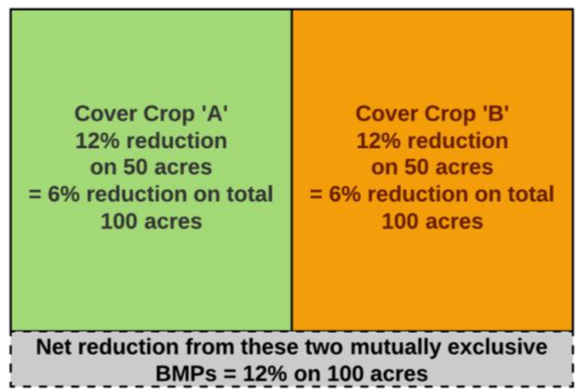


Figure 7 – Hypothetical example of two mutually exclusive BMPs with the same efficiency on 100 acres

Mutually exclusive BMPs can be thought of as **additive** since their efficiencies are added together. For example, if 50 acres of a 100-acre load source have cover crop A and 50 acres have cover crop B and both BMPs result in a 12 percent reduction on covered acres, then cover crop A effects a six percent reduction over the entire 100 acres as does cover crop B. The individual percentages can be added to arrive at a 12 percent total reduction for the load source. This is illustrated in Figure 7.

Alternatively, consider overlapping BMPs on a 100-acre load source with 100 acres of cover crop A at 12 percent reduction and 100 acres of a nutrient input reduction BMP with an eight percent reduction, as shown in Figure 8. The reductions are not additive since they apply to the same areas. The first BMP is applied, reducing the load to 88 percent of the original load. The second BMP causes an 8 percent reduction from that reduced load (i.e., an eight percent reduction to 88 percent of original load). Thus, the overall reduction is 19.04 percent (1.00 – ([1.00 – 0.08] × [1.00 – 0.12])). BMPs that can be applied to the same acre are called overlapping or **multiplicative**.

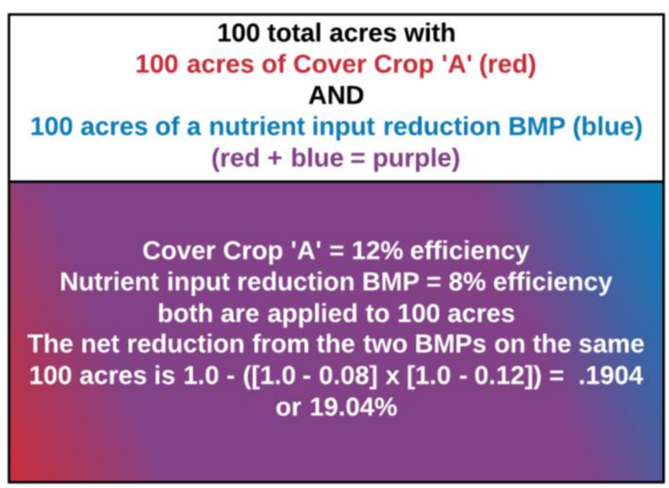


Figure 8 – Hypothetical example of two overlapping BMPs with different individual efficiencies on same 100 acres

When the Watershed Model generates the total efficiency of all BMPs, it first accounts for any load source change BMPs and then calculates the total efficiency of all BMPs for a single load source. The aggregate efficiency of sets of mutually-exclusive BMPs are calculated, and then overlapping BMPs are combined with the previously-calculated efficiencies. A pass-through factor for the cumulative sets of BMPs is calculated within the load source, land-river segment and agency for nitrogen, phosphorus and sediment (see section 4.1 for a description of load sources, land-river segments and agencies). Section 6 of the Watershed Model Documentation describes the equations and steps to calculate pass-through factors in more detail. For the purposes of this guide, it helps to understand that every BMP applied to a specific area contributes to the total pass-through factor for that area. Mutually-exclusive sets of BMPs and overlapping BMPs contribute to that net pass-through factor in different ways. The Watershed Model and tools like CAST do all the math, but it is easier to understand the results after learning the underlying concepts.

4. How are BMPs applied and distributed?

The application and distribution of BMPs can become complicated at a technical level, but is simpler to understand at a conceptual level. For those involved in annual BMP reporting and WIP development, it helps to understand these concepts, summarized below and described in more detail in Section 6.5 of the Watershed Model documentation:

- BMP distribution
- Load source groups
- Maximum implementation values

4.1 BMP distribution

BMPs are always applied in the Watershed Model at the smallest spatial scale: a single load source in a single land-river segment for an agency.

Load sources include different types of land use acres (e.g., pasture), as well as direct loads that are not associated with an area of land (e.g., direct manure deposition by cattle in a stream).

Land segments are portions of counties. River segments are uninterrupted lengths of a waterway and its adjacent area. The intersection of a land segment and river segment is a *land-river segment* (often referred to as “LRSeg” in Watershed Model source data and documentation). The spatial distribution also includes *agencies*, which are designations of federal and non-federal areas within a land river segment. There are nine federal agencies and three non-federal agencies in the Watershed Model, listed in *Table 3*.

Table 3 – List of federal and non-federal agency categories in the Phase 6 Watershed Model. Agency designations help stakeholders to better understand the attribution of load sources and BMPs within their geographic area.

Federal agencies in Watershed Model	Non-federal agencies in Watershed Model
Agricultural Research Service	Maryland State
Department of Defense	Maryland State Highway Administration
Other federal land	Non-federal
U.S. Forest Service	
U.S. Fish and Wildlife Service	
General Services Administration	
National Aeronautics and Space Administration	

National Park Service Smithsonian Institution	

The National Environmental Information Exchange Network (NEIEN) is used for tracking annual progress of BMP implementation. States can submit implementation of BMPs through NEIEN at a variety of scales—by latitude and longitude, county, state or hydrologic unit code (HUC). For geographic areas that cross the Chesapeake Bay watershed boundary, data can be submitted either for the entire county or for just the portion that is inside the watershed. For example, Chester County in Pennsylvania is mostly outside of the Chesapeake Bay watershed. BMPs can be submitted for only the watershed portion of Chester County or the entire county. If submitted for the entire county, they are assumed to be spread throughout the county.

When BMPs are submitted at a larger scale than land-river segment (for example, at a major-basin scale), they are distributed proportionately based on the number of receiving load source acres in each land-river segment within the larger-scale area (i.e., the land-river segments within a larger major basin). Figure 9 illustrates a hypothetical example of how this works for a single BMP reported for a whole county.

For planning scenarios, such as milestones and WIPs, more general data are needed; however, the same geographic designations can be used. In addition, BMPs can be submitted on the geographies listed in the CAST Source Data.

How do HUCs work?

Hydrologic Unit Codes (HUCs) are a common classification system for watersheds. The greater number of digits in a HUC, the smaller the area and more specific the designation. A four-digit HUC represents a subregion (e.g., 0205 is the Susquehanna River), six digits is a basin (e.g., 020501 is the Upper Susquehanna), eight digits is a sub-basin (e.g., 02050105 is the Chemung), ten digits is a watershed and twelve is a sub-watershed. Twelve-digit HUCs, on average, represent areas of only 10,000 to 40,000 acres according to the U.S. Geological Survey and USDA Natural Resources Conservation Service. HUC scales are available on even numbers from four to 12.

Source: U.S. Geological Survey and U.S. Department of Agriculture, Natural Resources Conservation Service, 2013, Federal Standards and Procedures for the National Watershed Boundary Dataset (WBD) (4 ed.): U.S. Geological Survey Techniques and Methods 11–A3, 63 p. Available at http://pubs.usgs.gov/tm/tm11a3/

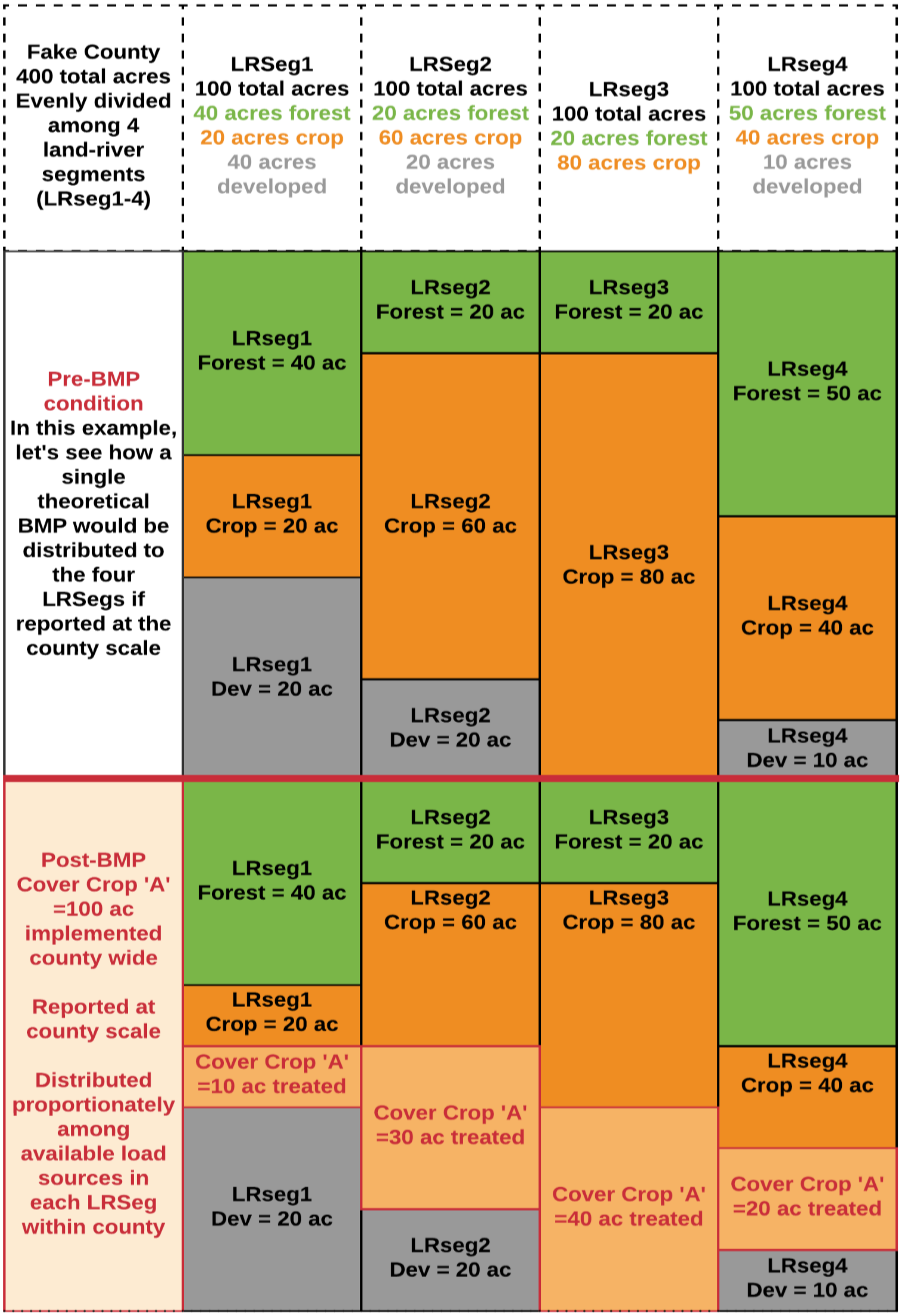


Figure 9 – Hypothetical example of how a single BMP is distributed among land-river segments within a county. This example is greatly simplified for illustrative purposes. Though it becomes more complex as more BMPs are added or as you move to larger scale (e.g., to major-basin or statewide scale) or finer specificity (e.g., to specific load sources and agencies within an LRseg), the same underlying logic applies.

4.2 Load source groups and order of load source change BMPs

BMPs can be submitted on a defined load source or animal groups, e.g., "crop" or "poultry." When submitted as a group, BMPs are divided according to the fraction of each area or load that comprises the group. The load source groups and animal groups are provided in the "source data" spreadsheet available through CAST (see "Load Source Group Components" or "Animal Group Components" tabs). Load source and animal groups can help to simplify BMP planning or reporting in cases where specific information is unknown.

Load source change BMPs that are applied to the same load source may be limited by the amount of load source available in that land-river segment for that agency. They are applied in an order such that BMPs higher on the list will be preferentially credited. Appendix 6B of the Watershed Model documentation shows the order and the load source that the BMP modifies. This information is also available in the Source Data spreadsheet on the CAST website.

Since Animal and Load Source BMPs can alter load sources available for other BMPs, they are credited prior to efficiency BMPs. Load reduction BMPs are credited last.

4.3 Enforcing maximum implementation values

BMP implementation values are capped at the available load source, which means that a load source cannot go below zero. Also, the sum of BMPs for a load source and land-river segment and agency cannot exceed the available area. If the BMP area exceeds the load source area, each BMP is reduced proportionally so that the sum of all the area equals the available area. An example:

- Submitted BMP amount:
  - Total acres available for the load source = 100
  - Cover Crop: Traditional Barley Early Drilled = 90%
  - Cover Crop: Traditional Forage Radish Plus Early Aerial = 60%
- Model Calculates:
  - Cover Crop: Traditional Barley Early Drilled acres: 90/(90+60)% × 100 = 60
  - Cover Crop: Traditional Forage Radish Plus Early Aerial acres: 60/(90+60)% × 100 = 40
- Result:
  - Cover Crop: Traditional Barley Early Drilled acres = 60
  - Cover Crop: Traditional Forage Radish Plus Early Aerial acres = 40

In the above example, the two BMPs are mutually exclusive and when added together cannot exceed the available area (100 acres). Therefore, they are reduced proportionately so that 60 acres of the barley cover crop and 40 acres of the forage radish cover crop are applied to the available load source area.

Tip: If using CAST, download the "BMPs Submitted vs. Credited" report from the reports page to verify that acres were available.

There are additional assumptions for maximum implementation specifically for the stream restoration BMP; if interested in that information, see section 6.5.4.1 of the Watershed Model documentation.

5. BMPs for future scenarios or planning scenarios

Some BMPs are available for simulation in the Watershed Model but are not approved for reporting in annual progress scenarios. If using CAST, you can choose which BMPs are available for the scenario you wish to create, either "official BMPs" or "planning BMPs."

Appendix B - Version History

Second Edition Updates – released November 16, 2022 or April 3, 2024.

Addition of the following BMP reference sheets:

- A11: Agricultural Stormwater Management Practices
- A18: Animal Mortality Management Practices
- A20: Poultry Litter Ammonia Control Practices
    - Poultry Litter Amendments + Biofilters
- A21: Agricultural Ditch Management Practices
    - Blind inlets
    - Drainage water management
    - P-removal structures
    - Saturated buffers
    - Denitrifying bioreactors
- A24: Nontidal Wetland Restoration, Creation, and Rehabilitation
- D3: Erosion and Sediment Controls for Construction Sites
- D4: Dirt and Gravel Roads Erosion and Sediment Control
- D8: Reducing Nutrients from Grey Infrastructure
- D10: Storm Drain Cleaning
- D11: Floating Treatment Wetlands
- D12: Impervious Cover Disconnections
    - Impervious Disconnection to Amended Soils
    - Impervious Surface Reduction
- D13: Urban Filter Strips
- N3: Algal Flow-way
- N4: Forest Harvesting Practices
- N5: Abandoned Mine Reclamation
- N6: Oyster Aquaculture Practices
- N7: Oyster Reef Restoration
- N8: Licensed Oyster Harvest
- S1: Septic Connection and Pumping
- S2: Advanced On-site Wastewater Treatment Systems
    - Septic Effluent – Enhanced
    - Septic Secondary Treatment
    - Septic Denitrification

Updates to existing BMP reference sheets:

- A5: Cover Crops – Commodity
    - Replaced photo
    - Updated language in qualifying conditions
        - “Commodity cover crops may be harvested, but if it received ***fall*** nutrient applications then it is not eligible as a BMP.”
- A-8 Pasture and Grazing

    - Included link to STAC workshop report
- A-12: Forest Buffers and Grass Buffers
    - Credit duration for Forest Buffers changed from 10 to 15 years.
- A-13: Forest Buffers and Grass Buffers with Stream Exclusion Fencing
    - Credit duration for Forest Buffers changed from 10 to 15 years.
- A-22: Tree Planting (Ag)
    - Credit duration changed from 10 years to 15 years.
    - Typo in date – changed to 2018.
- A-24: Wetland Restoration, Creation, and Rehabilitation
    - Added links to wetland BMP info sheets
    - Included creation and rehabilitation practices.
    - Removed wetland enhancement.
- D-5: Urban Stream Restoration
    - Edited information to reflect the 2020 urban stream restoration memos
        - Added Protocol 5 – Outfall and Gully stabilization projects
        - Default rate removed for new reporting after 6/30/2022
        - Added new and clarified qualifying conditions
        - Updated references/additional info section
- D-7: Urban Tree Planting
    - Credit duration changed from 10 to 15 years.

Updates to Introduction

- Additional BMPs added to table of contents.
- Disclaimer added to table of contents.
- Description for "Annual vs Cumulative BMPs" updated for clarity.
- Reworded misc. sections to improve clarity.

Updates to Appendix A

Section 2.6: Animal BMPs

- Recreated Figure 3 and reworded section to improve clarity.

Sections 5.1: Interim BMPs and 5.2 Land Policy BMPs were removed.

- Interim BMPs are not specified in the 2015 BMP Expert Panel Protocol. As such, the CBPO does not want to acknowledge practices that have not been reviewed in the appropriate context.
- Land Policy BMPs are likely to get updated and do not cover all the land policy BMP types. This is documented in the CAST documentation and is updated there. https://cast.chesapeakebay.net/Documentation#EditScenarioPolicyBMPs

A-1. Land Retirement and Alternative Crops

General Information

Farmers sometimes retire or convert cropland into less intensively managed vegetation such as hay or grasses. This is often done through voluntary state or federal conservation programs and typically focuses on marginal or highly erodible cropland. This land conversion is done for extended periods of time to reduce soil erosion, improve water quality, provide habitat or improve soil health.

Figure A-1-1. Land retired or converted to permanent vegetation requires less fertilizer and is not tilled or intensively managed once vegetation is established. Photo:

CBP Definition(s)

Alternative crops: Accounts for those crops that are planted and managed as permanent, such as warm season grasses, to sequester carbon in the soil.

Land retirement to Ag open space: Converts land area to hay without nutrients. Agricultural land retirement takes marginal and highly erosive cropland out of production by planting permanent vegetative cover such as shrubs, grasses and/or trees.

Land retirement to pasture: Converts land area to pasture. Agricultural land retirement takes marginal and highly erosive cropland out of production by planting permanent vegetative cover such as shrubs, grasses, and/or trees. Agricultural agencies have a program to assist farmers in land retirement procedures.

Specifications or Key Qualifying Conditions

There are no specific conditions for CBP purposes beyond the definitions above, with the expectation that reported cost-share practices conform to state or federal practice standards, and any non-cost-shared practices conform to the criteria described in the *Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report* (linked under Additional Information below).

Nitrogen, Phosphorus and Sediment Reductions

The reductions are equal to the difference between the prior higher-load crop land use and the new lower-load land use of either Ag Open Space or Pasture; average estimates of these BMP reductions for the Chesapeake Bay watershed-portion of the states are provided in Table A-1-1 below.

Table A-1-1. Average per-unit reductions for land retirement and alternative crop BMPs, by state, for nitrogen and sediment. These average load reductions are subject to change with the model. As statewide averages they may not reflect simulated reductions for practices in some areas. For current data or detailed methods for these estimated averages see "BMP Pounds Reduced and Costs by State." Available under "Develop Plans," [*http://cast.chesapeakebay.net/Documentation/DevelopPlans*](http://cast.chesapeakebay.net/Documentation/DevelopPlans).

Data from April 30, 2018 version of "BMP Pounds Reduced and Costs by State"	**Alternative crops** *(avg lbs reduced per acre)*		**Land retirement to Ag Open Space** *(avg lbs reduced per acre)*		**Land retirement to Pasture** *(avg lbs reduced per acre)*	
State	***TN***	***TSS***	***TN***	***TSS***	**TN**	**TSS**
Delaware	57	237	50	235	49	235
Maryland	24	875	20	708	17	799
New York	12	632	6	278	4	344
Pennsylvania	28	909	17	535	15	630
Virginia	31	919	11	318	15	555
West Virginia	19	1,712	5	190	4	371

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

The following load sources are applicable for the Alternative Crops BMP; if no load source or load source group is specified the default will be ROW.

- Double Cropped Land
- Full Season Soybeans
- Grain with Manure
- Grain without Manure
- Other Agronomic Crops
- Silage with Manure
- Silage without Manure
- Small Grains and Grains

Load sources below marked with an asterisk (*) are only applicable for Land Retirement to Ag Open Space and are not eligible for Land Retirement to Pasture. Otherwise, they are applicable for both BMPs. If no load source or load source group is specified the default will be ROW.

- Crop
- Crop Hay
- Crop Hay With Manure
- Crop With Manure
- Grains
- Hay
- Legume Hay
- Other Hay
- Pasture*
- Pasture Hay*
- Row
- Row With Manure
- Specialty
- Ag No Open*

Brief Description of BMP Simulation in the Model

The Land Retirement practices are *Load Source Change BMPs*. Each acre planted and reported under the Land Retirement BMP converts one acre from the previous load source to either Ag Open Space or Pasture. Each acre planted and reported under the Alternative Crops BMP converts one acre into Ag Open Space.

Annual or Cumulative? Cumulative (10-year credit duration; 5-years for Resource Improvement practices).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Alternative crops
  - Alternative crops/switchgrass RI (RI-3)
  - Land Retirement to Ag Open Space
  - Land Retirement to Pasture
  - Conversion to hayland RI (RI-14)
  - Conversion to pasture RI (RI-13)
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be ROW

- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the land area was retired.

Table A-1-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Alternative crops	Alternative crops; Alternative crop/Switchgrass RI (RI-3)	Carbon sequester alternative crop
Land retirement to Ag Open Space	Conservation cover; Conversion to hayland RI (RI-14); CREP Wildlife habitat; Critical area planting; Grass nutrient exclusion area on watercourse narrow; Land retirement; Permanent wildlife habitat, non-easement; Retirement of highly erodible land	Critical area planting (NRCS 342); Conservation cover (NRCS 327); permanent vegetative cover, retirement of highly erodible land
Land retirement to Pasture	Same NEIEN BMP names listed above for “Land Retirement to Ag Open Space” except “Conversion to Hayland (RI-14)” is not applicable; Conversion to pasture RI (RI-13); Pasture and hay planting	None

Additional Information

Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report: Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014. https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definition and benefits that have remained in use since review and approval by the CBP partnership’s source sector workgroups for tributary strategy development.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-2. Nutrient Management

General Information

Nutrient management planning has been a common practice for decades, as it helps the farmer maximize profits by balancing crop yields and nutrient inputs. Nutrient management has four basic components: nutrient source, rate, placement and timing. Under a Nutrient Management Plan, each of these four components is managed at the field or sub-field scale in a manner that supports crop productivity, achieves high nutrient use efficiency by the crop and minimizes nutrient loss.

Figure A-2-1. A tractor spreads liquid manure on a field. All crops need nutrients such as nitrogen and phosphorus to grow, and farmers can get those nutrients from animal manure, commercial inorganic fertilizers or both. Source: Chesapeake Bay Program.

CBP Definition(s)

Nutrient Management (NM): The implementation of a site-specific combination of nutrient source, rate, timing, and placement into a strategy that seeks to optimize agronomic and environmentally efficient utilization of nitrogen (N) and phosphorus (P). Improvement in nutrient-use efficiency necessitates documentation of nutrient management implementation strategies that are suitable for independent verification.

The BMPs for Nutrient Management are categorized into *Core Nutrient Management* and *Supplemental Nutrient Management* for both N and P. *Supplemental NM* is further divided by *Rate*, *Placement*, and *Timing*.

Nitrogen Core Nutrient Management: Applications of nitrogen are made in accordance to all of the following elements as applicable:

- Land-grant university recommendations for nitrogen applications at field level.
- Manure analysis and volume, using either test or book values to determine nitrogen content.
- Calibration of spreader/applicator.
- Yield estimates and cropping plan at the field level.
- Cropping and manure application history at the field level.

Figure A-2-2. A crop consultant collects a soil sample to test nitrogen availability in the soil. A test like this helps decide how much nitrogen the growing crop needs for optimum production. Source: NRCS Photo Gallery.

Phosphorus Core Nutrient Management: Applications of phosphorus are made in accordance to all of the following elements as applicable:

- Land-grant university recommendations for phosphorus at the field level. This may include recommendations resulting from advanced assessment (i.e., P Index, etc.) that recommend higher P application rates where the risk of P loss is low.
- Soil test for phosphorus levels at the field level. This requirement may be waived if restrictions on manure applications (rate, timing, and placement) are imposed that limit P application rates and management to the same degree as if the soil test result for phosphorus was in the "high" category.
- Manure analysis and volume using either test or book values to determine phosphorus content.
- Calibration of spreader/applicator.

- Yield estimates and cropping plan at the field level.
- Cropping and manure history at the field level.

Nitrogen Rate Supplemental NM: Applications of nitrogen are made in accordance to all elements of the Nitrogen Core practice, and one or more of the following practices are implemented resulting in a reduction in application rate of nitrogen:

- Nitrogen application rate made at less than land-grant university recommendations.
- Nitrogen applications split across the growing season, resulting in lower-than-planned applications.
- Nitrogen applications are made using variable rate goals, resulting in lower-than-planned applications.

Nitrogen Placement Supplemental NM: Applications of nitrogen are made in accordance to all elements of the Nitrogen Core practice, and one or more of the following practices are implemented resulting in better placement and utilization of nitrogen:

- Applications of inorganic nitrogen are injected into the subsurface or incorporated into the soil.
- Applications of nitrogen are made with setbacks from surface water features.

Nitrogen Timing Supplemental NM: Applications of nitrogen are made in accordance to all elements of the Nitrogen Core practice, and are split across the growing season into multiple applications to increase utilization of nitrogen.

Phosphorus Rate Supplemental NM: Applications of phosphorus are made in accordance to all elements of the Phosphorus Core practice, and one or more of the following practices are implemented resulting in a reduction in application rate of phosphorus:

- Applications of manure are based upon annual crop removal of phosphorus rather than nitrogen.
- Applications of phosphorus are made at less than land-grant university recommendations.
- Phosphorus applications are made using variable rate goals resulting in lower than planned applications.

Phosphorus Placement Supplemental NM: Applications of phosphorus are made in accordance to all elements of the Phosphorus Core practice, and one or more of the following practices are implemented resulting in better placement and utilization of nitrogen:

- Applications of inorganic phosphorus are injected into the subsurface or incorporated into the soil.
- Applications of phosphorus are made with setbacks from surface water features.

Phosphorus Timing Supplemental NM: Applications of phosphorus are made in accordance to all elements of the Phosphorus Core practice, and are made in seasons with a lower risk of phosphorus loss.

- Applications of phosphorus are split across the growing season resulting in lower than planned applications.

Specifications or Key Qualifying Conditions

All elements of the Core Nutrient Management BMP must be met to be eligible for one or more of the Supplemental BMPs for nitrogen and/or phosphorus.

Nitrogen, Phosphorus and Sediment Reductions

There are no sediment reductions for NM BMPs. Nutrient reductions vary for the Core and the three Supplemental NM practices for N and P. The acres of Core NM in a county impact the overall application goal for each crop within a county, using the values in Table A-2-1.

Table A-2-1. Core Nitrogen and Phosphorus NM Application Goal Multipliers

Land Use	Nitrogen *Non-NM*	Nitrogen Core *With NM*	Phosphorus *Non-NM*	Phosphorus Core *With NM*
Full Season Soybeans	1.2	1.0	1.5	1.0
Grain w/ Manure	1.3	1.0	3.0	1.0
Grain w/o Manure	1.2	1.0	1.5	1.0
Legume Hay	1.2	1.0	1.0	1.0
Silage w/ Manure	1.4	1.0	3.0	1.0
Silage w/o Manure	1.2	1.0	1.5	1.0
Small Grains and Grains	1.2	1.0	1.5	1.0
Double Cropped (Small Grains and Soybeans)	1.2	1.0	1.5	1.0
Specialty Crop High	1.3	1.0	2.0	1.0
Specialty Crop Low	1.2	1.0	2.0	1.0
Other Agronomic Crops	1.1	1.0	1.5	1.0
Other Hay	1.0	1.0	1.0	1.0
Pasture	1.0	1.0	1.0	1.0

Each supplemental practice is simulated as a percent reduction to estimated runoff from the appropriate land use, using the percent reductions listed in Table A-2-2.

Table A-2-2. Supplemental Nitrogen and Phosphorus Percent Reductions to Land Use Runoff.

Land Use	N Rate Supplemental	N Placement Supp.	N Timing Supp.	P Rate Supplemental	P Placement Supp.	P Timing Supp.
Full Season Soybeans	0%	0%	0%	5%	10%	1%
Grain w/ Manure	15%	5%	10%	10%	20%	20%
Grain w/o Manure	5%	3%	5%	5%	10%	1%
Legume Hay	0%	0%	0%	1%	10%	1%
Silage w/ Manure	15%	5%	10%	10%	20%	20%
Silage w/o Manure	5%	3%	5%	5%	10%	1%
Small Grains and Grains	5%	3%	10%	5%	10%	1%
Double Cropped (Small Grains and Soybeans)	5%	3%	10%	5%	10%	1%
Specialty Crop High	15%	5%	5%	5%	10%	1%
Specialty Crop Low	5%	3%	5%	5%	10%	1%
Other Agronomic Crops	5%	3%	5%	5%	10%	1%
Other Hay	0%	3%	5%	0%	10%	1%
Pasture	0%	0%	0%	0%	0%	0%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Full season Soybeans
- Grain with Manure
- Grain without Manure
- Silage with Manure
- Silage without Manure
- Small Grains and Grains
- Specialty Crop High
- Specialty Crop Low

- Other Agronomic Crops
- Other Hay
- Pasture

Because many of the land uses listed above represent rotational crops, it is not recommended that states track and report this level of detail. Instead, it is recommended that states report these acres on the land use group, “Crop,” which contains all of the above individual land uses.

Brief Description of BMP Simulation in the Model

The Core nutrient management practices are *Load Source Input Reduction BMPs*, while the Supplemental Nutrient Management practices are *Efficiency Value BMPs*. Each acre reported under the Core practices will adjust the nutrient application goal slightly from land-grant university recommendations using the values in Table A-2-1. For example, an acre of corn not receiving manure (a crop in the Grain without Manure land use) under the Nitrogen NM Core practice will have an application goal of 0.92 lbs. of nitrogen/bushel/acre. The modified land-grant university application goals will be increased by the multipliers provided in the tables above for each acre **not** under Core NM. All Supplemental NM practices are simulated as a percent reduction of the estimated runoff using the values in Table A-2-2.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes. Additionally, a single acre of land may qualify for all four types of NM BMPs (Core and three Supplemental) for both N and P if appropriate.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Nitrogen Core NM; Phosphorus Core NM; Nitrogen Rate Supplemental NM; Nitrogen Timing Supplemental NM; Nitrogen Placement Supplemental NM; Phosphorus Rate Supplemental NM; Phosphorus Timing Supplemental NM; Phosphorus Placement Supplemental NM
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be CROP
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year plan was active.

Table A-2-3. Synonymous BMP names for Watershed Model, NEIEN and other sources.

<table>
<tr><th>CBP or Expert Panel term</th><th>NEIEN BMP name</th><th>Other common practice names</th></tr>
<tr><td>Nitrogen Core NM</td><td>Nutrient Management Core N</td><td rowspan="8">NRCS 590,* E590118Z,* E590119Z,* E590118X*

*Acres of nutrient management cost-shared under the NRCS 590 or enhanced 590 standards do not automatically fulfill the Core or Supplemental NM definitions. However, partners can verify how many of the acres meet which Core and/or Supplemental NM definitions.</td></tr>
<tr><td>Phosphorus Core NM</td><td>Nutrient Management Core P</td></tr>
<tr><td>Nitrogen Placement Supplemental NM</td><td>Nutrient Management N Placement</td></tr>
<tr><td>Nitrogen Rate Supplemental NM</td><td>Nutrient Management N Rate</td></tr>
<tr><td>Nitrogen Timing Supplemental NM</td><td>Nutrient Management N Timing</td></tr>
<tr><td>Phosphorus Placement Supplemental NM</td><td>Nutrient Management P Placement</td></tr>
<tr><td>Phosphorus Rate Supplemental NM</td><td>Nutrient Management P Rate</td></tr>
<tr><td>Phosphorus Timing Supplemental NM</td><td>Nutrient Management P Timing</td></tr>
</table>

Additional Information

Expert panel report:
Coale, F., Osmond, D., Beegle, D., Meisinger, J., Fisher, T., & Q. Ketterings. 2016. Nutrient Management Practices for use in the Phase 6.0 Chesapeake Bay Program Watershed Model. CBP/TRS-307-16.
http://www.chesapeakebay.net/documents/Phase_6_NM_Panel_Report_11-28-2016_New_Template_FINAL.pdf

Example USDA NRCS National Conservation Practice Standards:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

USDA NRCS Nutrient Management:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/landuse/crops/npm/

International Plant Nutrition Institute. Video. The Role of 4R Nutrient Stewardship in Reducing Greenhouse Gas Emissions:
https://youtu.be/eD2SeH8IZZw

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol

A-3. Conservation Tillage

General Information

Conservation tillage involves the planting, growing and harvesting of crops with minimal disturbance to the soil. The amount of crop residue coverage is higher when compared to conventional or high tillage methods. This practice uses seeders and techniques that are more precise and requires fewer passes, which reduces soil disturbance. Greater crop residue coverage and lower soil disturbance protect against erosion from wind and rain.

Figure A-3-1. Corn growth with crop residue. Crop residue is a mix of stalks, leaves, roots or other plant materials left on the field following harvest. The residue helps prevent erosion from wind and rain while allowing the next crop to grow through. Source: CTIC

CBP Definition(s)

Conventional Tillage: Any tillage routine that does not achieve 15 percent crop residue coverage immediately after planting is considered conventional tillage and does not qualify as a BMP.

Low Residue Tillage: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 15 to 29 percent crop residue coverage immediately after planting each crop.

Conservation Tillage: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 30 to 59 percent crop residue coverage immediately after planting each crop.

High Residue, Minimum Soil Disturbance Tillage: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain at least 60 percent crop residue coverage immediately after planting each crop.

Figure A-3-2. Rows grown in the ridge till method. Source: CTIC

Specifications or Key Qualifying Conditions

The tillage routine must maintain 15 percent or greater crop residue coverage immediately after planting to be considered a BMP. There are no additional specifications or qualifying conditions beyond those described in the definitions above.

Nitrogen, Phosphorus and Sediment Reductions

Nutrient reductions vary based on hydrogeomorphic region (HGMR), while sediment reductions are consistent across all regions. It is not expected that the specific HGMR of a farm field is known, instead the reported acres are distributed by the model. For example, if 50 percent of cropland in a county is in Piedmont Carbonate and 50 percent Piedmont Crystalline, then the conservation tillage acres submitted for that county are split 50/50.

Table A-3-1. Nitrogen, Phosphorus and Sediment Efficiency Value Reductions for Tillage Practices

HGMR	Nitrogen Reductions (%)			Phosphorus Reductions (%)			Sediment Reductions (%)		
	Low Residue	Conser-vation Tillage	High Residue	Low Residue	Conser-vation Tillage	High Residue	Low Residue	Conser-vation Tillage	High Residue
Appalachian Plateau, Siliciclastic	5	10	14	7	17	27	18	41	79
Appalachian Plateau, Carbonate	5	10	14	7	27	38	18	41	79
Blue Ridge	5	10	14	8	50	63	18	41	79
Coastal Plain Dissected Upland	2	4	12	8	35	47	18	41	79
Coastal Plain Lowland	2	4	15	6	2	11	18	41	79
Coastal Plain Upland	2	4	12	7	16	26	18	41	79
Mesozoic Lowland	5	10	14	7	21	32	18	41	79
Piedmont Carbonate	5	10	14	9	60	74	18	41	79
Piedmont Crystalline	5	10	14	9	58	71	18	41	79
Valley and Ridge Carbonate	5	10	14	9	57	71	18	41	79
Valley and Ridge Siliciclastic	5	10	14	8	49	62	18	41	79

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Full season Soybeans
- Grain with Manure
- Grain without Manure
- Silage with Manure
- Silage without Manure
- Small Grains and Grains
- Double Cropped Land
- Specialty Crop High
- Specialty Crop Low
- Other Agronomic Crops

Because many of the land uses listed above represent rotational crops, it is not recommended that states track and report this level of detail. Instead, it is recommended that states report these acres on the land use group, "Crop," which contains all of the above individual land uses.

Figure A-3-3. Corn (left) and soybean (right) residue cover percentages (25, 50, 75, 90). The percentage of residue coverage increases from top to bottom for each crop in a column. Source: University of Nebraska Extension

Brief Description of BMP Simulation in the Model

All conservation tillage practices are *Efficiency Value BMPs*. Runoff from applicable load sources is reduced by the efficiency values listed below in Table A-3-1. For example, if a state submits that 100 percent of acres within a county in the Appalachian Plateau Siliciclastic region are covered by High Residue Tillage Management, then nitrogen from all acres will be reduced by 14 percent, phosphorus by 27 percent and sediment by 79 percent as compared to the same land under conventional tillage. If, however, only 50 percent of acres are reported for the same practice, then half the cropland in that county would be simulated as conventional tillage and half would have the respective nitrogen, phosphorus and sediment reductions for the High Residue Tillage Management BMP applied.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Low Residue Tillage may be reported under the names: Reduced Tillage
  - Conservation Tillage may be reported under the names: Conservation Tillage; Mulch Tillage; No Tillage, and; Ridge Tillage
  - High Residue, Minimum Soil Disturbance may be reported under the name: High Residue Tillage Management
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be CROP
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year residue was observed.

Table A-3-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Low Residue Tillage	Reduced Tillage	Residue and Tillage Management, No-Till (NRCS 329)*
Conservation Tillage	Conservation Tillage Mulch Tillage No Tillage Ridge Tillage	Residue and Tillage Management, No-Till (NRCS 329)* Residue and Tillage Management, Reduced Till (NRCS 345)*
High Residue, Minimum Soil Disturbance Tillage	High Residue Tillage Management	Residue and Tillage Management, No-Till (NRCS 329)*

*Acres cost-shared and implemented under the NRCS 329 standard do not automatically fulfill the CBP's definitions for Low Residue Tillage, Conservation Tillage, or High Residue, Minimum Soil Disturbance Tillage, but with proper verification can demonstrate how many acres meet which of the definitions. Likewise, acres cost-shared and implemented under the NRCS 345 standard do not automatically fulfill the CBP's definition for Conservation Tillage, but proper verification can demonstrate how many acres meet the definition.

Additional Information

Expert panel report:

Thomason, W., Duiker, S., Ganoe, K., Gates, D., McCollum, B., & M. Reiter. 2016. Conservation Tillage Practices for use in Phase 6 of the Chesapeake Bay Watershed Model. CBP/TRS-308-16. *http://www.chesapeakebay.net/documents/CT_6.0_Conservation_Tillage_EP_Revised_Full_Report_12-14-16.2_FINAL_NEW_TEMPLATE.pdf*

Example USDA NRCS National Conservation Practice Standards:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

USDA NRCS. Video. The Science of Soil Health: Using Cover Crops to Soak up Nutrients for the Next Crop:
https://youtu.be/CVf2yF19tx8

Conservation Technology Information Center: https://www.ctic.org/

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-4. Cover Crops – Traditional

General Information

Cover crops are short-term crops grown after the main cropping season to reduce nutrient and sediment losses from the farm field. The selected crop species and management of cover crops vary based on the farmer's needs and preferences.

Figure A-4-1. Farm field with visible cover crops. Source: Chesapeake Bay Program.

CBP Definition(s)

Traditional Cover Crop: A short-term crop grown after the main cropping season to reduce nutrient losses to ground and surface water by sequestering nutrients. This type of cover crop may not receive nutrients in the fall and may not be harvested in the spring.

Traditional Cover Crop with Fall Nutrient Applications: A short-term crop grown after the main cropping season to reduce nutrient losses to ground and surface water by sequestering nutrients. This type of cover crop is planted upon cropland where manure is applied following the harvest of a summer crop and prior to cover crop planting. The crop may not be harvested in the spring.

Specifications or Key Qualifying Conditions

As noted in the definitions, the application of nutrients in the fall determines which Traditional Cover Crop practice is applicable. Traditional Cover Crops are not harvested in the spring. If a cover crop is harvested (e.g., a winter cereal) then it would count as a Commodity Cover Crop (see A-5. Cover Crops – Commodity).

Figure A-4-2. As pictured here, cover crops such as ryegrass can be combined with other practices such as no-till management (see Sheet A-3: Conservation Tillage). These practices can help build organic matter, improving the soil health in addition to reducing erosion and nutrient pollution. Source: NRCS Soil Health Campaign, Flickr.

The planting date (early, standard, or late) is based on the average frost date for the area. *Early* means the cover crop is planted more than two weeks before the average frost date. *Standard* or *normal* is when the cover crops is planted between the average frost date and two weeks before that date. *Late* is when the cover crop is planted within three weeks after the average frost date.

Cover crop BMPs can also be distinguished by the planting or seeding method (aerial, drilled, other). *Aerial* includes seeding by airplane and other broadcast methods where the seed is not incorporated into the soil (including broadcast only and broadcast/stalk-chopped). *Drilled* involves planting with a seed drill, whether no-till or conventional till conditions apply. *Other* includes any non-drilled seeding method where the seed is incorporated into the soil, e.g., broadcast and disked.

Nitrogen, Phosphorus and Sediment Reductions

Nutrient reductions vary based on hydrogeomorphic region (HGMR), cover crop species, planting date and planting method.

The nitrogen efficiency values for Traditional Cover Crops range from 3 to 45 percent; the nitrogen values for Traditional Cover Crops with Fall Nutrients range from 6 to 32 percent. For Traditional Cover Crops both with and without fall nutrients, phosphorus effectiveness values range from 0 to 15 percent, and sediment effectiveness values range from 0 to 20 percent. Table A-4-1 lists the nitrogen, phosphorus and sediment efficiency values for two common cover crops –

Rye and Wheat – without fall nutrients. A complete list of the values for all cover crop variants is available in Appendix A of the expert panel report, as well as in the source data posted on the CAST website (http://cast.chesapeakebay.net/).

Table A-4-1. Traditional Cover Crop effectiveness values for total nitrogen (TN), total phosphorus (TP) and sediment (TSS). Only Rye and Wheat cover crops listed; full table of values available in panel report and CAST documentation.

	Coastal Plain/ Piedmont Crystalline/ Karst						Mesozoic Lowlands/ Valley and Ridge Siliciclastic					
	Low-till land uses			High-till land uses			Low-till land uses			High-till land uses		
BMP long name	TN (%)	TP (%)	TSS (%)	TN (%)	TP (%)	TSS (%)	TN (%)	TP (%)	TSS (%)	TN (%)	TP (%)	TSS (%)
Cover Crop Traditional Rye Early Drilled	45	0	0	45	15	20	34	0	0	34	15	20
Cover Crop Traditional Rye Early Other	38	0	0	38	15	20	29	0	0	29	15	20
Cover Crop Traditional Rye Early Aerial	25	0	0	25	15	20	19	0	0	19	15	20
Cover Crop Traditional Rye Normal Drilled	41	0	0	41	7	10	31	0	0	31	7	10
Cover Crop Traditional Rye Normal Other	35	0	0	35	7	10	27	0	0	27	7	10
Cover Crop Traditional Rye Late Drilled	19	0	0	19	0	0	15	0	0	15	0	0
Cover Crop Traditional Rye Late Other	16	0	0	16	0	0	12	0	0	12	0	0
Cover Crop Traditional Wheat Early Drilled	31	0	0	31	15	20	24	0	0	24	15	20
Cover Crop Traditional Wheat Early Other	27	0	0	27	15	20	20	0	0	20	15	20
Cover Crop Traditional Wheat Early Aerial	17	0	0	17	15	20	13.5	0	0	13.5	15	20
Cover Crop Traditional Wheat Normal Drilled	29	0	0	29	7	10	22	0	0	22	7	10
Cover Crop Traditional Wheat Normal Other	24	0	0	24	07	10	19	0	0	19	7	10
Cover Crop Traditional Wheat Late Drilled	13	0	0	13	0	0	10	0	0	10	0	0
Cover Crop Traditional Wheat Late Other	11	0	0	11	0	0	9	0	0	9	0	0

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

Because many of the applicable land uses represent rotational crops, it is not recommended that states track and report this level of detail. Instead, it is recommended that states report these acres on the land use group “Crop,” which contains all of the following individual land uses:

- Full season Soybeans
- Grain with Manure
- Grain without Manure
- Silage with Manure
- Silage without Manure
- Small Grains
- Specialty Crop High
- Specialty Crop Low
- Other Agronomic Crops
- Double-Cropped

Brief Description of BMP Simulation in the Model

All cover crop practices are *Efficiency Value BMPs*. Runoff from applicable load sources is reduced by the efficiency values listed in Table A-4-1 and Figure 1 in Appendix A of the expert panel report.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - There are many variants of Traditional Cover Crops available in the NEIEN appendix, which are not listed here. BMP names vary by the species of the cover crop, planting date (early, normal, late), and planting method (aerial, drilled, other). A smaller number of variants are also available for Traditional Cover Crops with Fall Nutrients.
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses (Full season Soybeans; Grain with Manure; Grain without Manure; Silage with Manure; Silage without Manure; Small Grains; Specialty Crop High; Specialty Crop Low; Other Agronomic Crops; Double-Cropped); if none are reported the default will be CROP
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year cover crop was observed.

Table A-4-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Traditional Cover Crop	There are 220 variants of traditional cover crops available in NEIEN. Not listed here due to space. The available species of cover crops for this BMP are listed in the right-hand column of this table.	Cover Crop (NRCS 340)* Wheat, Rye, Barley, Forage Radish, Annual Legume, Triticale, Legume plus Grass 25-50%, Legume plus Grass 50%, Annual Ryegrass, Oats, Brassica
Traditional Cover Crop with Fall Nutrients	There are 36 variants of traditional cover crops with fall nutrients available in NEIEN. Not listed here due to space. The available species of cover crops for this BMP are listed in the right-hand column of this table.	Wheat, Rye, Barley, Forage Radish, Annual Legume, Triticale, Legume plus Grass 25-50%, Legume plus Grass 50%, Annual Ryegrass, Oats, Brassica

*Acres implemented and reported as NRCS 340 will default to "Cover Crop Traditional Wheat Late Other," unless the state has other information to specify those acres as other cover crop variants.

Additional Information

Expert panel report:
Staver, K., White, C., Meisinger, J., Salon, P., & W. Thomason. 2016. Cover Crops Practices for use in Phase 6 of the Chesapeake Bay Watershed Model. CBP/TRS-310-16.
http://www.chesapeakebay.net/documents/Phase_6_CC_EP_Final_Report_12-16-2016-NEW_TEMPLATE_FINAL.pdf

Example USDA NRCS National Conservation Practice Standards:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-5. Cover Crops – Commodity

General Information

Cover crops are short term crops grown after the main cropping season to reduce nutrient and sediment losses from the farm field. The selected crop species and management of cover crops vary based on the farmer's needs and preferences. Winter cereals such as barley, rye and wheat are often harvested in the spring, unlike many traditional species of cover crops (see Sheet A-4. Cover Crops – Traditional).

Figure A-5-1. Winter wheat planted in the fall and harvested in the spring is an example of a Commodity Cover Crop. Source: Ken Staver, University of Maryland, with permission.

CBP Definition(s)

Commodity Cover Crop: A winter cereal crop planted for harvest in the spring which does not receive nutrient applications in the fall. Any winter cereal crop which did receive applications in the fall is not eligible for nutrient reductions.

Specifications or Key Qualifying Conditions

Commodity cover crops may be harvested, but if it received fall nutrient applications then it is not eligible as a BMP.

The planting date (early, standard, or late) is based on the average frost date for the area. *Early* means the cover crop is planted more than two weeks before the average frost date. *Standard* or *normal* is when the cover crop is planted between the average frost date and two weeks before that date. *Late* is when the cover crop is planted within three weeks after the average frost date.

Cover crop BMPs can also be distinguished by the planting or seeding method (aerial, drilled, other). *Aerial* includes seeding by airplane and other broadcast methods where the seed is not incorporated into the soil (including broadcast only and broadcast/stalk-chopped). *Drilled* involves planting with a seed drill, whether no-till or conventional till conditions apply. *Other* includes any non-drilled seeding method where the seed is incorporated into the soil, e.g., broadcast and disked.

Nitrogen, Phosphorus and Sediment Reductions

Nitrogen reductions range from 4 to 15 percent and vary based on hydrogeomorphic region (HGMR), planting date (early, standard or late) and whether they are applied to low- or high-till land uses. The effectiveness values for nitrogen are summarized in Table A-5-1. There are no phosphorus or sediment reductions associated with this BMP.

Table A-5-1. Commodity cover crop TN reductions. There are no TP or Sediment reductions associated with this BMP.

BMP	Coastal Plain, Piedmont Crystalline and Karst HGMRs		Mesozoic Lowlands, Valley and Ridge Silliciclastic HGMRs	
	Low-Till land uses	High-Till land uses	Low-Till land uses	High-Till land uses
	TN (%)	TN (%)	TN (%)	TN (%)
Commodity Cover Crop, Early	5	5	4	4
Commodity Cover Crop, Standard	10	10	8	8
Commodity Cover Crop, Late	15	15	12	12

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

Because the applicable land uses represent rotational crops, it is not recommended that states track and report this level of detail. Instead, it is recommended that states report these acres on the land use group, "Small Grains and Double-Crops," which contains all of the following individual land uses:

- Small Grains and Grains
- Double Cropped Land

Brief Description of BMP Simulation in the Model

All cover crop practices are *Efficiency Value BMPs*. Runoff from applicable load sources is reduced by the efficiency values listed in Table A-5-1.

Annual or Cumulative? Annual (1-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Commodity Cover Crop, Early
    - Commodity Cover Crop, Standard
    - Commodity Cover Crop, Late
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be Small Grains and Double-Crop
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year cover crop was observed.

Table A-5-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Commodity Cover Crop	Commodity Cover Crop, Early Commodity Cover Crop, Standard Commodity Cover Crop, Late There are ~142 other variants of commodity cover crops available in NEIEN, not listed here due to space, which are based on the crop species, planting date and planting method. The eligible species are listed in the right-hand column.	Cover Crop – Harvestable, Commodity Cover Crop. Harvestable commodity cover crops include: Barley, Rye, Ryegrass, Wheat, Clover/Wheat, Spring Oats, Oats, Canola/Rapeseed, Triticale

Additional Information

Expert panel report:
Staver, K., White, C., Meisinger, J., Salon, P., & W. Thomason. 2016. Cover Crops Practices for use in Phase 6 of the Chesapeake Bay Watershed Model. CBP/TRS-310-16.
http://www.chesapeakebay.net/documents/Phase_6_CC_EP_Final_Report_12-16-2016-NEW_TEMPLATE_FINAL.pdf

Example USDA NRCS National Conservation Practice Standards:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

Conservation Technology Information Center: https://www.ctic.org/

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016. Updates to this reference sheet were published on November 14, 2022.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-6. Animal Waste Management System

General Information

Manure is a resource that can be used in a variety of ways, but before it can be applied to a field or transported elsewhere, farms must first collect and store the manure. Farmers and other practitioners understand Animal Waste Management System (AWMS) as a general system that includes all aspects of managing manure (Figure A-6-2). However, the AWMS BMP, as defined by the CBP for purposes of annual BMP progress reporting and the Phase 6 Watershed Model, reflects manure storage and the expected improvements in manure recoverability. Manure storage improves the farmer's ability to manage manure through additional practices, such as Manure Treatment (A-15. Manure Treatment Thermochemical) or improved timing of field application (A-2. Nutrient Management).

Figure A-6-1. This dry manure stacking facility (at left in photo) is used to store manure until the farmer is ready to treat, transport or apply it. The pictured facility has a roof and concrete walls to prevent manure loss or runoff. Source: NRCS Photo Gallery.

CBP Definition(s)

Animal Waste Management System (AWMS): Any structure designed for collection, transfer and storage of manures and associated wastes generated from the confined portion of animal operations and complies with NRCS 313 (Waste Storage Facility) or NRCS 359 (Waste Treatment Lagoon) practice standards. Manure conserved through reduced storage and handling losses associated with AWMS implementation are available for land application or export from the farm.

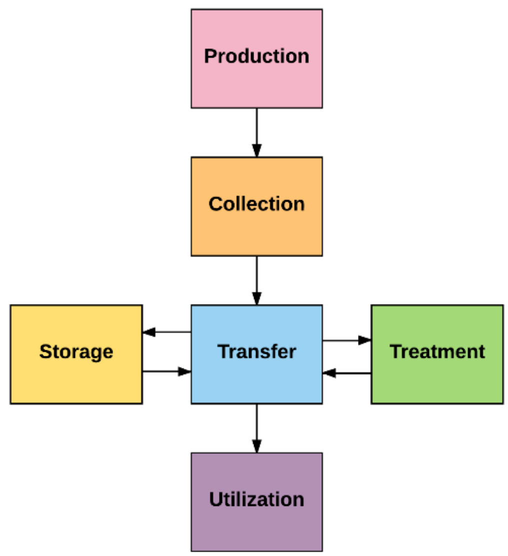


Figure A-6-2. Animal waste management is a general system that encompasses a range of management activities on the farm, including collection, storage, transfer and utilization of the manure. Adapted from NRCS 1992 Agricultural Waste Management Field Handbook, Chapter 9.

Specifications or Key Qualifying Conditions

There are no additional specifications or qualifying conditions beyond those described in the definitions above.

Nitrogen, Phosphorus and Sediment Reductions

AWMS practices alter the amount of manure that is recovered for subsequent field application or transport. There is no sediment load, and thus no sediment reduction, associated with animal manure and this practice. The amount of manure recovered by the BMP varies by the animal type, as shown in Table A-6-1. The values for manure recoverability in Table A-6-1 apply only to the confined portion of each type of animal operation. In other words, manure deposited on pasture or directly in a stream is not recoverable and not affected by the AWMS practice.

Table A-6-1. Manure recoverability before and after AWMS.

Animal Type	% Recoverable without AWMS	% Recoverable with AWMS
Beef	60	99
Dairy	75	95
Other Cattle	60	99
Hogs for Slaughter	90	99
Hogs for Breeding	90	99
Broilers	90	99
Layers	90	99

Turkeys	90	99
Pullets	90	99
Sheep	95	98
Horses	95	98
Goats	95	98

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

AWMS practices are applicable to all animal types in the Watershed Model (see Table A-6-1). When the specific animal type is not known, the practice can also be reported on "Poultry" or "Livestock."

Brief Description of BMP Simulation in the Model

AWMS practices are simulated as *Animal BMPs*. Specifically, the amount of manure that is lost from storage or handling is reduced according to the values listed in Table A-6-1, thus making the recovered manure available for transport or application to crops.

Annual or Cumulative? Cumulative (15-year credit duration)

Can this practice be combined with other BMPs? Yes. This practice is the only BMP that affects manure recoverability and any subsequent BMPs can also be applied.

Figure A-6-3. Storage practices come in different shapes and sizes. Storage pits or lagoons are used for liquid manure such as dairy cow or swine manure. Pictured is a lagoon in Virginia. Source: NRCS Photo Gallery.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Choose from available BMP names in the NEIEN Phase 6 Appendix
- *Measurement unit:* Choose from: Systems; (Animal)_AU; or Animals
- *Land Use:* N/A
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year system was constructed.

Table A-6-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Animal Waste Management System	Animal Waste Management System (AWMS)	Waste Storage Facility (NRCS 313) Waste Treatment Lagoon (NRCS 359) Waste Storage Structure, Dry Waste Storage Structure, Waste Storage Pond

Additional Information

Expert panel report:

Hawkins, S., Hamilton, D., McIntosh, B., Moyle, J., Risse, M., & P. Vanderstappen. 2016. Animal Waste Management Systems: Recommendations from the BMP Expert Panel for Animal Waste Management Systems in the Phase 6 Watershed Model. CBP/TRS-315-16.
http://www.chesapeakebay.net/documents/AWMS_EP_Report_WQGIT_approved_December_2016_final.pdf

eXtension.org – What does manure collection and storage look like? http://articles.extension.org/pages/74482/what-does-manure-collection-and-storage-look-like

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-7. Barnyard Runoff Control and Loafing Lot Management

General Information

Many farmers utilize roof gutters and other practices to help protect water quality and improve management of livestock production areas, including barnyards and loafing areas.

Figure A-7-1. Gutters, or roof runoff structures, can divert precipitation away from areas where animals and manure are present, which keeps the runoff water clean. Photo: USDA NRCS.

CBP Definition(s)

Barnyard runoff control includes the installation of practices to control runoff from barnyard areas. This includes practices such as roof runoff control, diversion of clean water from entering the barnyard and control of runoff from barnyard areas.

Loafing lot management is the stabilization of areas frequently and intensively used by people, animals or vehicles by establishing vegetative cover, surfacing with suitable materials, and/or installing needed structures. This does not include poultry pad installation.

Specifications or Key Qualifying Conditions

Cost-shared runoff control or stabilization must meet the standards of the federal or state program in which they are enrolled. Non-cost-shared gutters or runoff control structures must be documented and meet the CBP's criteria as defined for the relevant Resource Improvement (RI) practice (CBP RI-16, barnyard clean water diversion).

Nitrogen, Phosphorus and Sediment Reductions

The nitrogen, phosphorus and sediment reductions for barnyard runoff control and loafing lot management are summarized in Table A-7-1. The efficiency values are applied to permitted and non-permitted feeding space in the Watershed Model.

Table A-7-1. Nitrogen, phosphorus and sediment efficiency values for barnyard runoff control and loafing lot management in the Phase 6 Watershed Model

	Nitrogen *Efficiency (%)*	Phosphorus Efficiency (%)	Sediment Efficiency (%)
Barnyard Runoff Control	20	20	40
Loafing Lot Management	20	20	40

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

This BMP can be reported on feeding space load sources:

- Non-permitted Feeding Space
- Permitted Feeding Space

If the specific load source is not known the load source group "FEED" can be used, which includes both Non-permitted and Permitted Feeding Space load sources.

Brief Description of BMP Simulation in the Model

Both the barnyard runoff control and loafing lot management practices *Efficiency Value BMPs*. Each acre reported under the practices will reduce the nitrogen, phosphorus and sediment loads from feed space according to the efficiencies in Table A-7-1.

Annual or Cumulative? Cumulative (10-year credit duration for both barnyard runoff control and loafing lot management; 5-year credit duration for CBP RI-16, barnyard clean water diversion).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Barnyard Runoff Control
    - Loafing Lot Management
- *Measurement unit:* Acres or Percent.
- *Load Source:* Approved NEIEN agricultural feeding space load sources; if none are reported the default will be FEED.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year system was installed or inspected.

Table A-7-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Barnyard Runoff Control	Barnyard Runoff Control	Roof runoff structure (NRCS 558); Diversion (NRCS 362); Stormwater Runoff Control (NRCS 570); Trails and Walkways (NRCS 575)
Barnyard clean water diversion	Barnyard clean water diversion RI	Barnyard clean water diversion (CBP RI-16)
Loafing Lot Management	Loafing Lot Management	Loafing Lot Management System

Additional Information

Locate and consult your state and county USDA Field Office Technical Guide (FOTG) for details on conservation practices: https://efotg.sc.egov.usda.gov/

Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report: Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014. https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the Chesapeake Bay Program's Nutrient Subcommittee in 2003.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-8. Pasture and Grazing Management Practices

General Information

Many farmers allow horses, dairy cows, and beef cattle to eat grass or other forage vegetation – i.e., graze – in pastures during non-winter months. Grazing, movement and manure deposition by the animals encourages growth of pasture vegetation. However, animals can overgraze a pasture if there is not enough area to graze for the number of animals, or if they are not moved to a fresh area frequently enough. Overgrazing can lead to a loss of vegetative cover, soil erosion and nutrient runoff. By rotating animals to other areas or pastures, the recently grazed vegetation has an opportunity to regrow. Farmers consider a number of factors specific to their operational needs and capacity, such as animal type, pasture soils and vegetation, when determining the most effective way to manage their herd. Related BMPs, such as buffers with exclusion fencing (see A-13) or off-stream watering (see A-19), are not discussed here.

Figure A-8-1. Animals' diets may be supplemented in other ways by the farmer, but grazing time in a pasture allows animals to eat, drink, socialize, exercise, or relax at their own pace. Photos: USDA NRCS (top); Chesapeake Bay Program (bottom).

CBP Definition(s)

Horse Pasture Management: maintaining a 50% pasture cover with managed species and managing high traffic areas.

Precision Intensive Rotational/Prescribed Grazing: This practice utilizes a range of pasture management and grazing techniques to improve the quality and quantity of the forages grown on pastures and reduce the impact of animal travel lanes, animal concentration areas or other degraded areas. PG can be applied to pastures intersected by streams or upland pastures outside of the degraded stream corridor (35 feet width from top of bank). Pastures under the PG systems need to have a vegetative cover of 60% or greater.

Specifications or Key Qualifying Conditions

Jurisdictions may have additional requirements for management of grazing and pasture areas, such as stocking rates (animals per acre). For CBP purposes the only requirement is the minimum vegetative cover. These BMPs can be applied with or without related BMPs such as stream exclusion fencing or off-stream watering systems.

Nitrogen, Phosphorus and Sediment Reductions

The horse pasture management BMP receives no nitrogen reduction. Its phosphorus and sediment efficiency values are the same for all hydrogeomorphic regions (HGMRs) in the watershed. The BMP for precision intensive rotational/prescribed grazing has two different nitrogen efficiency values based on the HGMR as seen in Table A-8-1; the phosphorus and sediment efficiency values are 24 percent and 30 percent, respectively, regardless of HGMR.

Table A-8-1. Nitrogen, phosphorus and sediment efficiency values for horse pasture management and rotational grazing BMPs.

BMP	Hydrogeomorphic region (HGMR)	Nitrogen	Phosphorus	Sediment
Horse Pasture Management	All	0%	20%	40%

Precision Intensive Rotational/Prescribed Grazing	Appalachian Plateau Carbonate; Coastal Plain Dissected Uplands; Piedmont Carbonate; Valley and Ridge Carbonate; all Coastal Plain HGMRs	9%	24%	30%
Precision Intensive Rotational/Prescribed Grazing	Valley and Ridge Siliciclastic; Appalachian Plateau Siliciclastic; Mesozoic Lowlands; Blue Ridge; Piedmont Crystalline	11%	24%	30%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Pasture

Brief Description of BMP Simulation in the Model

The grazing and pasture management BMPs described here are *Efficiency Value BMPs*. One acre of pasture is treated for each acre reported under the BMPs, using the efficiency values in Table A-8-1.

Annual or Cumulative? Cumulative (10-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Horse Pasture Management
  - Precision Intensive Rotational/Prescribed Grazing
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be Pasture
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year grazing plan/system was implemented.

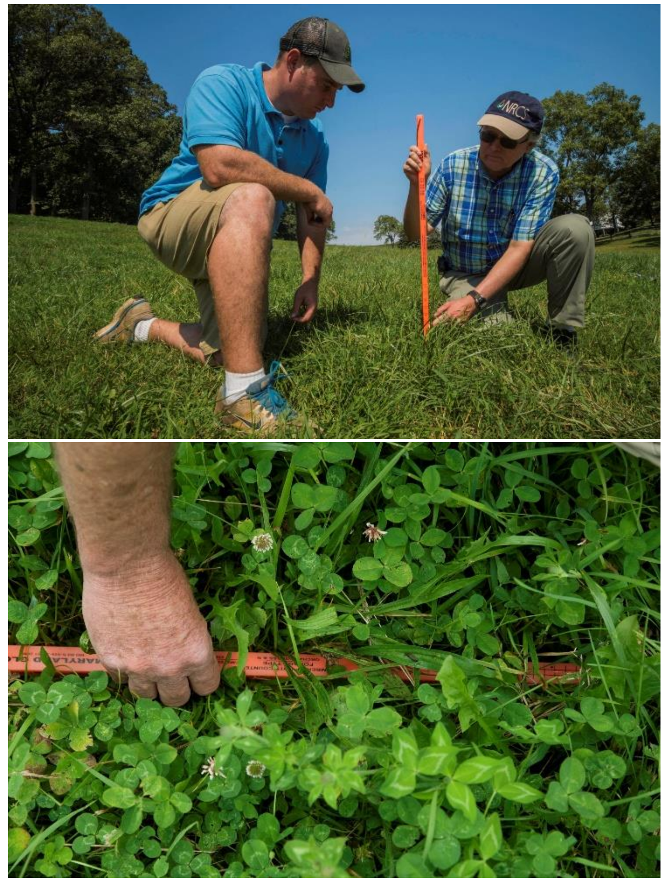


Figure A-8-2. Grazing systems that maintain healthy, dense vegetative cover in a pasture throughout the year are beneficial to water quality. Photos: USDA NRCS.

Table A-8-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Horse Pasture Management	Horse Pasture Management	Prescribed grazing (NRCS 528 or 528A)
Precision Intensive Rotational/Prescribed Grazing	Grazing land protection; Prescribed grazing; Rotational grazing RI (RI-15)	Managed intensive grazing; Prescribed grazing (NRCS 528 or 528A)

Additional Information

Chesapeake Bay Program. 2015. [Video]. Restoration Spotlight: The Grass Whisperer *gets to the root of grazing.* https://vimeo.com/144890052

USDA NRCS. Pasture resources. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/landuse/rangepasture/pasture/

University of Maryland Extension. Publications: [Horse] Pasture Management: https://extension.umd.edu/horses/resources/publications

Hansen, D. & Dubin, M. 2010. Developing a Protocol for Development and Review of Reduction Efficiencies for Best Management Practices: Test Case of Pasture Management. Chesapeake Bay Program, Scientific and Technical Advisory Committee. Publication 10-006. https://cast-content.chesapeakebay.net/documents/GrazingPastureMgmt2010.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definition and benefits that were reviewed and approved by the Agriculture Workgroup and WQGIT in 2010. Updates to this reference sheet were published on November 14, 2022.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-9. Stream Restoration (Ag)

General Information

New stream restoration techniques have been pioneered in the Chesapeake Bay watershed to restore streams. Approaches to stream restoration include natural channel design, regenerative stream channel and legacy sediment removal. Stream restoration projects require state and federal permits and thus extensive regulatory review. Projects often take multiple years from concept to construction, involving high costs and extensive effort from multiple stakeholders at the community, state and federal level. Note: This BMP reference sheet is targeted for the agricultural sector. See Sheets N-1: Stream Restoration (Urban and Non-Urban) and D-5: Urban Stream Restoration if interested in developed or general sectors, though the information is the same.

Figure A-9-1. Stream restoration projects can improve the health of aquatic resources and can be one of the more cost-effective practices to reduce nutrient and sediment loads in urban watersheds. A stream prior to restoration (top) that has an eroded stream bank and channel can be restored so that natural processes reduce the erosive energy of the stream flow during storm events. The bottom picture is the same stream shortly after completion of the project. Photos: US Fish and Wildlife Service.

CBP Definition(s)

Natural Channel Design (NCD) applies the principles of stream geomorphology to maintain a state of dynamic equilibrium among water, sediment, and vegetation that creates a stable channel.

Legacy Sediment Removal (LSR) seeks to remove legacy sediments from the stream and its floodplain and thereby restore the natural potential of aquatic resources including a combination of streams, floodplains, and wetlands.

Regenerative Stream Channel (RSC, aka Regenerative Stormwater Conveyance) uses in-stream weirs in perennial streams to increase the interaction with the floodplain during smaller storm events. These projects may also include sand seepage wetlands and other habitats to increase the stream's connection with its floodplain. Only wet channel RSC practices are eligible as stream restoration projects. Dry channel RSC projects are considered a runoff reduction retrofit practice, which is not applicable to agricultural load sources (see Sheet D-2: Stormwater Retrofits).

Stream Restoration refers to any NCD, RSC, LSR or other restoration project that meets the qualifying conditions for credits, including environmental limitations and stream functional improvements.

Specifications or Key Qualifying Conditions

There are further protocol-specific qualifying criteria detailed in other resources listed under Additional Information below. All projects must meet the following criteria to be eligible for credit:

- Reach restored must be greater than 100ft in length.
- Reach restored must be actively enlarging or degrading.
- Reach restored MAY NOT be tidally influenced.
- The project MAY NOT be primarily designed to protect public infrastructure. Bank armoring and rip rap are not eligible for stream restoration credit.
- Restoration plan must utilize a comprehensive approach to stream restoration design, addressing long-term stability of the channel, banks, and floodplain.
- Must comply with all state and federal permitting requirements, including 404 and 401 permits.

Stream restoration is a carefully designed intervention to improve the hydrologic, hydraulic, geomorphic, water quality, and biological condition of degraded urban streams, and must not be implemented for the sole purpose of nutrient or sediment reduction. Restoration projects should be developed through a functional assessment process, such as the stream functions pyramid (Harman et al., 2012) or functional equivalent.

Nitrogen, Phosphorus and Sediment Reductions

There are three general protocols to define the pollutant load reductions from stream restoration practices. There is also a default rate for historic projects and new projects that cannot conform to the recommended reporting requirements.

- Protocol 1. Credit for prevented sediment during storm flow
- Protocol 2. Credit for in-stream nitrogen processing during base flow
- Protocol 3. Credit for reconnection to the floodplain

For details on how to use the protocols consult the resources listed under Additional Information.

Table A-9-1. Summary of stream restoration protocols for nitrogen, phosphorus and sediment reductions.

Protocol	TN (lbs/ linear ft/ year)	TP (lbs/ linear ft/ year)	TSS (lbs/ linear ft/ year)
Protocol 1. Prevented sediment	Site-specific	Site-specific	Site-specific
Protocol 2. In-stream nitrogen processing	Site-specific	N/A	N/A
Protocol 3. Floodplain reconnection	Site-specific	Site-specific	Site-specific
Default for existing/non-conforming projects*	0.075	0.068	248**
*The existing/non-conforming rates were adjusted following a test drive period. These adjustments are explained in Appendix G of the expert panel report. **Because small stream loads are explicitly modeled in the Phase 6 tools, no sediment delivery factors are needed to reduce the default edge-of-field rate of 248 lbs of TSS/linear ft/year published by the panel.			

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Stream Bed and Bank

The practice can only be applied to the "Stream Bed and Bank" load source, but it is recommended to distinguish the BMP based on its sector using the appropriate secondary BMP designation of either "Urban Stream Restoration" or "Non-Urban Stream Restoration."

Brief Description of BMP Simulation in the Model

All stream restoration practices are *Load Reduction BMPs,* which means they are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment from the edge-of-stream load. To calculate the pounds reduced for each protocol, follow the methods and examples described in the panel report and other resources listed under Additional Information. The protocols are additive. So, a project that reduces 100 lbs TN under Protocol 1, 25 lbs TN under Protocol 2, and 30 lbs TN under Protocol 3 has a net reduction of 155 lbs TN. As another example, pretend the project design is unknown for a project planned to restore 1,000 linear feet of a degraded stream. Using the default rate for that project yields reductions of 7.5 lbs TN, 6.8 lbs TP and 24,800 lbs TSS, which would be removed from the edge-of-stream load in the Watershed Model. Load reduction BMPs such as stream restoration cannot remove more pounds of nitrogen, phosphorus or sediment than are available in a watershed, however. So, the Watershed Model does enforce maximum reductions that are described in Section 6.5.4.1 of the Watershed Model documentation.

Annual or Cumulative? Cumulative (10-year credit duration for non-urban stream restoration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Non-Urban Stream Restoration Protocol
  - Non-Urban Stream Restoration
- *Measurement unit(s): Length restored (feet); Protocol 1 TN (lbs); Protocol 1 TP (lbs); Protocol 1 TSS (lbs); Protocol 2 TN (lbs); Protocol 3 TN (lbs); Protocol 3 TP (Lbs); Protocol 3 TSS (lbs).*
- *Load Source:* Stream Bed and Bank.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year the project was completed.

Table A-9-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

<table>
<tr><th>CBP or Expert Panel term</th><th>NEIEN BMP name</th><th>Other common practice names</th></tr>
<tr><td>Stream Restoration (Ag)</td><td>Non-Urban Stream Restoration Protocol*</td><td rowspan="2">natural channel design, legacy sediment removal, regenerative stream channel or regenerative stormwater conveyance (wet channel only)</td></tr>
<tr><td>Stream Restoration (Ag)</td><td>Non-Urban Stream Restoration**</td></tr>
<tr><td colspan="3">* Uses protocols 1-3 summarized in Table A-9-1. Requires unit of feet in addition to the pounds reduced for each respective protocol.
** For use when specific project design is not known. Requires unit of feet.</td></tr>
</table>

Additional Information

Expert panel report:

Berg, J., Burch, J., Cappuccitti, D., Filoso, S., Fraley-McNeal, L., Goerman, D., Hardman, N., Kaushal, S., Medina, D., Meyers, M., Kerr, B., Stewart, S., Sullivan, B., R. Walter & J. Winters. 2013. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. Prepared by T. Schueler, Chesapeake Stormwater Network, and B. Stack, Center for Watershed Protection. Test-drive revisions approved by the WQGIT September 8, 2014. https://www.chesapeakebay.net/documents/Stream_Panel_Report_Final_08282014_Appendices_A_G.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-4: Urban Stream Restoration. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network. BMP Resources, Urban Stream Restoration: http://chesapeakestormwater.net/bmp-resources/urban-stream-restoration/

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs & C. Miller. 2012. A function-based framework for developing stream assessments, restoration goals, performance standards and standard operating procedures. U.S. Environmental Protection Agency. Office of Wetlands, Oceans and Watersheds. Washington, D.C. EPA 843-K-12-006. https://www.epa.gov/sites/production/files/2015-08/documents/a_function_based_framework_for_stream_assessment_3.pdf

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All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-10. Dairy Precision Feeding and Forage Management

General Information

Dairy cows are given a regular diet of feed, typically composed of grains and forage. Feed can often be the most expensive component of an operation. Feeding dairy cows more efficient amounts of nutrients reduces nitrogen and phosphorus excreted in their manure, which benefits both water quality and the farmer’s bottom line.

Figure A-10-1. It is important to farmers to balance the cows’ nutritional needs with the amount, type and cost of feed. Photo: Chesapeake Bay Program.

CBP Definition(s)

*Dairy precision feeding and/or forage management r*educes the quantity of phosphorus and nitrogen fed to livestock by formulating diets within 110% of Nutritional Research Council recommended level in order to minimize the excretion of nutrients without negatively affecting milk production.

Specifications or Key Qualifying Conditions

This BMP is only applicable to dairy operations.

Nitrogen, Phosphorus and Sediment Reductions

There are no sediment reductions for this BMP; nitrogen and phosphorus reductions are in Table A-10-1 below.

Table A-10-1. Nitrogen and phosphorus effectiveness values for dairy precision feeding BMP.

BMP	Nitrogen (%)	Phosphorus (%)
Dairy precision feeding and forage management	24	25

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Feeding Space, Permitted Feeding Space or Non-Permitted Feeding Space

Brief Description of BMP Simulation in the Model

The dairy precision feeding and forage management practice is an *Animal BMP* that reduces the concentration of nitrogen and phosphorus in dairy manure by 24 and 25 percent, respectively, which reduces the nutrient load applied to eligible cropland from manure.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

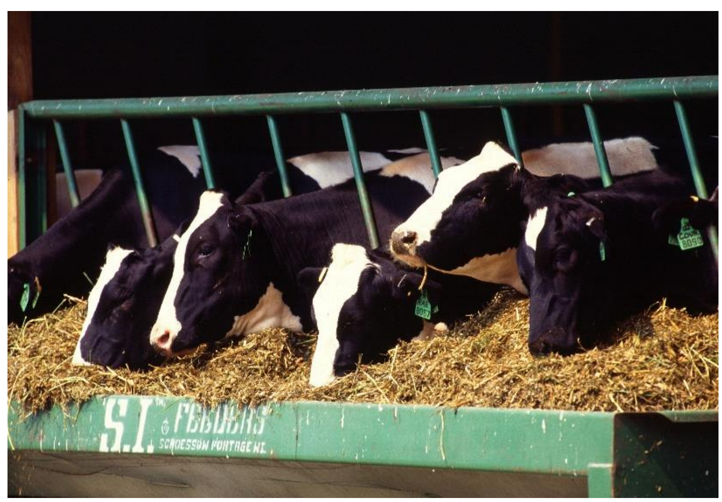

Figure A-10-2. Feed management allows for more efficient nutrient utilization while providing dairy cows with the energy and proteins they need to be healthy and productive. Photo: USDA

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Feed management

- *Measurement unit:* Animal count, animal units or percent
- *Animal type:* Dairy
- *Land Use:* Feeding Space, Permitted Feeding Space or Non-Permitted Feeding Space
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year

Table A-10-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Dairy precision feeding and/or forage management	Feed management	Feed Management (NRCS 592) for dairy

Additional Information

Harrison, J.H., et al. 2013. An introduction to NRCS Feed Management Practice Standard 592: http://articles.extension.org/pages/11312/an-introduction-to-natural-resources-conservation-service-nrcs-feed-management-practice-standard-592

eXtension.org, Dairy video archive: http://articles.extension.org/pages/15830/dairy-video-archive

Penn State Extension. Precision feeding dairy heifers: strategies and recommendations. https://extension.psu.edu/precision-feeding-dairy-heifers-strategies-and-recommendations

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This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in 2009.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-11. Agricultural Stormwater Management Practices

General Information

Runoff from agricultural structures and paved areas associated with confined animal production can contribute to the pollution of local waters. Agricultural stormwater management practices, such as ponds, constructed wetlands, and grass swales, are designed and constructed to treat stormwater from these facilities. These practices are often configured in a treatment train, implementing two or more practices that reduce the source of pollutants in conjunction with practices that reduce the delivery of pollutants from a site.

Figure A-11-1. A pond with wetlands on Hambleton Creek attracts a great egret near fields of soybeans on farmland owned by Sam Owings in Chestertown, Md., on July 15, 2016. Owings developed a cascading system of stormwater basins to manage stormwater on his land. (Photo by Will Parson/Chesapeake Bay Program). https://flic.kr/p/2qTyFz4.

If facilities exceed a certain size, many Bay states will require them to capture and treat agricultural stormwater through regulations such as the National Pollutant Discharge Elimination System (NPDES) stormwater construction, Municipal Separate Storm Sewer Systems (MS4), and/or Confined Animal Feeding Operation (CAFO) permits.

CBP Definition(s)

Agricultural Stormwater Management BMP: Agricultural stormwater associated with confined agricultural livestock production land area through practices that reduce nutrient and sediment pollutant loads through engineered mechanisms such as settling or filtering. Enter units of acres treated or percent of acres treated.

Specifications or Key Qualifying Conditions

In most cases, agricultural stormwater management practices are designed and constructed according to engineering criteria and specifications outlined in state urban stormwater design manuals, although some states allow employment of standardized plans to address agricultural stormwater for poultry houses and similar facilities. For Chesapeake Bay Program (CBP) purposes, this does not include any practices that fall under existing feeding space BMPs nor any practices applied to cropland or pasture sources. In addition, reductions from all feed space BMPs, including agricultural stormwater management, cannot exceed the existing load from feed space (i.e., feed space loads cannot drop below zero due to agricultural stormwater management practices).

Nitrogen, Phosphorus and Sediment Reductions

A default credit calculation for a performance standard of one inch will be applied to the acres of agricultural ditch BMPs reported. The default reduction efficiencies are displayed below in Table A-11-1.

Table A-11-1. Summary of recommended reduction efficiencies for the agricultural stormwater management BMP.

BMP Name	Reduction Efficiency		
	TN %	TP%	Sed.%
Agricultural Stormwater Management	35	55	70

States can request an alternate average performance standard for their state, through an approval process within the CBP. This alternate performance standard would then be used to represent default credit for agricultural stormwater management systems in that state. Agricultural stormwater practices are likely to be used in conjunction with other CBP-approved BMPs to reduce loads from feeding space acres. In such a scenario, load reductions to be credited to agricultural stormwater practices would be taken from the nutrient load remaining after reductions are taken for associated BMPs (e.g., animal waste management systems, barnyard runoff control, loafing lot management).

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Feeding Space
- Permitted Feeding Space
- Non-permitted Feeding Space

Brief Description of BMP Simulation in the Model

The agricultural stormwater management BMP is considered an *Efficiency Value BMP*, which reduces total nitrogen, phosphorus or sediment loads from eligible load sources according to the percentage values listed in Table A-11-1. Reductions from these practices will be credited to the edge-of-stream feed space pollution loads after Animal Waste Management Systems are accounted for. These efficiency reductions can be combined with efficiency reductions from other practices, such as barnyard runoff control.

Annual or Cumulative? Cumulative (10-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Agricultural Stormwater Management.
- *Measurement unit:* Acres treated by BMP.
- *Land Use:* Feeding Space.
- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Date the project was completed.

Table A-11-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other practice names
Agricultural Stormwater Management	Agricultural Stormwater Management	None

Additional Information

Expert Panel Establishment Group (EPEG) Report:

Recommendations Regarding Agricultural Stormwater Management Practices (Jan 18, 2018). Agricultural Stormwater Management Practices Expert Panel Establishment Group. Approved by the CBP AgWG on February 15, 2018, WTWG on April 5, 2018, and WQGIT on June 11, 2018. https://www.chesapeakebay.net/what/publications/recommendations-regarding-agricultural-stormwater-management-practices

University of Maryland Extension. A Guide for Poultry House Construction in Maryland. Fact Sheet. https://extension.umd.edu/sites/extension.umd.edu/files/publications/Check%20list%20new%20House%20Construction.pdf

New York State Department of Environmental Conservation. Construction Stormwater Toolbox: https://dec.ny.gov/environmental-protection/water/water-quality/stormwater/construction-stormwater-toolbox

Pennsylvania Stormwater Best Management Practices Manual: http://www.depgreenport.state.pa.us/eLibrary/GetFolder?FolderID=4673

Version and History Statement

This info sheet was first published on April 3, 2024 and reflects the BMP definitions and reductions approved by the WQGIT in June 2018. All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-12. Forest Buffers and Grass Buffers

General Information

Figure A-12-1. Aerial view of a riparian forest buffer. Buffers reduce the impact of pollutants from upland sources while providing additional habitat and environmental benefits. Photo: USDA NRCS

Forest buffers and grass buffers are widely implemented conservation practices in the region. This reference sheet is applicable to forest buffers and grass buffers planted in agricultural cropland settings. For buffers in agricultural pasture settings, see A-13: Forest and Grass Buffers with Stream Exclusion Fencing. For forest buffers in developed areas, see D-7: Urban Tree Planting BMPs.

CBP Definition(s)

Forest Buffer: Linear wooded areas that help filter nutrients, sediments and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width is 100 feet, with a 35 feet minimum width required.

Forest Buffer – Narrow: Linear strips of wooded areas maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow forest buffer strips are between 10 and 35 feet in width.

Grass Buffer: Linear strips of grass or other non-woody vegetation maintained to help filter nutrients, sediment and other pollutants from runoff. The recommended buffer width for buffers is 100 feet, with a 35 feet minimum width required.

Grass Buffer – Narrow: Linear strips of grass or other non-woody vegetation maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow grass buffers are between 10 and 35 feet in width.

Figure A-12-2. Aerial view of a forest buffer recently planted to expand an existing riparian forested area. Buffers reduce the impact of pollutants from upland sources while providing additional habitat and environmental benefits. Photo: Chesapeake Bay Program

Specifications or Key Qualifying Conditions

These practices are only applicable on converted cropland; see Reference Sheet A-13 for applicable buffer practices on pasture. Any buffer less than 35 feet in (average) width is only eligible for the *narrow* buffer practices. Cost-shared buffers must meet the standards of the federal or state program in which they are enrolled. Non-cost-shared buffers must be documented and meet the CBP's criteria as defined for the relevant Resource Improvement (RI) practices (CBP RI-7,8 for grass buffers; CBP RI-9,10 for forest buffers).

Nitrogen, Phosphorus and Sediment Reductions

The net reductions in nitrogen, phosphorus and sediment for forest buffers are significant, but not simple to quantify without the use of CAST (http://cast.chesapeakebay.net/). There is a load source change of the buffered area from the previous land use (e.g., cropland) into forest, which reduces the simulated load. Then there is also an efficiency applied to upland acres that further reduces pollutant loads. The efficiency values applied to upland acres vary based on the hydrogeomorphic region where the buffer is installed; the values are summarized in Table A-12-1. Narrow buffers are only simulated as a load source change to forest and do not receive the additional upland treatment summarized in the tables below.

Table A-12-1. Nitrogen, phosphorus and sediment efficiency values applied to upland acres for agricultural forest buffers and grass buffers in the Phase 6 Watershed Model, by hydrogeomorphic region (HGMR). Note: These efficiency values are not applicable to narrow buffers (between 10 and 35 feet in width).

	Nitrogen Efficiency (%)	Nitrogen Efficiency (%)	Phosphorus Efficiency (%)	Sediment Efficiency (%)
	applied on 4 upland acres per 1 acre of buffer	applied on 4 upland acres per 1 acre of buffer	applied on 2 upland acres per 1 acre of buffer	applied on 2 upland acres per 1 acre of buffer
HGMR	**Forest Buffer**	**Grass Buffer**	**Forest Buffer and Grass Buffer**	**Forest Buffer and Grass Buffer**
Coastal Plain Dissected Uplands	65	46	42	56
Piedmont Carbonate	46	32	36	48
Appalachian Plateau Siliciclastic	54	38	42	56
Coastal Plain Uplands	31	21	45	60
Appalachian Plateau Carbonate	54	38	42	56
Piedmont Crystalline	56	39	42	56
Valley and Ridge Carbonate	34	24	30	40
Valley and Ridge Siliciclastic	46	32	39	52
Blue Ridge	34	24	30	40
Coastal Plain Lowlands	19	13	45	60
Mesozoic Lowlands	34	24	30	40

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Cropland
- Cropland and Hay
- Cropland and Hay Eligible for Manure
- Cropland Eligible for Manure
- Grains not Double Cropped
- Hay
- Leguminous Hay
- Other Hay
- Row Crops
- Row Crops Eligible for Manure
- Specialty Cropland

Forest and grass buffers can be reported on any of the above load source groups. The default load source group is Cropland and Hay, or “CropHay”.

Brief Description of BMP Simulation in the Model

The forest buffer and grass buffer practices are both simulated as a *Load Source Change with an Efficiency Value* in the Watershed Model. Each acre reported under the practices will be converted to the forest or agricultural open space load sources, respectively, and then there is an additional reduction in upland loads using the efficiency values in Table A-12-1. For example, one acre of cropland that is converted into a riparian forest buffer will increase the overall acres of forest by one and reduce the amount of cropland by that same amount. Additionally, the nitrogen load from four other acres will be reduced by 31 percent (assuming the buffer is installed in a Coastal Plain Upland setting for this example); the phosphorus and sediment loads from two acres will be reduced by 45 and 60 percent, respectively. If the one acre in this example was instead used for a grass buffer then it would be simulated in the same way, except the acre of cropland would be converted to agricultural open space and the upland acres would be treated using the efficiency value of 21 percent for nitrogen. The efficiency values for phosphorus and sediment, and the ratio of acres treated are the same for both forest and grass buffers. While it is difficult to estimate the net reductions of this practice without the use of CAST, the net load reduction can be significant.

Annual or Cumulative? Cumulative (15-year credit duration for forest buffers and RI-9,10 practices; 5-year credit duration for grass buffers and RI-7,8 practices).

Can this practice be combined with other BMPs? Yes, acres of upland load sources treated by regular forest or grass buffers can also receive other eligible agriculture BMPs. The area of land converted to either forest or agricultural open space by the buffer, however, cannot receive additional BMPs. Narrow buffers cannot be combined with other BMPs since they do not treat upland acres and only change the load source of the buffered area.

Figure A-12-3. Aerial view of a grass buffer. Photo: USDA NRCS.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Forest Buffer-Upland
        - Forest Buffer
        - Forest Buffer-Narrow
        - Grass Buffer
        - Grass Buffer-Narrow
- *Measurement unit:* Area of buffer (acres)
- *Land Use:* Approved NEIEN agricultural load source groups; if none are reported the default will be CropHay.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year buffer was installed.

Table A-12-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Forest Buffer	Forest Buffer	Riparian Forest Buffer (NRCS 391); Riparian Buffer (FSA CP22);
	Forest Buffer on Watercourse RI	Forest Buffer on Watercourse (CBP RI-10)
Forest Buffer-Narrow	Forest Buffer-Narrow	
	Forest Nutrient Exclusion Area on Watercourse RI	Forest Nutrient Exclusion Area on Watercourse (CBP RI-9)
Grass Buffer	Grass Buffer	Riparian Herbaceous Cover (NRCS 390); Filter Strip (NRCS 393); Filter Strip (FSA CP21); Field Border (NRCS 386); Grass Waterway (NRCS 412); Grass Waterway, Noneasement (FSA CP8A);
	Grass Buffer on Watercourse RI	Grass Buffer on Watercourse (CBP RI-8)
Grass Buffer-Narrow	Grass Buffer-Narrow	
	Grass Nutrient Exclusion Area on Watercourse RI	Grass Nutrient Exclusion Area on Watercourse (CBP RI-7)

Additional Information

Expert panel report:

Belt, K., Groffman, P., Newbold, D., Hession, C., Noe, G., Okay, J., Southerland, M., Speiran, G., Staver, K., Hairston-Strang, A., Weller, D., & D. Wise. 2014. Recommendations of the Expert Panel to Reassess Removal Rates for Riparian Forest and Grass Buffers Best Management Practices. Prepared by S. Claggett, US Forest Service and Tetra Tech, Inc. Approved by CBP Water Quality Goal Implementation Team, October 2014. https://www.chesapeakebay.net/documents/Riparian_BMP_Panel_Report_FINAL_October_2014.pdf

T. Simpson and S. Weammert (Lane). 2009. Riparian Forest Buffer Practice (Agriculture) and Riparian Grass Buffer Practice Definition and Nutrient and Sediment Reduction Effectiveness Estimates. In Mid-Atlantic Water Program, *Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed*. T. Simpson and S. Weammert (Lane), eds. Final Report, December 2009. Pages 469-506. http://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

Locate and consult your state and county USDA Field Office Technical Guide (FOTG) for details on conservation practices: https://efotg.sc.egov.usda.gov/

Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report: Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014. https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Chesapeake Riparian Forest Buffer Network: http://chesapeakeforestbuffers.net/

Chesapeake Bay Program. Video and webpage. Forest Buffers. https://www.chesapeakebay.net/issues/forest_buffers

Version and History Statement

This info sheet was first published on August 10, 2018 reflects the BMP definitions and reductions approved by the WQGIT in 2009 and 2014. Updates to this reference sheet were published on November 14, 2022.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-13. Forest Buffers and Grass Buffers with Stream Exclusion Fencing

General Information

Forest buffers and grass buffers are widely implemented conservation practices in the region. This reference sheet is only applicable to buffers planted in agricultural pasture settings, which includes fencing. See D-7: Urban Tree Planting BMPs for information about forest buffers in developed settings. For buffers in cropland agricultural settings, see A-12: Forest Buffers and Grass Buffers.

Figure A-13-1. A recently planted forest buffer, with exclusion fencing to prevent livestock from entering the buffered area or stream. When installing a riparian forest buffer in a pasture it is standard to include exclusion fencing. Many such conservation practices in the Chesapeake Bay Watershed are cost-shared through programs such as the US Department of Agriculture's Conservation Reserve Enhancement Program (CREP) and Environmental Quality Incentives Program (EQIP).

CBP Definition(s)

Forest Buffer: Linear wooded areas that help filter nutrients, sediments and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width is 100 feet, with a 35 feet minimum width required.

Forest Buffer – Narrow: Linear strips of wooded areas maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow forest buffer strips are between 10 and 35 feet in width.

Grass Buffer: Linear strips of grass or other non-woody vegetation maintained to help filter nutrients, sediment and other pollutants from runoff. The recommended buffer width for buffers is 100 feet, with a 35 feet minimum width required.

Grass Buffer – Narrow: Linear strips of grass or other non-woody vegetation maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow grass buffers are between 10 and 35 feet in width.

When buffers are implemented along a pasture *exclusion fencing* is installed to prevent livestock from grazing and trampling the buffer or entering the stream.

Figure A-13-2. Fencing combined with grass or forest buffers protect streams from animal waste and streambank erosion. Photo: USDA

Specifications or Key Qualifying Conditions

These buffer practices with exclusion fencing are only applicable on converted pasture; see Reference Sheet A-12 for applicable buffer practices on converted cropland. Any buffer less than 35 feet in (average) width is only eligible for the *narrow* buffer practices. Cost-shared buffers must meet the standards of the federal or state program in which they are enrolled. Non-cost-shared buffers must be documented and meet the CBP's criteria as defined for the relevant Resource Improvement (RI) practices (CBP RI-4a,4b for narrow grass and forest buffers, respectively; CBP RI-5 for grass buffers and CBP RI-6 for forest buffers).

Nitrogen, Phosphorus and Sediment Reductions

The net reductions in nitrogen, phosphorus and sediment for forest and grass buffers in the Watershed Model are significant, but not simple to estimate without the use of CAST (http://cast.chesapeakebay.net/). There is a load source change from the previous land use (cropland) into either forest (forest buffer) or agricultural open space (grass buffer), which reduces the simulated load. Then there is also an efficiency applied to upland acres that further reduces pollutant loads. The efficiency values applied to upland acres vary based on the hydrogeomorphic region where the buffer is installed; the efficiency values are summarized in Table A-13-1. Narrow buffers are only simulated as a load source change to forest or agricultural open space and do not receive the additional upland treatment summarized in Table A-13-1.

Table A-13-1. Nitrogen, phosphorus and sediment efficiency values applied to upland acres for agricultural forest buffers and grass buffers in the Phase 6 Watershed Model, by hydrogeomorphic region (HGMR). Note: These efficiency values are not applicable to narrow buffers (between 10 and 35 feet in width).

	Nitrogen Efficiency (%)	Nitrogen Efficiency (%)	Phosphorus Efficiency (%)	Sediment Efficiency (%)
	applied on 4 upland acres per 1 acre of buffer	applied on 4 upland acres per 1 acre of buffer	applied on 2 upland acres per 1 acre of buffer	applied on 2 upland acres per 1 acre of buffer
HGMR	**Forest Buffer**	**Grass Buffer**	**Forest Buffer and Grass Buffer**	**Forest Buffer and Grass Buffer**
Coastal Plain Dissected Uplands	65	46	42	56
Piedmont Carbonate	46	32	36	48
Appalachian Plateau Siliciclastic	54	38	42	56
Coastal Plain Uplands	31	21	45	60
Appalachian Plateau Carbonate	54	38	42	56
Piedmont Crystalline	56	39	42	56
Valley and Ridge Carbonate	34	24	30	40
Valley and Ridge Siliciclastic	46	32	39	52
Blue Ridge	34	24	30	40
Coastal Plain Lowlands	19	13	45	60
Mesozoic Lowlands	34	24	30	40

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Pasture

Forest and grass buffers with exclusion fencing can only be applied on Pasture in the Watershed Model.

Brief Description of BMP Simulation in the Model

The forest buffer and grass buffer practices are both simulated as a *Load Source Change with an Efficiency Value* in the Watershed Model. Each acre reported under the practices will be converted to the forest or agricultural open space load sources, respectively, and then there is an additional reduction in upland loads using the efficiency values in Table A-13-1. For example, one acre of cropland that is converted into a riparian forest buffer will increase the overall acres of forest by one and reduce the amount of cropland by that same amount. Additionally, the nitrogen load from four other acres will be reduced by 31 percent (assuming the buffer is installed in a Coastal Plain Upland setting for this example); the phosphorus and sediment loads from two acres will be reduced by 45 and 60 percent, respectively. If the one acre in this example was instead used for a grass buffer then it would be simulated in the same way, except the acre of cropland would be converted to agricultural open space and the upland acres would be treated using the efficiency value of 21 percent for nitrogen. The efficiency values for phosphorus and sediment, and the ratio of acres treated are the same for both forest and grass buffers. Forest and grass buffer practices with exclusion fences have a unique additional benefit because they also reduce the amount of manure applied to the riparian pasture load source and shift the manure to the pasture load source. While it is difficult to estimate the net reductions of this practice without the use of CAST, the net load reduction can be significant.

Annual or Cumulative? Cumulative (15-year credit duration; 5-year credit duration for RI practices)

Can this practice be combined with other BMPs? Yes, acres of upland load sources treated by forest or grass buffers can also receive other eligible agriculture BMPs. The area of land converted to either forest or agricultural open space by the buffer, however, cannot receive additional BMPs. Narrow buffers cannot be combined with other BMPs since they do not treat upland acres and only change the load source of the buffered area.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Buffer-Streamside
    - Forest Buffer-Streamside with Exclusion Fencing
    - Forest Buffer-Narrow with Exclusion Fencing
    - Grass Buffer-Streamside with Exclusion Fencing
    - Grass Buffer-Narrow with Exclusion Fencing
- *Measurement unit:* Area of buffer (acres)* or Length (feet). Optional: Width (feet), Number of Animal Units (AU) excluded by fence. *If reported in units of acres only, a default of 22.9 animal units per acre is calculated and the manure is then applied to pasture instead of riparian pasture deposition.
- *Land Use:* Pasture
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year buffer was installed.

Table A-13-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Forest Buffer (with exclusion fence)	Forest Buffer-Streamside with Exclusion Fencing	Riparian Forest Buffer (NRCS 391); Riparian Buffer (FSA CP22);
	Exclusion Fence with Forest Buffer RI	Watercourse Access Control-Trees aka Exclusion Fence with Forest Buffer RI (CBP RI-6)
Forest Buffer-Narrow (with exclusion fence)	Forest Buffer-Narrow with Exclusion Fencing	
	Exclusion Fence with Narrow Forest Buffer RI	Watercourse Access Control-Narrow Trees, aka Exclusion Fence with Narrow Forest Buffer RI (CBP RI-4b)
Grass Buffer (with exclusion fence)	Grass Buffer-Streamside with Exclusion Fencing	Riparian Herbaceous Cover (NRCS 390); Filter Strip (NRCS 393); Filter Strip (FSA CP21); Field Border (NRCS 386); Grass Waterway (NRCS 412); Grass Waterway, Noneasement (FSA CP8A);
	Exclusion Fence with Grass Buffer RI	Watercourse Access Control-Grass aka Exclusion Fence with Grass Buffer RI (CBP RI-5)
Grass Buffer-Narrow (with exclusion fence)	Grass Buffer-Narrow with Exclusion Fencing	
	Exclusion Fence with Narrow Grass Buffer RI	Watercourse Access Control-Narrow Grass, aka Exclusion Fence with Narrow Grass Buffer RI (CBP RI-4a)

Additional Information

Expert panel report:

Belt, K., Groffman, P., Newbold, D., Hession, C., Noe, G., Okay, J., Southerland, M., Speiran, G., Staver, K., Hairston-Strang, A., Weller, D., & D. Wise. 2014. Recommendations of the Expert Panel to Reassess Removal Rates for Riparian Forest and Grass Buffers Best Management Practices. Prepared by S. Claggett, US Forest Service and Tetra Tech, Inc. Approved by CBP Water Quality Goal Implementation Team, October 2014.
https://www.chesapeakebay.net/documents/Riparian_BMP_Panel_Report_FINAL_October_2014.pdf

T. Simpson and S. Weammert (Lane). 2009. Riparian Forest Buffer Practice (Agriculture) and Riparian Grass Buffer Practice Definition and Nutrient and Sediment Reduction Effectiveness Estimates. In Mid-Atlantic Water Program, *Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed*. T. Simpson and S. Weammert (Lane), eds. Final Report, December 2009. Pages 469-506.
http://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

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Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report:
Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014. https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Chesapeake Riparian Forest Buffer Network:
http://chesapeakeforestbuffers.net/

Chesapeake Bay Program. Video and webpage. Forest Buffers.
https://www.chesapeakebay.net/issues/forest_buffers

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in 2009 and 2014. Updates to this reference sheet were published on November 16, 2022.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-14. Manure Treatment (Composting)

General Information

Composting is a type of manure treatment that involves decomposition of solid organic materials in the presence of oxygen, leading to a stable end product called *compost.* Compost is a valuable product once it meets maturity requirements, including a Carbon-to-Nitrogen (C:N) ratio less than or equal to 25. Other measures of compost maturity require additional metrics as delineated by industry accepted indices. Mature compost can be applied to nearby fields or transported off the farm to be sold or applied elsewhere.

Figure A-14-1. A handful of finished compost. Photo: Chesapeake Bay Program

CBP Definition(s)

There are four categories of composting systems and twelve total BMPs defined by the CBP. The four composting systems are listed below.

1. *In-Vessel and Rotating Bin*
2. *Forced Aeration*
3. *Turned Pile and Windrows*
4. *Static (passive) Pile and Windrows*

The BMPs are further distinguished based on the bulking agent and its C:N ratio. A bulking agent is the material or media added to the composting system that increases the porosity and aeration capacity of the manure. Carbonaceous bulking agents – such as wood chips, sawdust or straw – also add degradable carbon to the composting mixture. Each of the four composting systems are divided into three BMPs: (1) when the bulking agent or its C:N ratio are unknown; (2) when the bulking agent or its C:N ratio are known and C:N > 100, and (3) when the bulking agent or its C:N are known and the C:N < 100.

Figure A-14-2. Forced aeration systems, or aerated static piles, use blowers to provide oxygen into the compost pile instead of turning or moving the pile. Photo: Jason Governo, U. of Georgia.

Table A-14-1. Nitrogen efficiency values for manure composting BMPs.

Composting system	**CAST BMP Short Name**	**TN Removal (%)**
In-Vessel and Rotating Bin- Standard	MTT7†	10
In-Vessel and Rotating Bin- C:N>100**	MTT8	11
In-Vessel and Rotating Bin- C:N<100**	MTT9	13
Forced Aeration- Standard	MTT10	25
Forced Aeration- C:N>100**	MTT11	28
Forced Aeration- C:N<100**	MTT12	32
Turned Pile and Windrow- Standard	MTT13	25
Turned Pile and Windrow- C:N>100**	MTT14	28
Turned Pile and Windrow- C:N<100**	MTT15	32
Static Pile and Windrow- Standard	MTT16	26
Static Pile and Windrow- C:N>100**	MTT17	29
Static Pile and Windrow- C:N<100**	MTT18	33

† Default BMP if the type of composting system is unknown
***Carbon-to-Nitrogen factor of bulking agent*

Specifications or Key Qualifying Conditions

By definition, finished compost has a C:N at or below 25. Manure composting BMPs are only applicable to agricultural operations and excludes composting systems used for animal mortality management. In-house windrowing of poultry litter between flocks is not considered a composting BMP, but is considered a storage process.

Figure A-14-3. In-Vessel composting is performed in an insulated silo, channel, or bin using a high-rate, controlled aeration system designed to provide optimal conditions. Rotating Drum Composters are a subset of in-vessel composters that aerate compost by turning the compost inside a rotating drum. Photo: Jason Governo, U. of Georgia.

Nitrogen, Phosphorus and Sediment Reductions

As seen in Table A-14-1, composting BMPs only provide nitrogen reductions. This accounts for the portion of N transformed and removed to the atmosphere. All phosphorus is retained in the final solid product. Transport of the final product may or may not provide additional reductions in N or P not accounted for in Table A-14-1 (see A-16: Manure Transport).

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Load Source
    - Permitted Feeding Space; Nonpermitted Feeding Space
- Animal Groups, which may include some overlap among categories
    - All animals; livestock; poultry; beef; broilers; cattle; chickens; dairy; goats; hogs and pigs for breeding; hogs for slaughter; horses; layers; other cattle; pullets; sheep and lambs; swine; turkeys

Brief Description of BMP Simulation in the Model

Manure composting practices are categorized as *Manure Transport BMPs*. Manure transport BMPs directly influence the amount of nutrients available from animal manure for field application and subsequent BMPs. The total application of manure could be reduced in a county if a jurisdiction indicated that manure was treated and/or transported out of that county. However, the crop nutrient need is not changed; other sources of nutrients will make up the difference in the crop need where they are available. Nutrients are applied to meet the nitrogen crop need. This can result in an over application of phosphorus where manure is the nutrient source. In cases where manure becomes less available and is replaced with inorganic fertilizer, there is a decrease in phosphorus. There may be an increase in nitrogen loads, since nitrogen from inorganic fertilizer is more likely to run off to streams than nitrogen from manure. In some cases, there is no change in nutrient loads. In cases where there is a great deal of manure in a county and not much cropland, there is a decrease in both nitrogen and phosphorus. A portion of the reduced nitrogen amount is applied to the feeding space load source in the source county at the edge-of-tide. Analysis of edge-of-stream loads will not show this BMP's full effect since some of the nitrogen is applied to back to the source county's edge-of-tide load.

Figure A-14-4. Turned Piles and Windrows rely on frequent turning, usually with specialized machinery, to aerate the compost. Photo: Robb Meinen, Penn State.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Manure Treatment Rotating Bin (MTT7-9);
  - Manure Treatment Forced Aeration (MTT10-12);
  - Manure Compost Turned Pile Windrow (MTT13-15);
  - Manure Compost Static Pile Windrow (MTT16-18);
- *Measurement unit:* Dry tons.
- *Animal Group:* Eligible on any animal type or animal group; if none are reported the default will be "all animals."
- *Load Source:* Approved NEIEN agricultural load sources; if none are reported the default will be FEED
- *County From:* County or Outside Watershed (where manure or litter originated)*
- *County To:* County or Outside Watershed (destination of composted product)*
- *Date of implementation:* Year manure was treated.

**Note that the location of the composting facility is not needed, only the "County From" and "County To" for the manure and the end product.*

Figure A-14-5. Static (passive) piles and windrows rely on natural aeration. Heat generated during composting rises and pulls air into the pile. Piles are turned or mixed occasionally. This is usually accomplished by moving the pile from one bin to another or moving the windrow to a new area. Photo: Clatsop County (OR) SWCD.

Table A-14-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
In-Vessel and Rotating Bin- Standard	Manure Treatment Rotating Bin (MTT7) †	In-vessel; rotating bin; rotating drum;
In-Vessel and Rotating Bin- C:N>100	Manure Treatment Rotating Bin High CN (MTT8)	In-vessel; rotating bin; rotating drum;
In-Vessel and Rotating Bin- C:N<100	Manure Treatment Rotating Bin, Low CN (MTT9)	In-vessel; rotating bin; rotating drum;
Forced Aeration- Standard	Manure Treatment Forced Aeration (MTT10)	Aerated static pile;
Forced Aeration- C:N>100	Manure Compost Forced Aeration High CN (MTT11)	Aerated static pile;
Forced Aeration- C:N<100	Manure Compost Forced Aeration Low CN (MTT12)	Aerated static pile;
Turned Pile and Windrow- Standard	Manure Compost Turned Pile Windrow (MTT13)	Turned pile; turned windrow;
Turned Pile and Windrow- C:N>100	Manure Compost Turned Pile Windrow High CN (MTT14)	Turned pile; turned windrow;
Turned Pile and Windrow- C:N<100	Manure Compost Turned Pile Windrow Low CN (MTT15)	Turned pile; turned windrow;
Static Pile and Windrow- Standard	Manure Compost Static Pile Windrow (MTT16)	Static pile; static windrow;
Static Pile and Windrow- C:N>100	Manure Compost Static Pile Windrow High CN (MTT17)	Static pile; static windrow;
Static Pile and Windrow- C:N<100	Manure Compost Static Pile Windrow Low CN (MTT18)	Static pile; static windrow;
† Default BMP if the type of composting system is unknown		

Additional Information

Hamilton, D., Cantrell, K., Chastain, J., Ludwig, A., Meinen, R., Ogejo, J. & J. Porter. 2016. Manure Treatment Technologies: Recommendations from the Manure Treatment Technologies Expert Panel to the CBP's WQGIT to define Manure Treatment Technologies as a Best Management Practice. Hamilton, D., and J. Hanson, Editors. CBP/TRS-311-16. https://www.chesapeakebay.net/documents/MTT_Expert_Panel_Report_WQGIT_approved_Sept2016.pdf

Farm Manure-to-Energy Initiative. 2016. Final Report: Using Excess Manure to Generate Farm Income in the Chesapeake Bay Region's Phosphorus Hotspots. Full report and accompanying materials available at http://articles.extension.org/pages/73602/farm-manure-to-energy-initiative-in-the-chesapeake-region-report-january-2016

Chesapeake Bay Commission, Chesapeake Bay Foundation, Maryland Technology Development Corporation and Farm Pilot Project Coordination, Inc. 2012. Manure to Energy: Sustainable Solutions for the Chesapeake Bay Region. http://www.chesbay.us/Publications/manure-to-energy%20report.pdf

Science of Composting. Video. Webinar #1 of Mid-Atlantic Composting and Compost Use Webinar Series. https://youtu.be/ZgnilGcBcL0

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in September 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-15. Manure Treatment (Thermochemical)

General Information

Manure treatment practices stabilize and reduce organic matter, thereby reducing nuisance conditions and making plant nutrients more marketable for off-farm use. Treatment practices can also enable more cost-effective manure transport (see A-16: Manure Transport). There are many technologies available to treat livestock and poultry manure, including anaerobic digestion, settling practices, mechanical separation of manure liquids and solids, and composting (see A-14: Manure Composting). All of these practices provide numerous benefits to the farmer and the environment. However, not all manure treatment technologies remove nitrogen or phosphorus from the manure that ends up applied or transported. Composting and thermochemical practices are the only ones with CBP-approved nitrogen removal benefits.

Figure A-15-1. Combustion system at poultry operation. Photo: Livestock and Poultry Environmental Learning Center (LPELC).

CBP Definition(s)

The Chesapeake Bay Program has defined BMPs for three types of thermochemical conversion (TCC) processes used for manure treatment: combustion, gasification and pyrolysis. Any directly monitored or measured treatment system can also earn credit for Total Nitrogen (TN) removal as a BMP, regardless of what technology the system is comprised of.

Pyrolysis is the conversion of organic matter in the absence of oxygen. Pyrolysis temperatures range between 575 and 1,475˚F (300 to 800°C). Organic matter is broken down to produce some combination of liquids, gases and solids, depending on the type of pyrolysis process. *Fast Pyrolysis* has a short residence time (seconds) and moderate temperatures, and is primarily used to produce bio-oil (up to 75% by weight of feedstock). *Slow Pyrolysis* has longer residence times (hours to days) and lower temperatures and is used to produce char.

Gasification is the thermochemical reformation of biomass in a low oxygen or starved oxygen environment, using air or steam as reaction medium. Gasification temperatures range between 1,870 and 2,730˚F (1,000 to1,500°C). The main purpose of gasification is to produce syngas–primarily CO, H_2, Methane (CH_4) and other light weight hydrocarbons.

Combustion is the direct consumption of dry manure to produce heat without generating intermediate fuel gases or liquids. Combustion temperatures range between 1,500 and 3,000˚F (820 to 1,650°C). Usually, excess air is supplied to ensure maximum fuel conversion. Combustion produces CO_2, H_2O, ash and heat, with the heat typically used for steam production.

Figure A-15-2. Thermochemical conversions (TCC) processes are high-temperature chemical-reforming processes that convert organic matter into a combination of syngas, bio-oil and char/ash. Photo: LPELC.

A *data-driven or directly monitored manure treatment system* utilizes one or more of manure treatment technologies. The technologies may be proprietary or non-proprietary and may be used in any sequence to produce one or more end products for transport or land application. On-farm or multi-farm centralized manure treatment systems reported under this category will have unique transfer efficiencies that must be determined using monitoring data collected on site.

Specifications or Key Qualifying Conditions

These BMPs are applicable to systems designed for treatment of animal manure and do not apply to systems used for animal mortality management.

Nitrogen, Phosphorus and Sediment Reductions

As seen in Table A-15-1, thermochemical BMPs only provide nitrogen reductions. This accounts for the portion of N transformed and removed to the atmosphere. All phosphorus is retained in the final solid product. Transport of the final product may or may not provide additional reductions in N or P not accounted for in Table A-15-1 (see below and A-16: Manure Transport).

Table A-15-1. Nitrogen reductions for thermochemical manure treatment practices.

Practice name	BMP short name in CAST and NEIEN	TN removal
Slow pyrolysis	MTT1	25%
Fast pyrolysis	MTT2	75%
Gasification-Low Heat	MTT3	25%
Gasification-High Heat	MTT4	85%
Combustion	MTT5	85%
Combustion-High Heat	MTT6	95%
Directly Monitored	MTT19	Monitored

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Load Source
    - Permitted Feeding Space; Nonpermitted Feeding Space
- Animal Groups, which may include some overlap among categories
    - All animals; livestock; poultry; beef; broilers; cattle; chickens; dairy; goats; hogs and pigs for breeding; hogs for slaughter; horses; layers; other cattle; pullets; sheep and lambs; swine; turkeys

Brief Description of BMP Simulation in the Model

Manure treatment practices are categorized as *Manure Transport BMPs*. Manure transport BMPs directly influence the amount of nutrients available from animal manure for field application and subsequent BMPs. The total application of manure could be reduced in a county if a jurisdiction indicated that manure was treated and/or transported out of that county. However, the crop nutrient need is not changed; other sources of nutrients will make up the difference in the crop need where they are available. Nutrients are applied to meet the nitrogen crop need. This can result in an over application of phosphorus where manure is the nutrient source. In cases where manure becomes less available and is replaced with inorganic fertilizer, there is a decrease in phosphorus. There may be an increase in nitrogen loads, since nitrogen from inorganic fertilizer is more likely to run off to streams than nitrogen from manure. In some cases, there is no change in nutrient loads. In cases where there is a great deal of manure in a county and not much cropland, there is a decrease in both nitrogen and phosphorus. A portion of the reduced nitrogen amount is applied to the feeding space load source in the source county at the edge-of-tide. Analysis of edge-of-stream loads will not show this BMP's full effect since some of the nitrogen is applied to back to the source county's edge-of-tide load.

Annual or Cumulative? Annual (1-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Manure Treatment Slow Pyrolysis (MTT1);
    - Manure Treatment Fast Pyrolysis (MTT2);
    - Manure Treatment Low Heat Gasification (MTT3);
    - Manure Treatment High Heat Gasification (MTT4);

    - Manure Treatment Combustion (MTT5);
    - Manure Treatment High Heat Combustion (MTT6);
    - Manure Treatment Direct Monitor (MTT19)*
- *Measurement unit:* Dry tons. *For the directly monitored BMP, the amount of nitrogen reduced also is reported (lbs TN). This amount reduced is used instead of a factor.
- *Animal Group:* Eligible on any animal type or animal group; if none are reported the default will be "all animals."
- *Load Source:* Approved NEIEN agricultural load sources; if none are reported the default will be FEED
- *County From:* County or Outside Watershed (where manure or litter originated)**
- *County To:* County or Outside Watershed (destination of end product)**
- *Date of implementation:* Year manure was treated.

***Note that the location of the treatment system is not needed, only the "County From" and "County To" for the manure and the end product.*

Table A-15-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Slow Pyrolysis	Manure Treatment Slow Pyrolysis (MTT1)	None
Fast Pyrolysis	Manure Treatment Fast Pyrolysis (MTT2)	None
Gasification-Low Heat	Manure Treatment Low Heat Gasification (MTT3)	None
Gasification-High Heat	Manure Treatment High Heat Gasification (MTT4)	None
Combustion	Manure Treatment Combustion (MTT5)	None
Combustion-High Heat	Manure Treatment High Heat Combustion (MTT6)	None
Directly monitored manure treatment systems; data-driven manure treatment systems	Manure Treatment Direct Monitor (MTT19)	Can be any combination of proprietary or non-proprietary system with appropriate monitoring data

Additional Information

Expert panel report:

Hamilton, D., Cantrell, K., Chastain, J., Ludwig, A., Meinen, R., Ogejo, J. & J. Porter. 2016. Manure Treatment Technologies: Recommendations from the Manure Treatment Technologies Expert Panel to the CBP's WQGIT to define Manure Treatment Technologies as a Best Management Practice. Hamilton, D., and J. Hanson, Editors. CBP/TRS-311-16. https://www.chesapeakebay.net/documents/MTT_Expert_Panel_Report_WQGIT_approved_Sept2016.pdf

Farm Manure-to-Energy Initiative. 2016. Final Report: Using Excess Manure to Generate Farm Income in the Chesapeake Bay Region's Phosphorus Hotspots. Full report and accompanying materials available at http://articles.extension.org/pages/73602/farm-manure-to-energy-initiative-in-the-chesapeake-region-report-january-2016

Chesapeake Bay Commission, Chesapeake Bay Foundation, Maryland Technology Development Corporation and Farm Pilot Project Coordination, Inc. 2012. Manure to Energy: Sustainable Solutions for the Chesapeake Bay Region. http://www.chesbay.us/Publications/manure-to-energy%20report.pdf

Thermal Manure-to-Energy Systems for Farms. Videos, case studies and other informational resources. http://articles.extension.org/pages/68455/thermal-manure-to-energy-systems-for-farms

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in September 2016. All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-16. Manure Transport

General Information

Animal manure is a valuable source of carbon and nutrients for farmers. Animal operations sometimes transport their collected manure to other farms or facilities to utilize its nutrients, which includes nitrogen and phosphorus.

Figure A-16-1. A truck is loaded with chicken litter, which is a mixture of manure, bedding and other materials collected from the floor of a chicken house. Animal manure and poultry litter is sometimes transported to other farms for field application or sent to facilities where it is converted into organic fertilizer products. Photo: USDA

CBP Definition(s)

Manure Transport: Transport of excess manure in or out of a county. Manure may be of any type—poultry, dairy, or any of the animal categories. Transport should only be reported for county to county transport. Movement within the same county should not be included.

Specifications or Key Qualifying Conditions

None for CBP purposes beyond what is included in the definition. States may have requirements for haulers or producers that are not summarized here.

Nitrogen, Phosphorus and Sediment Reductions

There are no sediment reductions for the manure transport practice. Nitrogen and phosphorus reductions depend on the animal type, destination and amount (tons) of manure transported. Specific information about the nitrogen and phosphorus content of (dry) manure and litter can be found in Chapter 3 (Table 3-2) of the Watershed Model documentation and the Poultry Litter Subcommittee Report.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Load Source
  - Permitted Feeding Space; Nonpermitted Feeding Space
- Animal Groups, which may include some overlap among categories
  - All animals; livestock; poultry; beef; broilers; cattle; chickens; dairy; goats; hogs and pigs for breeding; hogs for slaughter; horses; layers; other cattle; pullets; sheep and lambs; swine; turkeys

Brief Description of BMP Simulation in the Model

The manure transport practice is a *Manure Transport BMP*. Manure transport BMPs directly influence the amount of nutrients available from animal manure for field application and subsequent BMPs. The total application of manure could be reduced in a county if a jurisdiction indicated that manure was transported out of that county. However, the crop nutrient need is not changed; other sources of nutrients will make up the difference in the crop need where they are available. Nutrients are applied to meet the nitrogen crop need. This can lead to application of phosphorus in excess of crop need where manure is the nutrient source. In cases where manure becomes less available and is replaced with inorganic fertilizer, there is a decrease in phosphorus. There may be an increase in nitrogen loads, since nitrogen from inorganic fertilizer is more likely to run off to streams than nitrogen from manure. In some cases, there is no change in nutrient loads. In cases where there is a great deal of manure in a county and not much cropland, there is a decrease in both nitrogen and phosphorus.

Annual or Cumulative? Annual (1-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*

- Manure Transport

- *Measurement unit:* Dry tons or Wet tons. Note: Calculations are done using dry tons, so if wet tons are reported they are converted to dry tons for you.
- *Animal Group:* Eligible on any animal type or animal group; if none are reported the default will be "all animals."
- *Load Source:* Approved NEIEN agricultural load sources; if none are reported the default will be FEED
- *County From:* County or Outside Watershed (where manure or litter originated)
- *County To:* County or Outside Watershed (destination of manure or litter)
- *Date of implementation:* Year manure was transported.

Figure A-16-2. Some Bay states help farmers identify certified manure haulers that will transport excess manure to areas that need it. Photo: Maryland Department of Agriculture.

Table A-16-1. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Manure Transport	Manure Transport	Manure/litter hauling; manure/litter transport

Additional Information

Poultry Litter Subcommittee. 2015. Recommendations to estimate poultry nutrient production in the Phase 6 Watershed Model. https://www.chesapeakebay.net/documents/recommendations_to_estimate_poultry_nutrients_for_phase_6_model_03062015.pdf

Manure Value and Economics. Webpage and additional resources: http://articles.extension.org/pages/8652/manure-value-and-economics

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definition and benefits that have remained in use since review and approval by the CBP partnership's source sector workgroups for tributary strategy development.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-17. Manure Incorporation or Injection

General Information

Figure A-17-1. Specialized equipment is used for manure incorporation and injection. Manure incorporation requires machinery that mixes dry, semi-dry or liquid organic nutrient sources – such as manure, bio-solids, and compost – into the soil

Manure is a byproduct of animal agriculture and is a valuable fertilizer for crop production. Applying manure to the soil surface is a common method for distributing manure and its nutrients on crop fields. However, this results in the loss of ammonia nitrogen, can cause odor issues and increases the risk of phosphorus runoff. When manure is incorporated or injected into the soil the potential odors or loss of nutrients are reduced. There are many different specialized pieces of equipment that enable farmers to incorporate or inject manure into the soil based on their needs or manure used.

CBP Definition(s)

Manure Incorporation is defined as the mixing of dry, semi-dry, or liquid organic nutrient sources (including manures, biosolids, and compost) into the soil profile within a specified time period from application by a range of field operations (≤24hr for full ammonia loss reduction credit and 3 days for P reduction credit(s)). These methods can provide nutrient loss reductions that may differ for P and N by method used. Nutrient loss reductions are primarily due to lower ammonia-N volatilization and in many cases lower dissolved P and N losses in surface runoff. Nutrient loss reductions may vary with timing between application and soil mixing, degree of soil mixing, and percent soil surface disturbance. The CBP has established two categories of incorporation:

High disturbance incorporation provides the highest degree of mixing of organic nutrient sources into the root zone, but effectively eliminates the erosion control benefits of conservation tillage. Incorporation plus additional field operations retain <30% of residue cover at planting.

Figure A-17-2. Manure injection mechanically applies the organic nutrients – manure, bio-solids, or compost – into the root zone with surface soil closure at the time of application. This offers the greatest nutrient reduction and odor reduction due to limited soil disruption, amount of material left on the soil and immediate soil closure. Photo: Livestock and Poultry Environmental Learning

Low disturbance incorporation: leaves greater quantities of organic nutrient sources on the soil surface, but maintains most of the benefits of conservation tillage. Incorporation plus additional field operations retains at least 30 % of residue cover at planting to meet criteria for the Phase 6 Conservation Tillage practice.

Manure Injection is a specialized category of placement in which organic nutrient sources (including manures, biosolids, and composted materials) are mechanically applied into the root zone with surface soil closure at the time of application. Injection is expected to provide the greatest level of nutrient loss reduction to both atmospheric and surface runoff pathways (including both dissolved and sediment bound nutrients), as well as odor reduction, due to limited quantities of material left on the soil surface, limited soil disruption, and immediate soil closure. Total soil surface disturbance for injection plus planting and any other field operations should be less than 40% so that the practice is compatible with the Low Residue, Strip Till/No-Till practice.

Specifications or Key Qualifying Conditions

Manure must be incorporated into the soil within 1-3 days to be eligible for the manure incorporation (late) BMPs and must be incorporated within 24 hours to be eligible for the incorporation (early) BMPs. The expert panel report (see Additional Information below) provides other qualifying conditions, such as appropriate application technologies for injection and incorporation (low-disturbance). Any tillage system is appropriate for high-disturbance incorporation, but not all tillage systems may be consistent with disturbance or crop residue requirements for separate BMPs such as conservation tillage.

Nitrogen, Phosphorus and Sediment Reductions

Only nitrogen and phosphorus efficiencies have been established for these practices. Any sediment loss reductions associated with injection or low disturbance incorporation are addressed through corresponding conservation tillage BMPs (see A-3: Conservation Tillage). Phosphorus efficiency values differ based on whether the practice is implemented in an area of the Coastal Plain or in any other hydrogeomorphic region (HGMR), as shown in Table A-17-1.

Table A-17-1. Nitrogen and Phosphorus Efficiency Values for Manure Incorporation and Injection BMPs

BMP	Nitrogen *All HGMRs* (%)	Phosphorus *Coastal Plain HGMRs* *(%)*	Phosphorus *All other HGMRs* *(%)*
Incorporation Low Disturbance Early*	8	14	24
Incorporation Low Disturbance Late**	8	14	24
Incorporation High Disturbance Early*	8	14	12
Incorporation High Disturbance Late**	8	14	12
Injection	12	22	36
*Early = manure is incorporated into soil within 24 hours of application **Late = manure is incorporated into soil between 1 and 3 days of application			

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Cropland Eligible for Manure*
- Row Crops Eligible for Manure*
- Specialty Cropland*
- Cropland and Hay Eligible for Manure
- Hay
- Leguminous Hay
- Other Hay
- Pasture
- Pasture and Hay

Manure Injection and Manure Incorporation Low Disturbance (Early or Late) can be applied to any of the above land use groups. Manure Incorporation High Disturbance (Early or Late) is only applicable to the load source groups above with an asterisk (*).

Brief Description of BMP Simulation in the Model

The manure incorporation and injection practices are *Efficiency Value BMPs*. All nitrogen and phosphorus loads from acres treated by manure injection or incorporation are simulated as a percent reduction of the estimated runoff using the values in Table A-17-1.

Annual or Cumulative? Annual (1-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Manure Incorporation Low Disturbance Early
  - Manure Incorporation Low Disturbance Late
  - Manure Incorporation High Disturbance Early
  - Manure Incorporation High Disturbance Late
  - Manure Injection
- *Measurement unit:* Acres or percent
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be Row Crops Eligible for Manure
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year practice was implemented.

Table A-17-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Immediate Low Disturbance Manure Incorporation	Manure Incorporation Low Disturbance Early	None
Low Disturbance Manure Incorporation	Manure Incorporation Low Disturbance Late	None
Immediate High Disturbance Manure Incorporation	Manure Incorporation High Disturbance Early	None
High Disturbance Manure Incorporation	Manure Incorporation High Disturbance Late	None
Manure Injection	Manure Injection	None

Additional Information

Expert panel report:

Dell, C., Allen, A., Dostie, D., Meinen, R., & R. Maguire. 2016. Manure Incorporation and Injection Practices for use in Phase 6.0 of the Chesapeake Bay Program Watershed Model. D. Meals (ed.) with M. Dubin, L. Gordon, J. Sweeney & C. Brosch. CBP/TRS-309-16. https://www.chesapeakebay.net/documents/Phase_6_FINAL_MII_Final_Report_FINAL.pdf

Maguire, R., Beegle, D., McGrath, J., & Q. Ketterings. 2018. Manure Injection in No-Till and Pasture Systems. Virginia Cooperative Extension, Publication CSES-22P.
https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/CSES/CSES-22/CSES-231.pdf

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A-18. Animal Mortality Management (Composting)

General Information

Figure A-18-1. Animal mortality composting facility. Source: [Animal Mortality Composting - Blanchard Demonstration Farms (blancharddemofarms.org)](blancharddemofarms.org).

The unplanned mortality of animals involved in agricultural production can result in water quality and public health impacts, such as increased nutrient pollution and the spread of diseases. Animal mortality management practices can protect surface and groundwater by minimizing contamination from dead animal carcasses, as well as preventing the spread of pathogens to service providers who are responsible for handling the carcasses. Mortality management can include methods such as composting, incineration or offsite disposal.

CBP Definition(s)

Animal mortality disposal by composting: The handling, storage and disposal of poultry, livestock or other routine animal mortalities by composting including one or more of the following, alone or in combination: static piles and windrows (a.k.a. passive piles), turned windrows, static aerated windrows, a bin system, a tunnel composter, or in-vessel composter such as a rotating drum. An implementor must report units of animal units or tons of carcasses of dead animal for an annual practice or in units of systems for a structural system.

Animal mortality disposal by landfill or rendering is the handling, storage and disposal of poultry, livestock or other routine animal mortalities by internment in a landfill or processing at a rendering facility. An implementor must report units of animal units or tons of carcasses of dead animal by animal type for an annual practice or in units of systems for a structural system.

Animal mortality disposal by burial is the handling and disposal of poultry, livestock, or other routine animal mortalities by placing the carcass or carcasses below ground into an excavated pit, hole, or trench, which is then covered or capped. This practice is considered a baseline management practice and not as a reportable CBP BMP for nutrient reduction credit.

Animal mortality disposal by incineration is the handling, storage and disposal of poultry, livestock or other routine animal mortalities by thermochemical conversion using combustion, gasification, pyrolysis, or some combination of those methods. The methods result in gaseous and solid byproducts. It is expected that most nitrogen is transformed and lost to the atmosphere, while all phosphorus remains available for land application or for transport. An implementor must report units of animal units or tons of carcasses of dead animal by animal type for an annual practice or in units of systems for a structural system.

Specifications or Key Qualifying Conditions

Any mortality management practice or method mentioned that meets the definitions above and treats routine animal mortalities from one of the animal groups listed in the table below is eligible for credit. Practices or methods used for catastrophic mortality events are not eligible under this set of practices. Practices or methods that are also used to treat manure should not be reported twice, i.e., they should not be reported as both mortality and manure treatment practices. Additional guidelines for specificiations can be found in the Natural Resource Conservation Service (NRCS) Conservation practice standards, as well as the Resource Improvement (RI) report (pages 11 – 12).

Table A-18-1. CAST conversion rates of animals per system.

State	Animal Name	Average animal count per system	Animals per Animal Unit (AU)	Acres per animal count
All	Turkeys	3,744	38.33866	0.000023
All	Beef	22	1.14	0.001890
DC	Broilers	198,096	163.93	0.000003
DE	Broilers	198,096	136.9826	0.000003
MD	Broilers	198,096	163.93	0.000003
NY	Broilers	198,096	178.0822	0.000003
PA	Broilers	198,096	178.5749	0.000003
VA	Broilers	198,096	175.4352	0.000003
WV	Broilers	198,096	256.3884	0.000003
All	Dairy	84	0.74	0.002881
All	Goats	13	15.38	0.000344
All	Swine (hogs and pigs for breeding)	428	2.222222	0.000311
All	Swine (hogs for slaughter)	74	3.703704	0.000111
All	Horses	7	1	0.006765
All	Layers	1,720	250	0.000040
All	Other cattle	43	3.34	0.002385
All	Pullets	9,734	352.5	0.000010
All	Sheep and lambs	33	10	0.000574

Nitrogen, Phosphorus and Sediment Reductions

The reduction efficiencies for animal mortality management practices are shown below in Table A-18-2. When reporting these practices, jurisdictions must include the animal type and either the animal count or animal number (AUs) of mortality of the production/inventory of the operation during the reporting period, or the weight (tons) of carcasses disposed using the BMP. All systems, tons, animal counts or AU are converted to acres using the standard conversions.

Table A-18-2. Summary of recommended reduction efficiencies for the agricultural stormwater management BMP.

BMP Name	Reduction Efficiency		
	TN %	TP%	Sed.%
Burial	0	0	N/A
Compost	0.124	0.059	N/A
Incineration	0.372	0.059	N/A
Rendering	0.372	0.059	N/A

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Feeding Space
- Permitted Feeding Space
- Non-permitted Feeding Space

Brief Description of BMP Simulation in the Model

The animal mortality management BMP is considered an *Efficiency Value BMP*, which reduces total nitrogen and phosphorus loads from eligible load sources according to the percentage values listed in Table A-18-2.

Annual or Cumulative? Cumulative (5-year credit duration).

Can this practice be combined with other BMPs? Each mortality BMP is mutually exclusive from one another; however, the mortality practices are not mutually exclusive with other practices applied to the feeding space load source. In other words, only one type of mortality BMP can be applied for a given set of animals, but other non-mortality BMPs can still be applied (e.g., barnyard runoff control or loafing lot management).

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Animal mortality disposal by incineration
    - Animal Mortality Facility (NRCS316), Animal Compost Structure RI, Composter Facilities, Composting Facility, Dead Bird Composting Facility, Animal mortality disposal by composting
    - Animal mortality disposal by rendering or landfill.
- *Measurement unit:*
    - au , Unit = count
    - beef , Unit = count
    - broilers , Unit = count
    - dairy heifers , Unit = count
    - goats , Unit = count
    - hogs and pigs , Unit = count
    - hogs for slaughter , Unit = count
    - horses , Unit = count
    - layers , Unit = count
    - livestock , Unit = count
    - no , Unit = count
    - no systems , Unit = count
    - no. systems , Unit = count
    - number , Unit = count
    - other cattle , Unit = count
    - poultry , Unit = count
    - pullets , Unit = count
    - sheep and lambs , Unit = count
    - st , Unit = count
    - swine , Unit = count
    - systems , Unit = count
    - turkeys , Unit = count
- *Land Use:* Permitted feeding operation, non-permitted feeding operation, feeding operation.
- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Date the animal mortality management practice was implemented.

Table A-18-3. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other practice names
Animal mortality disposal by composting RI-2: Animal compost structure	Animal mortality disposal by composting	NRCS Practice 316: Animal Mortality Facility; Animal Compost Structure RI; Composter Facilities; Composting Facilities; Dead Bird Composting Facility
	Animal mortality disposal by incineration	
	Animal mortality disposal by rendering or landfill	

Additional Information

Expert panel report:
Hamilton, D., Bass, T.M., Gumbert, A., Hovingh, E., Hutchinson, M., Lim, T.-T., Means, S., and G. Malone. (2021). Estimates of nutrient loads from animal mortalities and reductions associated with mortality disposal methods and Best Management Practices (BMPs) in the Chesapeake Bay Watershed. Edited by J. Hanson, A. Gumbert & D. Hamilton. Approved by the CBP WQGIT on July 24, 2023. Available at https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Animal-Mortality-Mngmnt-Expert-Panel-Report-WQGIT-Approved.pdf

NRCS Conservation Practice Standard. Animal Mortality Facility (Practice 316). https://www.nrcs.usda.gov/sites/default/files/2022-08/Animal_Mortality_Facility_316_CPS_9_2105.pdf

Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report: Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014. Pages 11 – 12. https://www.chesapeakebay.net/documents/RI_Report_5_8-8- 14.pdf

Version and History Statement

This info sheet was first published on April 3, 2024 and reflects the BMP definitions and reductions approved by the WQGIT in July 2023. All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-19. Off-stream Watering Without Fencing

General Information

When livestock have access to the stream as a water source, they degrade the areas along the streambank, increasing erosion while also depositing manure directly into the stream. Alternatively, when livestock have water sources away from the stream, there is less erosion and their manure is less likely to wash into the stream.

Figure A-19-1. Alternative water sources away from the stream keep livestock in pasture or heavy use areas, reducing erosion and manure deposition to the stream. Photos: USDA NRCS.

CBP Definition(s)

Off-stream watering without fencing: This BMP requires the use of alternative drinking water sources, such as permanent or portable livestock water troughs placed away from the stream corridor. Implementing off-stream shade for livestock is encouraged where applicable. The water supplied to the facilities can be from any source, including pipelines, spring developments, water wells and ponds. In-stream watering facilities, such as stream crossings or access points, are not considered in this definition. The modeled benefits of alternative watering facilities can be applied to pasture acres in association with improved pasture management systems such as rotational grazing.

Watering trough (CBP Resource Improvement Practice, RI-18): A permanent or portable device to provide an adequate amount and quality of drinking water for livestock.

Specifications or Key Qualifying Conditions

This BMP is only applicable for livestock pastures that do not have stream exclusion practices, as pastures that exclude livestock from streams already provide alternative water sources as part of those practices. See buffers with exclusion fencing (A-13) as an example. Otherwise, there are no specific conditions for CBP purposes. It is expected that reported cost-share practices conform to state or federal practice standards, and that any non-cost-shared practices conform to the criteria described in the *Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report* (linked under Additional Information below).

Nitrogen, Phosphorus and Sediment Reductions

Table A-19-1. Supplemental Nitrogen and Phosphorus Percent Reductions to Land Use Runoff.

BMP	Nitrogen (%)	Phosphorus (%)	Sediment (%)
Off-stream watering without fencing	5	8	10

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Pasture

Brief Description of BMP Simulation in the Model

The off-stream watering without fencing BMP is an *Efficiency Value BMP*. Each acre of pasture reported under the BMP will have its nitrogen, phosphorus and sediment loads reduced using the values in Table A-19-1.

Annual or Cumulative? Cumulative (10-year credit duration; 5-year credit duration for RI-18).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Off-stream watering without fencing
    - Watering trough RI
- *Measurement unit:* Acres; if only the number of systems is known, this can be reported and NEIEN will convert to acres
- *Land Use:* Pasture
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year watering system was implemented.

Table A-19-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Off stream watering without fencing; Alternative water source;	Alternative water system; extension of CREP watering system; watering facility; watering trough RI (RI-18)	Watering facility (NRCS 614)

Additional Information

Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report: Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014. https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in May 2010.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-20. Poultry Litter Ammonia Control Practices

General Information

There are two established practices for reducing hazardous ammonia emissions from poultry houses: poultry litter amendments and biofilters. Poultry litter amendments prevent poultry manure ammonium from transforming into ammonia gas, a process known as volatilization. Reducing ammonia volatilization improves air quality and poultry health, saves energy by reducing the need for ventilation, retains nitrogen in litter for use as fertilizer, and decreases leaching and runoff of soluble phosphorus and heavy metals from land-applied litter. Biofilters treat volatilized ammonia before it leaves the poultry house by directing air through a filter. Air is directed through a mixture of organic materials that break down ammonia and transform it into non-hazardous chemical compounds before it exits the poultry house. Biofilters also reduce particulate matter emissions, odors and microbial bioaerosol and hydrogen sulfide emissions.

Figure A-20-1. NRCS Practice Code 591: Amendments for the treatment of agricultural waste is the treatment of manure, process wastewater, stormwater runoff from lots or other high intensity areas, and other wastes with chemical or biological additives. Source: NRCS Tennessee (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/tn/home/?cid=nrcs144p2_027179)

CBP Definition(s)

Poultry Litter Treatment: A surface application of alum, an acidifier, to poultry litter to acidify poultry litter and maintain ammonia in the non-volatile ionized form (ammonium).

Poultry House Biofilters: These poultry housing ventilation systems pass air through a biofilter media that incorporates a layer of organic material, typically a mixture of compost and wood chips or shreds. These support a microbial population and reduce ammonia emissions by oxidizing volatile organic compounds into carbon dioxide, water, and inorganic salts.

Specifications or Key Qualifying Conditions

To receive ammonia emission reduction credit, alum must be applied at a rate of 250 lbs per 1000 square feet. Consult your local NRCS representative to determine the necessary local, state and federal laws to follow during application, and for help with application products, rates, methods, handling, storage and timing.

Nitrogen, Phosphorus and Sediment Reductions

The ammonia reductions for poultry litter amendments are displayed in Table A-20-1.

Table A-20-1. Ammonia Emission Reductions for Poultry Litter Amendments and Biofilters.

Animal Type	Ammonia Reduction	
	Poultry Litter Amendments	Biofilters
Broilers	50%	60%
Layers	50%	60%
Pullets	50%	60%
Turkeys	50%	60%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Poultry.
- Chickens.
- Layers.

- Pullets.
- Broilers.
- Turkeys.

Brief Description of BMP Simulation in the Model

Poultry litter amendments and biofilters are simulated as *Animal BMPs* that reduce the amount of gaseous ammonia released into the atmosphere. The reduction in nitrogen associated with these BMPs is calculated as part of the edge-of-tide (EOT) nitrogen load.

Annual or Cumulative? Poultry litter amendments are annual (one-year credit duration) and biofilters are cumulative (three-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

For poultry litter amendments, jurisdictions should report the following:

- *BMP Name:*
  - Amendments for the Treatment of Agricultural Waste.
- *Measurement unit:* Animal Count.
- *Land Use:* Feed space.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year.

For biofilters, jurisdictions should report the following:

- *BMP Name:*
  - Biofilters.
- *Measurement unit:* Animal count.
- *Land Use:* Feed space.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year.

Table A-20-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Poultry litter amendments	Amendments for the treatment of agricultural waste	Amendments for treatment of agricultural waste (NRCS 591); Chemical treatment for poultry litter
Biofilters	Biofilters	None

Additional Information

T. Simpson and S. Weammert (Lane). 2009. Ammonia Emissions Reduction: Litter Treatment, Biofilters, and Covers: Definition and Nutrient and Sediment Reduction Effectiveness Estimates. T. Simpson and S. Weammert (Lane), eds. Final Report, December 2009. Pages 30-55. https://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

USDA NRCS Field Office Technical Guides: http://www.nrcs.usda.gov/technical/efotg/

USDA NRCS National Handbook of Conservation Practices (NHCP):
http://www.nrcs.usda.gov/technical/standards/nhcp.html

USDA NRCS and EPA. 2017. Reference Guide for Poultry and Livestock Production Systems.
https://www.epa.gov/sites/default/files/2017-01/documents/web_placeholder.pdf

Livestock and Poultry Environmental Learning Community:
https://lpelc.org/technologies-for-mitigating-ammonia-emissions-from-animal-agriculture/

Version and History Statement

This info sheet was first published on November 14, 2022 and reflects the BMP definitions and reductions developed through Simpson and Weammert (Lane) and approved by the WQGIT in 2009.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-21. Agricultural Ditch Management Practices

General Information

Drainage systems in poorly drained soils with seasonally high water tables are essential for agricultural productivity. There are extensive networks of drainage ditches throughout the Chesapeake Bay watershed and the installation of subsurface tile drainage on cropland has increased in recent years. These systems can accelerate the flux of drain water and dissolved nutrients to receiving waters, affecting both crop yields and receiving water quality. Several practices such as blind inlets, bioreactors and saturated buffers have been developed and tested to reduce nutrient and/or sediment losses associated with such drainage systems and are increasingly incorporated in BMP implementation planning.

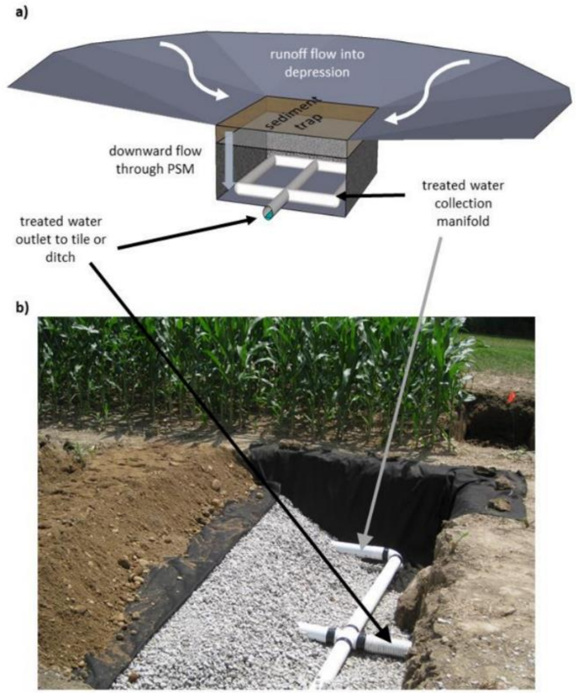

Figure A-21-1. a) Diagram of typical blind inlet and b) cutaway of a blind inlet in the field. Source: Upper image from Penn and Bowen, 2017, lower image from USDA-ARS. See Expert Panel Report (p.18).

CBP Definition(s)

Blind Inlets: Drain structure backfilled with pervious materials (gravel or sand) that filter drainage water prior to entering subsurface tile drain. Eligible when installed to replace existing tile riser.

Blind Inlets with P-sorbing materials: Drain structure backfilled with phosphorus sorption material solid media that filter drainage water prior to entering subsurface tile drain. Eligible when installed to replace existing tile riser.

Denitrifying Bioreactors: Structure that diverts agricultural tile-drainage water to pass through a media chamber filled with a carbon source for denitrification of dissolved nitrate to occur.

Monitored Denitrifying Bioreactor for spring or seep: Structure that diverts emerging groundwater to pass through a media chamber filled with a carbon source for denitrification of dissolved nitrate to occur. The treated flow volume and nitrate concentrations are directly measured to calculate the annual removal of nitrogen.

Drainage Water Management: The process of managing water discharges from surface and/or subsurface agricultural drainage systems, which raises and lowers the water level within the soil profile throughout the year following an operation and maintenance (O&M) plan.

P removal systems: A landscape-scale filter that traps dissolved phosphorus from agricultural drainage water using phosphorus sorption material.

Monitored P removal system: A landscape-scale filter that traps dissolved phosphorus from animal production areas using phosphorus sorption material. Credit is given for the amount of phosphorus removed (lbs).

Saturated buffers: Diversion of tile-line flow to a subsurface, using perforated distribution pipe to divert and spread drainage system discharge to a vegetated area to increase soil saturation.

Specifications or Key Qualifying Conditions

Each agricultural ditch and drainage management practice has specifications or key qualifying conditions to be eligible for credit. For example, blind inlets are not eligible for water quality benefits unless they are installed to replace an existing open inlet. For a full list of specifications of each practice, consult the expert panel report (see Additional Resources below).

Nitrogen, Phosphorus and Sediment Reductions

The nutrient and sediment reductions for agricultural ditch BMPs are displayed below in Table A-21-1.

Table A-21-1. Summary of recommended reduction efficiencies for agricultural ditch BMPs.

BMP Name	Reduction Efficiency			Credit Duration
	TN %	TP%	Sed.%	
Blind Inlets	0	40	60	5 years
Blind Inlets with P-sorbing Materials	0	50	60	5 years
Denitrifying Bioreactors	20	0	0	10 years
Monitored Denitrifying Bioreactor for Spring or Seep	Measured (lbs-N)	0	0	1 year
Drainage Water Management	30	0	0	1 year
P-removal Systems	0	50	60	4 years
Monitored P Removal System for Animal Production Area	0	Measured (lbs-P)	0	1 year
Saturated Buffers	20	0	0	10 years

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

For P-removal systems applied to animal production areas, the following load sources can be reported. If the specific load source group is not known, the load source group "FEED" can be used, which includes both permitted and non-permitted feeding space load sources.

- Permitted Feeding Space.
- Non-permitted Feeding Space.

For all other agricultural ditch management BMPs, the following load sources can be reported. If no load source or load source group is specified, the default will be "AG'.

- Ag Open Space.
- Double Cropped Land.
- Full Season Soybeans.
- Grain with Manure.
- Grain without Manure.
- Leguminous Hay.
- Other Agronomic Crops.
- Other Hay.
- Pasture.
- Silage with Manure.
- Silage without Manure.
- Small Grains and Grains.
- Specialty Crop High.
- Specialty Crop Low.

Brief Description of BMP Simulation in the Model

The saturated buffer BMP is a *Load Source Change with Efficiency Value BMP* that first converts eligible crop load sources to Ag Open Space. The practice then reduces total nitrogen loads from upland acres by 20%. Ten upland acres are treated per acre of saturated buffer.

All other agricultural ditch management BMPs are considered *Efficiency Value BMPs*, which reduce total nitrogen, phosphorus or sediment loads from eligible load sources according to the percentage values listed in Table A-21-1.

Annual or Cumulative? Drainage Water Management, Monitored Denitrifying Bioreactor for Spring or Seep and Monitored P-removal System for Animal Production Areas are all annual practices (one-year credit duration). The other ag ditch management BMPs are cumulative practices. See Table A-21-1 for credit durations of each practice.

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

For blind inlets or blind inlets with P-sorbing materials, jurisdictions should report the following information:

- *BMP Name:*
    - Blind Inlet OR Blind Inlet with P-sorbing materials.
- *Measurement unit:* Drained Area (Acres) OR Count (number of eligible blind inlets) for conversion to acres at one acre per blind inlet.
- *Land Use:* All crop, pasture and hay load source groups; if none are reported, the default is AG.
- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year the inlet was installed.

For denitrifying bioreactors, jurisdictions should report the following information:

- *BMP Name:*
    - Bioreactor.
- *Measurement unit:* Drained Area (Acres) OR Count (conversion to acres at five acres per one bioreactor)
- *Land Use:* All crop, pasture and hay load source groups; if none are reported, the default is AG.
- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year the bioreactor was installed.

For directly measured water spring bioreactors, jurisdictions should report the following information:

- *BMP Name:*
    - Monitored Spring Bioreactor.
- *Measurement unit:* Pounds of nitrogen removed (lbs.).
- *Land Use:* AG.
- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year the measured removal occurred.

For drainage water management, jurisdictions should report the following information:

- *BMP Name:*
    - Drainage water management.
- *Measurement unit:* Effective Drainage Control Area (Acres), a.k.a. Control Zone, Impacted Area or Drained Area.
- *Land Use:* All crop, pasture and hay load source groups; default is AG.
- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year practice was implemented.

For P-removal systems, jurisdictions should report the following information:

- *BMP Name:*
    - P-removal system.
- *Measurement unit:* Treated Area (acres) OR Count [Conversion to acres at five acres per system].
- *Land Use:* All crop, pasture and hay load source groups; default is AG.

- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year the system was implemented.

For P-removal systems applied to animal production areas, jurisdictions should report the following information:

- *BMP Name:*
    - Monitored P-removal system.
- *Measurement unit:* Pounds of phosphorus removed (lbs).
- *Land Use:* Feed space (permitted or non-permitted).
- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year the measured removal occurred.

For saturated buffers, jurisdictions should report the following information:

- *BMP Name:*
    - Saturated Buffer.
- *Measurement unit:* Area of buffer (acres) OR length of buffer (linear feet);
    - Note: If the linear feet option is chosen, then NEIEN will assume that each project is 30 feet wide in compliance with NRCS practice code 604 and convert to acres.
- *Land Use:* All crop, pasture and hay load source groups; default is AG
- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year the saturated buffer was implemented.

Table A-21-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other practice names
Blind Inlet	Subsurface drain Underground outlet	NRCS 620 NRCS 606 Gravel inlet; French drain
Blind Inlet with P-sorbing materials		
Denitrifying Ditch Bioreactor		NRCS 605
Monitored Denitrifying Bioreactor for Spring or Seep		
P-removal system		NRCS 782
Monitored P-removal system for animal production area		
Saturated Buffer		NRCS 684
Drainage Water Management		NRCS 554

Additional Information

Expert panel report:

Bryant, R., Baldwin, A., Cahall, B., Christianson, L., Jaynes, D., Penn, C., and S. Schwartz. (2019). Best Management Practices for Agricultural Ditch Management in the Phase 6 Chesapeake Bay Watershed Model. Collins, L., Hanson, J. and C. Gill, editors. CBP/TRS-326-20. Approved by the CBP WQGIT March 23, 2020. https://www.chesapeakebay.net/documents/Ag_Ditches_BMP_panel_report_WQGIT_Approved_Mar2020.pdf

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A-22. Tree Planting (Agricultural)

General Information

Forests provide a host of environmental benefits. They reduce the quantity and velocity of surface runoff, improve local water quality and offer wildlife habitat, to name just a few. To protect these benefits, it is important to conserve and maintain existing forested areas, but there are also opportunities to expand forest coverage through tree planting in agricultural areas. This reference sheet pertains to tree planting in agricultural settings (for Forest Buffers see A-12 and A-13; for tree planting practices in developed areas see D-7).

Figure A-22-1. Tree planting on agricultural lands provides numerous environmental benefits, including improved water quality, especially when the trees create forested areas. Photo: USDA NRCS

CBP Definition(s)

Tree planting includes any trees planted on agricultural land, except those used to establish riparian forest buffers, targeting lands that are highly erodible or identified as critical resource areas.

Specifications or Key Qualifying Conditions

This BMP does not apply to trees planted as riparian buffers or for trees planted in developed settings, which are separate BMPs.

Nitrogen, Phosphorus and Sediment Reductions

Nitrogen, phosphorus and sediment reductions are determined based on the prior land use that is converted to forest. Actual simulated reductions will vary based on your specific area and can be calculated in CAST, but an average per-acre reduction is provided in Table A-22-1 for reference.

Table A-22-1. Average nitrogen, phosphorus and sediment reductions per acre of agricultural tree planting. Actual reductions will vary and can be calculated in CAST. All values in the table are pounds removed at the edge-of-tide. Source: BMP Pounds Reduced and Costs by State (April 30, 2018 version) available online at http://cast.chesapeakebay.net/Documentation/DevelopPlans

State	Nitrogen *Average reduction (lbs/ac, Edge of Tide)*	Phosphorus *Average reduction (lbs/ac, Edge of Tide)*	Sediment *Average reduction (lbs/ac, Edge of Tide)*
Delaware	52.6	0.3	241
Maryland	21.2	0.7	703
New York	5.8	0.2	229
Pennsylvania	18.1	0.4	505
Virginia	11.5	0.5	309
West Virginia	6.7	0.2	165

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

Agricultural tree planting can be reported on any of the load source groups below; the default is the combined group “AG.”

- Ag Open Space

- Double Cropped Land
- Full season Soybeans
- Grain with Manure
- Grain without Manure
- Legume Hay
- Other Agronomic Crops
- Other Hay
- Silage with Manure
- Silage without Manure
- Small Grains and Grains
- Specialty Crop High
- Specialty Crop Low
- Pasture

Figure A-22-2. Newly planted young trees benefit from cylindrical tubes –or "shelters" – and wooden stakes that protect them from harsh conditions and predation by deer as they establish their roots and grow. Photo: Chesapeake Bay Program.

Brief Description of BMP Simulation in the Model

The agricultural Tree Planting practice is a *Load Source Change BMP*. Each acre planted and reported under the BMP converts one acre from an AG load source into Forest.

Annual or Cumulative? Cumulative (15-year credit duration).

Can this practice be combined with other BMPs? No. An area converted to the Forest load source by this BMP is no longer eligible for application of other agricultural BMPs.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:* Tree Planting
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be AG
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year trees were planted.

Table A-22-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Tree planting (agriculture)	Tree planting	Reforestation; forest planting; tree planting; Windbreak/shelter establishment (NRCS 380); Tree/Shrub Establishment (NRCS 612); Tree Planting (FSA CP3); Hardwood Tree Planting (FSA CP3A)

Additional Information

A Guide for Forestry Practices in the Chesapeake Bay TMDL Phase III Watershed Implementation Plans. Prepared by the Forestry Workgroup. *https://www.chesapeakebay.net/what/publications/25951*

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definition and benefits that have remained in use since review and approval by the CBP partnership's source sector workgroups for tributary strategy development. Updates to this reference sheet were published on November 14, 2022.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-23. Soil Conservation and Water Quality Plans

General Information

A Soil Conservation and Water Quality Plan (SCWQP) is a comprehensive plan that considers management of natural resources on agricultural lands and utilizes BMPs that control soil erosion and manage runoff. These plans include a range of management practices such as crop rotations and structural practices such as sediment basins or grade stabilization structures. The CBP accounts for several major practices under their own unique BMPs, such as conservation tillage (A-3) or pasture and grazing management (A-8). The benefits from a number of other common practices without their own standalone BMPs as defined by the CBP are simulated under this Soil Conservation and Water Quality Plan BMP.

Figure A-23-1. At a farmer's request professional conservation agents – from university extension offices, state/local conservation districts, NRCS or FSA offices, or private consulting firms – assist them to develop conservation plans that consider an appropriate suite of practices for their operation's specific erosion and runoff concerns. Photo: USDA NRCS.

CBP Definition(s)

Soil Conservation and Water Quality Plan: For CBP purposes, these are farm conservation plans that involve a combination of agronomic, management and engineered practices that protect and improve soil productivity and water quality and prevent deterioration of natural resources on all or part of a farm. Plans must meet applicable NRCS technical standards.

Specifications or Key Qualifying Conditions

As noted above, for CBP purposes plans and any associated conservation practices implemented must meet applicable NRCS technical standards. Plans are subject to other state-specific programmatic requirements, where they exist; the term used for a "Soil Conservation and Water Quality Plan" may vary based on state programs but the purpose of the qualifying conservation plans remains the same.

Nitrogen, Phosphorus and Sediment Reductions

Nutrient and sediment reductions vary for this BMP based on the load source they apply to, as summarized in Table A-23-1 below.

Table A-23-1. Nitrogen, Phosphorus and Sediment Efficiency Values for Soil Conservation and Water Quality Plan BMP, by load source.

Load source	Nitrogen	Phosphorus	Sediment
Ag Open Space	3%	5%	8%
Double Cropped Land	8%	15%	25%
Full Season Soybeans	8%	15%	25%
Grain w/ Manure	8%	15%	25%
Grain w/o Manure	8%	15%	25%
Legume Hay	3%	5%	8%
Other Agronomic Crops	8%	15%	25%
Other Hay	3%	5%	8%
Pasture	5%	10%	14%
Silage w/ Manure	8%	15%	25%
Silage w/o Manure	8%	15%	25%
Small Grains and Grains	8%	15%	25%

Specialty Crop High	8%	15%	25%
Specialty Crop Low	8%	15%	25%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Ag
- Ag No Open
- Ag Open Space
- Crop
- Crop Hay
- Crop Hay with Manure
- Crop with Manure
- Grains
- Hay
- Legume Hay
- Other Hay
- Pasture
- Pasture Hay
- Row
- Row with Manure
- Specialty

The BMP is applicable to any load source groups listed above; if none is selected, the default is "AG."

Brief Description of BMP Simulation in the Model

The Soil Conservation and Water Quality Plan is an *Efficiency Value BMP*. Each acre reported under the BMP has its load reduced by the percent reductions listed in Table A-23-1.

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Conservation Plans
    - Conservation Plans/SCWQP
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be CROP
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year plan was developed.

Table A-23-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Soil Conservation and Water Quality Plan; Conservation Planning: Field and Pasture Erosion Control Practices	Conservation Plans; Conservation Plans/SCWQP	Name used for these conservation plans may vary based on state programs; may involve multiple practices, not listed here due to space.

Additional Information

Maryland Department of Agriculture. 2017. [Brochure] What is a Soil Conservation and Water Quality Plan?
http://mda.maryland.gov/resource_conservation/Documents/scwqplan.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions developed through Simpson and Weammert (Lane) and approved by the WQGIT in 2009.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-24. Nontidal Wetland Restoration

General Information

Figure A-24-1. An earthen ditch plug returns marginal cropland to functional wetland condition in Maryland. Source: USDA NRCS.

Wetlands provide numerous crucial environmental functions such as wildlife habitat, flood protection and water quality improvements. Many organizations throughout the Chesapeake Bay Watershed work to restore sites that were previously converted from wetlands for other use back to their natural wetland condition; this is known as wetland restoration or re-establishment. Wetland restoration can be done in both tidally influenced and nontidal freshwater systems, but this BMP is only applicable to nontidal areas. See Sheet N-2: Urban and Non-Urban Shoreline Erosion Control and Management for protocols that are applicable to wetland restoration in tidal areas.

CBP Definition(s)

Definitions for wetland practices used by the Chesapeake Bay Program do not affect regulatory or other legal definitions that exist for federal, state or local programs. To account for the range of nontidal wetland practices that occur in the Chesapeake Bay Watershed, yet distinguish practices based on key differences, four BMP categories have been established: restoration, rehabilitation, enhancement and creation. All four are defined here for reference, but the nutrient and sediment reductions associated with rehabilitation, enhancement and creation are currently under review by a BMP expert panel and therefore not summarized here.

Wetland Restoration (re-establishment): The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former wetland.

Wetland Rehabilitation: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions to a degraded wetland.

Wetland Enhancement: The manipulation of the physical, chemical, or biological characteristics of a wetland to heighten, intensify, or improve a specific function(s).

Wetland Creation (establishment): The manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist at a site

Of these four categories, restoration and creation are considered *acreage gains*, which means there is an increase in the total area of wetlands. The other two – rehabilitation and enhancement – are considered *functional gains* because they do not change the overall acres of wetlands, but they do improve the wetland's function from its current state.

Specifications or Key Qualifying Conditions

Wetland restoration practices are critical to meeting the Chesapeake Bay's water quality 2025 goals under both the Chesapeake Bay TMDL and the 2014 Watershed Agreement. However, the conversion or alteration of high quality wetlands strictly for the purposes of nitrogen, phosphorus or sediment load reductions should be avoided. Changing the functions and/or values of existing high quality wetland systems and high quality non-wetland ecosystems that already provide denitrification and phosphorous or sediment trapping should not be pursued. Also, important ecosystems such as rare and endangered species habitat, older growth forests, unique ecotones (i.e. Delmarva Bays, Magnolia bogs, critical fish spawning areas, among others) should not be priorities for wetland practices solely for the nutrient and sediment reductions under the Bay TMDL. Each project should be assessed based on federal, state, and local regulatory requirements, according to best professional judgments in the field, and supported by benchmarks presented in state and federal guidance documents.

Nitrogen, Phosphorus and Sediment Reductions

The net reductions in nitrogen, phosphorus and sediment for wetland restoration buffers are significant, but not simple to quantify without the use of CAST (http://cast.chesapeakebay.net/). There is a load source change of the restored area from the previous land use (e.g., cropland) into wetland, which reduces the simulated load. Then there is also an efficiency applied to upland acres that further reduces pollutant loads. The efficiency values applied for nitrogen, phosphorus and sediment are 42, 40 and 31 percent, respectively. The number of upland acres that are treated by the efficiency values varies based on the hydrogeomorphic region where the wetland restoration project was implemented, as summarized in Table A-24-1.

Table A-24-1. Upland acres treated, nutrient and sediment efficiency values for wetland restoration in the Phase 6 Watershed Model, by hydrogeomorphic region.

Phase 6 Watershed Model HGMR	Other (Headwater)	Floodplain	Nitrogen efficiency (%)	Phosphorus efficiency (%)	Sediment efficiency (%)
Appalachian Plateau Siliciclastic	1	2	42	40	31
Valley and Ridge Siliciclastic	1	2	42	40	31
Blue Ridge	2	3	42	40	31
Piedmont Crystalline Mesozoic Lowlands	2	3	42	40	31
Western Shore: Coastal Plain Uplands Coastal Plain Dissected Uplands	4	6	42	40	31
Eastern Shore: Coastal Plain Uplands	1	2	42	40	31
Eastern Shore: Coastal Plain Dissected Uplands	2	3	42	40	31
Coastal Plain Lowlands	2	3	42	40	31
Piedmont Carbonate Valley and Ridge Carbonate Appalachian Plateau Carbonate	2	3	42	40	31

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Agriculture
- Agriculture without Open Space
- Cropland
- Cropland and Hay
- Cropland and Hay Eligible for Manure
- Cropland Eligible for Manure
- Grains not Double Cropped
- Hay
- Leguminous Hay
- Other Hay
- Pasture
- Pasture and Hay
- Row Crops
- Row Crops Eligible for Manure
- Specialty Cropland

Wetland restoration can be reported on any of the above load source groups. The default load source group is Agriculture, or “AG.”

Brief Description of BMP Simulation in the Model

The wetland restoration practice is simulated as a *Load Source Change with an Efficiency Value* in the Watershed Model. Each acre reported under the practice is converted to either the Nontidal Floodplain Wetland or Headwater/Isolated Wetland load sources, and then there is an additional reduction to upland loads using the efficiency values in Table A-24-1. For example, one acre of marginal cropland that is restored back to its historical wetland condition will increase the overall acres of wetland by one and reduce the amount of cropland by that same amount. Additionally, the nitrogen load from four other acres will be reduced by 42 percent (assuming the restored wetland is not in the floodplain and is in a Western Shore Coastal Plain Upland setting for this example); the phosphorus and sediment loads from four acres will be reduced by 40 and 31 percent, respectively. While it is difficult to estimate the net reductions of this practice without the use of CAST, the net load reduction can be significant.

Annual or Cumulative? Cumulative. No credit duration.

Can this practice be combined with other BMPs? Yes, acres of upland load sources treated by wetland restoration can also receive other eligible agriculture BMPs. The area of land converted to either Nontidal Floodplain Wetland or Headwater or Isolated Wetland, however, cannot receive additional BMPs since wetland enhancement and wetland rehabilitations are the only two BMPs applied to wetland load sources.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Wetland Restoration – Floodplain
  - Wetland Restoration – Headwater
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be AG
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year wetland restoration was completed.

Table A-24-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Wetland Restoration	Wetland Restoration – Floodplain Wetland Restoration – Headwater	Wetland restoration (NRCS 657); CRP or CREP wetland restoration (CP23) and wetland restoration, non-floodplain (CP23A); restore hydrology to prior-converted agricultural land (cropland or pasture); elevate subsided marsh and re-vegetate; ditch plugging on cropland; legacy sediment removal

Additional Information

Expert panel report:

Mason, P., Spagnolo, R., Boomer, K., Clearwater, D., Davis, D., Denver, J., Hartranft, J., Henicheck, M., McLaughlin, E., Miller, J., Staver, K., Strano, S., Stubbs, Q., Thompson, J. & T. Uybarreta. 2016. Wetlands and wetland restoration: Recommendations of the Wetland Expert Panel for the incorporation of non-tidal wetland best management practices (BMPs) and land uses in the Phase 6 Chesapeake Bay Watershed Model. CBP/TRS-314-16. https://www.chesapeakebay.net/documents/Wetland_Expert_Panel_Report_WQGIT_approved_December_2016.pdf

Nontidal Wetland BMPs fact sheet: https://www.chesapeakebay.net/what/publications/28332

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-1. Stormwater Performance Standards

General Information

In the past several years, all of the Bay jurisdictions have adopted more stringent stormwater regulations, written new stormwater design criteria and shifted to low impact development practices. This means that new development and redevelopment will have less post-construction impact on water quality in local streams and the Bay, because nutrient and sediment loads will be closer to pre-development levels under these stormwater performance standards.

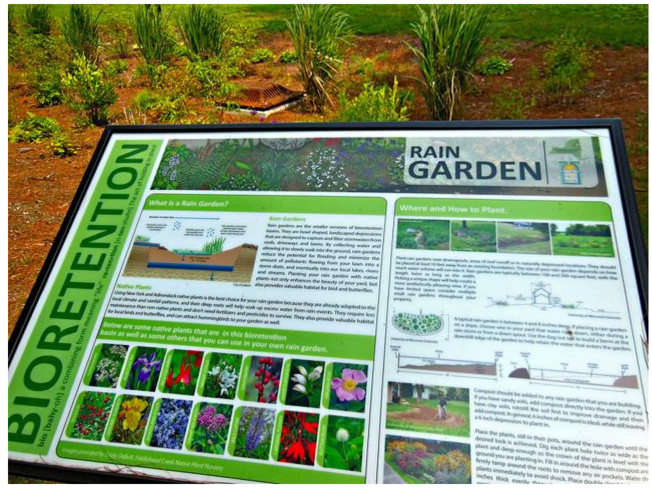

Figure D-1-1. Bioretention is one type of practice that can be used to reduce stormwater pollution that runs off from impervious areas such as roads, buildings, and parking lots. Photo: Diane Cordell, Flickr

CBP Definition(s)

Stormwater Performance Standards (aka Stormwater Practices for New and Redevelopment Projects): This refers to the range of structural and non-structural measures installed over the entire development (or redevelopment) site to reduce runoff, flooding and downstream bank erosion, as well as improve stream water quality. These practices capture stormwater runoff generated over a wide range of storm events and then treat it through some combination of settling, filtering, adsorption or biological uptake to remove nutrients and sediment.

Runoff Reduction is the total post-development runoff volume that is reduced through canopy interception, soil amendments, evaporation, rainfall harvesting, engineered infiltration, extended filtration or evapotranspiration. Stormwater practices that achieve at least a 25 percent reduction of the annual runoff volume are classified as *Runoff Reduction (RR) practices* and therefore earn a higher net removal rate. Stormwater practices that employ a permanent pool, constructed wetlands or sand filters are classified as *Stormwater Treatment (ST) practices* that have less runoff reduction capability and therefore lower removal rates than RR practices.

Common types of ST and RR practices are listed in Table D-1-1.

Table D-1-1. Classification of BMPs based on runoff reduction capability. Source: New State Performance Standards BMP Expert Panel, 2012.

Stormwater Treatment (ST) Practices	**Runoff Reduction (RR) Practices**
Constructed wetland	*Non-structural Practices*
Filtering practices (e.g., sand filter)	Landscape restoration/reforestation
Wet swale	Riparian buffer restoration
Wet pond	Impervious disconnection
	Sheet flow to vegetated filter strip or open space
	Non-Structural BMPs, Pennsylvania 2006 BMP Manual, Chapter 5
	Structural Practices
	Environmental site design practices in 2007 Maryland Stormwater BMP Manual
	Bioretention and rain garden
	Dry channel regenerative stormwater conveyance (Dry Channel RSC)
	Dry swale
	Expanded tree pits
	Grass channels and bioswales
	Green roofs
	Green streets
	Infiltration practices (aka infiltration basin, infiltration bed, infiltration trench, dry well/seepage pit, landscape infiltration)
	Permeable pavement (aka porous pavement)
	Rainwater harvesting (aka capture and re-use)

Specifications or Key Qualifying Conditions

These are practices installed on a newly developed or a redeveloped site. Practices installed to treat an existing development that is untreated, or inadequately treated, are considered retrofits (see D-2: Stormwater Retrofits). Consult the expert panel report for additional suggested qualifying conditions and your corresponding state stormwater BMP manual for specific design specifications or requirements.

Figure D-1-2. Permeable pavement is a type of runoff reduction (RR) practice because it allows processes such as filtration and evapotranspiration to occur. This approach reduces runoff and removes a greater portion of pollutants than stormwater treatment (ST) practices that employ a permanent pool – such as wet ponds, wet swales, and constructed wetlands – because such practices simply provide storage and treatment before discharge. Photo: CBP.

Nitrogen, Phosphorus and Sediment Reductions

Each pollutant (nitrogen, phosphorus and sediment) has its own equation and "adjustor curve" for RR and ST practices, as shown in Figure D-1-3 for nitrogen. The y-axis shows the percent of pollutant removal (%) based on the runoff depth captured by the practice per impervious acres in its drainage area (shown on the x-axis as inches per impervious acre).

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed Land Uses (Non-Regulated, MS4 and CSS) except construction

It is recommended that states report these practices on the appropriate land use group, i.e., either "Nonregulated," "MS4" or "CSS." Alternatively, the combined group "MS4CSSNonRegulated" can be used; this combined group is the default if one of the three is not specified.

Brief Description of BMP Simulation in the Model

All stormwater practices that comply with new performance standards are *Efficiency Value BMPs,* whose efficiency is determined by curves and underlying equations, such as those in Figure D-1-3 for total nitrogen. Pollutant loads from the site are reduced by the corresponding efficiency values. For example, Figure D-1-3 indicates that an ST practice that captures one inch of runoff per one impervious acre reduces nitrogen from the total treatment area by about 35 percent, whereas an RR practice that also treats one inch of runoff per one impervious acre reduces nitrogen from the total treatment area by

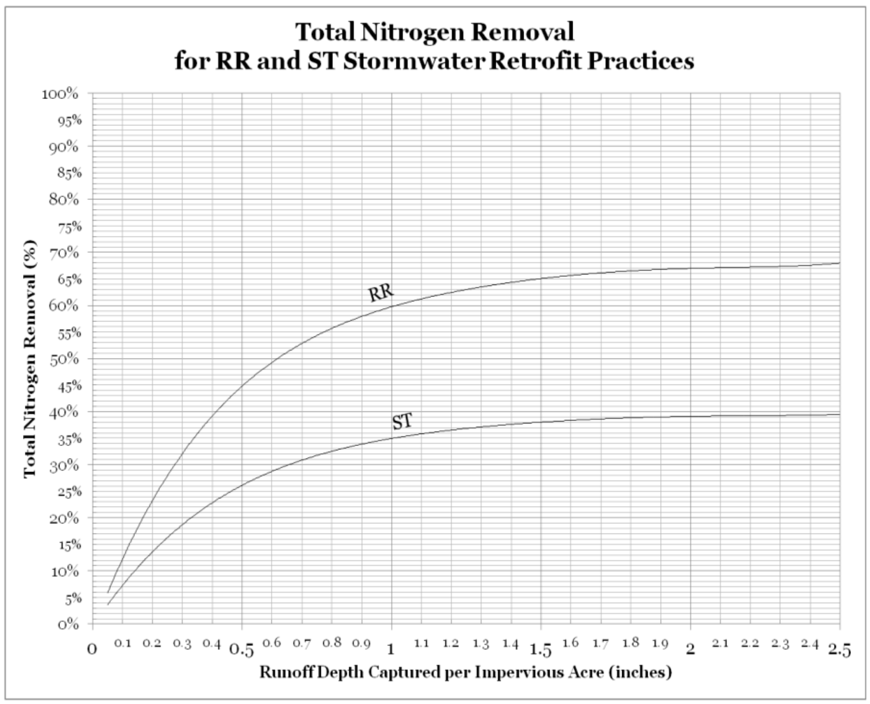

Figure D-1-3. "Adjustor" curves of estimated nitrogen removal for runoff reduction (RR) and stormwater treatment (ST) retrofit practices. Separate curves for phosphorus and sediment are not pictured here but are available in the expert panel report and other resources listed below. Source: Chesapeake Stormwater Network. Use the standard equation for "Runoff Depth Captured per Impervious Acre" (in inches) to find the appropriate location on the X-axis:

Runoff depth captured per Impervious Acre= $\frac{12 \times RS}{IA}$

RS = Runoff Storage Volume (acre-feet) is the amount of volume treated by the stormwater practice

IA = Impervious Area in acres

about 60 percent. Multiple practices on a single site can be combined to calculate the removal for the whole site. In cases where both RR and ST practices are implemented on a site the dominant type of practice can be used to determine which curve applies for the site as a whole, unless your state stormwater contact indicates otherwise (see the resources listed under Additional Information).

Annual or Cumulative? Cumulative (10-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Retrofit Runoff Reduction
  - Retrofit Stormwater Treatment
- *Measurement unit(s):* Runoff storage volume; impervious acres; acres treated
- *Land Use:* Approved NEIEN Developed load source groups (Non-Regulated, MS4, CSS); if none are reported the default load source group will be combination of all three (MS4CSSNonRegulated).
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year practice was installed.

Table D-1-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
New State Stormwater Performance Standards (aka Stormwater Practices for New Development and Redevelopment), Runoff Reduction (RR) practices	New Runoff Reduction (RR)*	Bioretention, Dry swale, Infiltration, Permeable pavement, Green roof, Dry channel regenerative stormwater conveyance
New State Stormwater Performance Standards (aka Stormwater Practices for New Development and Redevelopment), Stormwater Treatment (ST) practices	New Stormwater Treatment (ST)*	Constructed wetland, Filtering practices (e.g., sand filter), Wet swale, Wet pond
* Stormwater Performance Standards (Sheet D-1) and Retrofits (Sheet D-2) BMPs are not distinguished within CAST. All BMPs in these two categories are listed only as "RR" or "ST". While there is no distinction in CAST, jurisdictions have separate goals and milestones based on whether the practices are for new or existing development and should thus report them differently in NEIEN. For planning purposes, please select "Stormwater Performance Standards" in CAST if you wish to simulate Retrofit BMPs.		

Additional Information

Expert panel report:

Comstock, S., Crafton, S., Greer, R., Hill, P., Hirschman, D., Karimpour, S., Murin, K., Orr, J., Rose, F., & S. Wilkins. 2012. Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards. Prepared by T. Schueler and C. Lane, Chesapeake Stormwater Network. Revised with updated curves January 2015. http://www.chesapeakebay.net/documents/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Performance-Standards-LONG_012015.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-2: Stormwater Practices for New and Redevelopment Projects. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network, Archived (2014) webcast: Crediting BMPs used for New and Redevelopment Webcast: http://chesapeakestormwater.net/events/webcast-ms4-implementers-and-the-bay-tmdl-crediting-bmps-used-for-new-and-redevelopment/

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in October 2012.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-2. Stormwater Retrofits

General Information

Stormwater retrofits are a diverse group of projects that reduce nutrient and sediment loads from existing development. Though there are many retrofit designs and practices, they all basically function the same way: retrofit practices capture polluted stormwater runoff in temporary storage areas, where physical and biological mechanisms help prevent nutrients, sediment, or other pollutants from reaching local waterways.

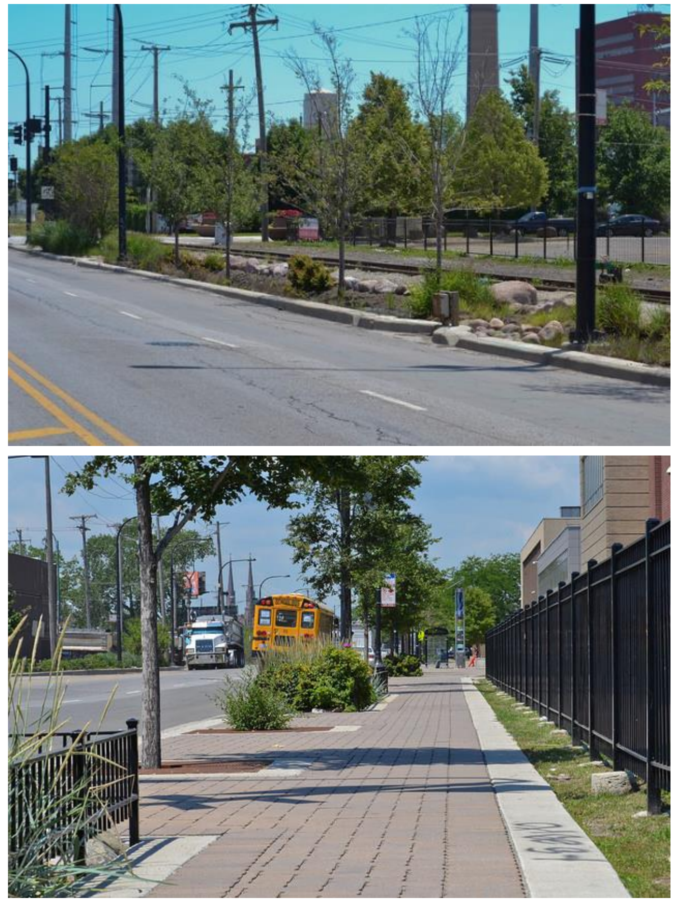

Figure D-2-1. Retrofit projects often combine multiple practices, such as bioretention and rain gardens, bioswales and pervious pavement to improve stormwater management in a developed area. Photos: Center for Neighborhood Technology, Flickr.

CBP Definition(s)

Stormwater retrofits can be classified into two broad project categories: *New retrofits* or *existing BMP retrofits.*

New retrofits: New retrofit projects create storage to reduce nutrients on land that is not currently receiving stormwater treatment. Common examples of new retrofit facilities include creating new storage:

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

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

Existing BMP retrofits: An existing stormwater practice is either converted into a different type of practice that is more effective at removing pollutants, enhanced by increasing the amount of runoff it can treat and/or increasing its hydraulic retention time, or restored to renew its performance.

Runoff Reduction is the total post-development runoff volume that is reduced through canopy interception, soil amendments, evaporation, rainfall harvesting, engineered infiltration, extended filtration or evapotranspiration. Retrofit projects that achieve at least a 25 percent reduction of the annual runoff volume are classified as *Runoff Reduction (RR) practices* and therefore earn a higher net removal rate. Retrofit practices that employ a permanent pool, constructed wetlands or sand filters are classified as *Stormwater Treatment (ST) practices* that have less runoff reduction capability and therefore lower removal rates than RR practices.

Common types of ST and RR practices are listed in Table D-2-1.

Specifications or Key Qualifying Conditions

Retrofit projects apply to existing development that is currently untreated or inadequately treated by one or more stormwater practices. Practices installed on a newly developed or redeveloped site are categorized under Stormwater Performance Standards (see Sheet D-1). Consult the expert panel report for additional suggested qualifying conditions and your corresponding state stormwater BMP manual for specific design specifications or requirements.

Nitrogen, Phosphorus and Sediment Reductions

Each pollutant (nitrogen, phosphorus and sediment) has its own equation and "adjustor curve" for RR and ST practices, as shown in Figure D-2-3 for nitrogen. The y-axis shows the percent of pollutant removal (%) based on the runoff depth captured by the practice per impervious acres in its drainage area (shown on the x-axis as inches per impervious acre).

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed Land Uses (Non-Regulated, MS4 and CSS) except construction

It is recommended that states report these practices on the appropriate land use group, i.e., either "Nonregulated," "MS4" or "CSS." Alternatively, the combined group "MS4CSSNonRegulated" can be used; this combined group is the default if one of the three is not specified.

Brief Description of BMP Simulation in the Model

All stormwater retrofit practices are *Efficiency Value BMPs,* with an added exception that their efficiency value is determined by curves and underlying equations such as those in Figure D-2-2 for total nitrogen. Runoff from the applicable impervious area is reduced by the corresponding efficiency values. For example, an ST practice that captures one inch of runoff per one impervious acre reduces nitrogen from that area by about 35 percent, whereas an RR practice that also treats one inch of runoff per one impervious acre reduces nitrogen from that area by about 60 percent. Multiple practices on a single site can be combined to calculate the removal for the whole site. In cases where both RR and ST practices are implemented on a site the dominant type of practice can be used to determine which curve applies for the site as a whole, unless your state stormwater contact indicates otherwise (see the resources listed under Additional Information).

Annual or Cumulative? Cumulative (10-year credit duration).

Table D-2-1. Classification of BMPs based on runoff reduction capability. Source: New State Performance Standards BMP Expert Panel, 2012.

Stormwater Treatment (ST) Practices	**Runoff Reduction (RR) Practices**
Constructed wetland	*Non-structural Practices*
Filtering practices (e.g., sand filter)	Landscape restoration/reforestation
Wet swale	Riparian buffer restoration
Wet pond	Impervious disconnection
	Sheet flow to vegetated filter strip or open space
	Non-Structural BMPs, Pennsylvania 2006 BMP Manual, Chapter 5
	Structural Practices
	Environmental site design practices in 2007 Maryland Stormwater BMP Manual
	Bioretention and rain garden
	Dry channel regenerative stormwater conveyance (Dry Channel RSC)
	Dry swale
	Expanded tree pits
	Grass channels and bioswales
	Green roofs
	Green streets
	Infiltration practices (aka infiltration basin, infiltration bed, infiltration trench, dry well/seepage pit, landscape infiltration)
	Permeable pavement (aka porous pavement)
	Rainwater harvesting (aka capture and re-use)

Urban Filter Strips: Another expert panel developed specific methods to compute removal for urban filter strips used in a retrofit context, please consult their report to see how credit is provided for this practice located here: http://chesapeakestormwater.net/bay-stormwater/baywide-stormwaterpolicy/urban-stormwater-workgroup/urban-filter-strips/

Dry Ponds: Retrofits of existing dry ponds or dry extended detention ponds do NOT use the adjustor curves to define their pre-retrofit performance. They use lower pollutant removal rates shown in Table A-5 of the Expert Panel Report (see Additional Information section).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Retrofit Runoff Reduction
  - Retrofit Stormwater Treatment
- *Measurement unit(s):* Runoff storage volume; impervious acres; acres treated
- *Land Use:* Approved NEIEN Developed load source groups (Non-Regulated, MS4, CSS); if none are reported the default load source group will be combination of all three (MS4CSSNonRegulated).
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year practice was installed.

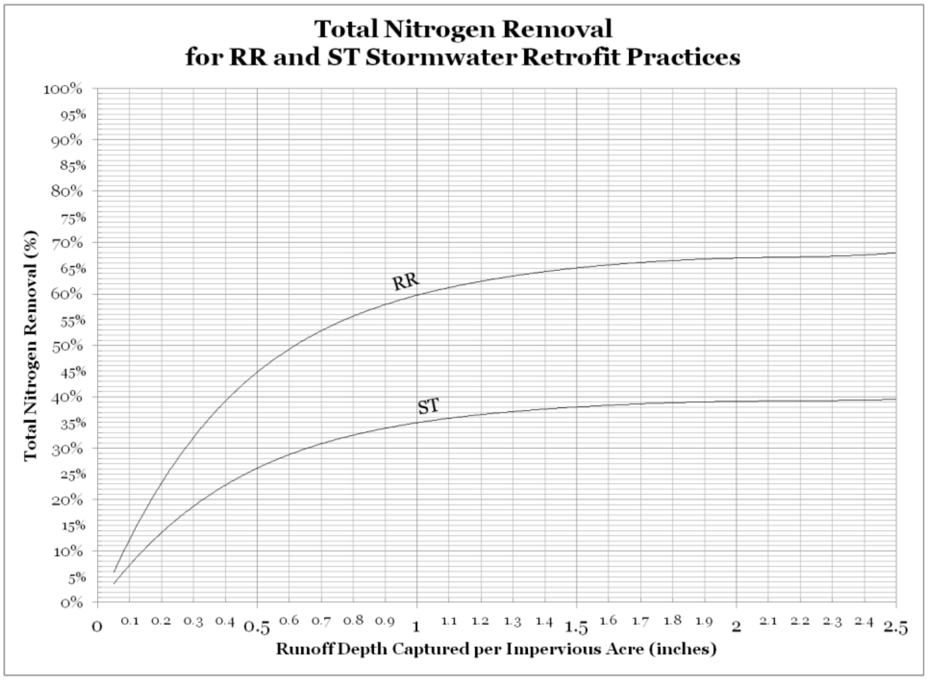

Figure D-2-2. "Adjustor" curves of estimated nitrogen removal for runoff reduction (RR) and stormwater treatment (ST) retrofit practices. Separate curves for phosphorus and sediment are not pictured here but are available in the expert panel report and other resources listed below. Source: Chesapeake Stormwater Network. Use the standard equation for "Runoff Depth Captured per Impervious Acre" (in inches) to find the appropriate location on the X-axis:

Runoff depth captured per Impervious Acre= $\frac{12 \times RS}{IA}$

RS = Runoff Storage Volume (acre-feet) is the amount of volume treated by the stormwater practice

IA = Impervious Area in acres

Table D-2-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Stormwater Retrofit, Runoff Reduction (RR) practices	Retrofit Runoff Reduction (RR)*	Bioretention, Dry swale, Infiltration, Permeable pavement, Green roof, Dry channel regenerative stormwater conveyance
Stormwater Retrofit, Stormwater Treatment (ST) practices	Retrofit Stormwater Treatment (ST)*	Constructed wetland, Filtering practices (e.g., sand filter), Wet swale, Wet pond
* Stormwater Performance Standards (Sheet D-1) and Retrofits (Sheet D-2) BMPs are not distinguished within CAST. All BMPs in these two categories are listed only as "RR" or "ST". While there is no distinction in CAST, jurisdictions have separate goals and milestones based on whether the practices are for new or existing development and should thus report them differently in NEIEN. For planning purposes, please select "Stormwater Performance Standards" in CAST if you wish to simulate Retrofit BMPs.		

Additional Information

Expert panel report:

Bahr, R., Brown, T., Hansen, L.J., Kelly, J., Papacosma, J., Snead, V., Stack, B., Stack, R., & S. Stewart. 2012. Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects. Prepared by T. Schueler and C. Lane, Chesapeake Stormwater Network. Revised with updated curves January 2015. http://www.chesapeakebay.net/documents/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Retrofits-long_012015.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-1: Urban Stormwater Retrofits. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network, Archived (2014) webcast: Accounting for Urban Stormwater Retrofits: http://chesapeakestormwater.net/events/webcast-ms4-implementers-and-the-bay-tmdl-retrofits/

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in October 2012.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-3. Erosion and Sediment Controls for Construction Sites

General Information

The term erosion and sediment control (ESC) refers to a combination of different erosion prevention and sediment control practices that are applied and maintained at different stages of a construction site. Erosion controls are used to prevent exposed soils from eroding, while sediment controls capture sediment that has eroded and traps it before it can leave the construction site.

Figure D-3-1. Sediment running off a construction site. Source: Chesapeake Bay Program.

CBP Definition(s)

Erosion and Sediment Control Level 1: This level includes ESC practices implemented under historical performance standards from approximately 2000 or before. The sediment trapping requirements were typically 1,800 cubic feet/acre, stabilization requirements were less rapid, and inspections occurred less frequently, among other factors. Use this BMP where specific control measures are unknown. Level 1 ESC practices are assumed during the calibration phase of the Watershed Model (1985-2005).

Erosion and Sediment Control Level 2: This level of performance reflects the more stringent ESC requirements that have been adopted by local and state governments and generally conform to the standard requirements in EPA's 2012 Construction General Permit. These include a greater sediment treatment capacity (typically 3,600 cubic feet/acre), surface outlets, more rapid vegetative cover for temporary and permanent stabilization, and improved design specifications for individual ESC practices to enhance sediment trapping or removal.

Erosion and Sediment Control Level 3: This level of performance reflects the gradual shift to improve performance by expanded use of passive chemical treatment within Level 2 ESC practices. Chemical treatment involves the passive use of polyacrylamide (PAM) and other flocculants. The treatment relies solely on gravity to control the sediment in construction site runoff (e.g., adding PAM granules to a check dam, erosion control fabric, or running basin flows across a block or sock containing flocculants). This approach also integrates other design features to enhance the performance of individual practices, such as skimmers, baffles, surface outlets, compost, and strong geo-textiles. Level 3 also involves more frequent inspection and maintenance, and more stringent requirements for phasing and resource protection.

Specifications or Key Qualifying Conditions

A developer must submit an ESC plan for their construction project that specifies a unique combination of erosion and sediment controls for the unique conditions of the site. The plan is reviewed as part of the state and/or local land development approval process, and the ESC practices must be installed prior to construction activity. Construction sites are inspected periodically to ensure the practices are intact and working properly to prevent off-site sediment discharge. For additional suggested qualifying conditions or requirements, consult the expert panel report (see Additional Information below).

Figure D-3-2. Equipment rests on a construction site with stormwater barriers in place on Oct. 27, 2009. Source: Alicia Pimental/Chesapeake Bay Program.

Nitrogen, Phosphorus and Sediment Reductions

Sediment removal rates for ESC practices differ depending on which performance level they fall into. Table D-3-I displays sediment reductions jurisdictions can claim for each qualifying acre of erosion and sediment control. There are no nutrient removal rates for construction sites in the current version of the model.

Table D-3-I. Sediment Removal Rates for Construction Sites with Erosion and Sediment Control Practices.

ESC Scenario	Discharged Load	Effective Removal Rate
ESC Sites Operating at Level 1	3.1 t/ac/yr	74 %
ESC Sites Operating at Level 2	1.75 t/ac/yr	85 %
ESC Sites Operating at Level 3	1.25 t/ac/yr	90 %

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Construction (Regulated, CSS)

Brief Description of BMP Simulation in the Model

All ESC practices are *Efficiency Value BMPs.* The total reductions to loads are determined by the Watershed Model as the product of the efficiency reduction listed in Table D-3-I, the acres of construction land within the model segment, and the total sediment loads simulated for those acres.

Annual or Cumulative? Annual (1-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Erosion and Sediment Control
  - Erosion and Sediment Control Level 1
  - Erosion and Sediment Control Level 2
  - Erosion and Sediment Control Level 3
- *Measurement unit(s):* Number of acres tracked within the reported geographic unit
- *Land Use:* Construction (Regulated, CSS)
- *Geographic location:* Approved NEIEN geographies include: County; County (CBWS only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); or State (CBWS only)
- *Date of implementation:* Date practice was installed/permitted.

Table D-3-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Erosion and Sediment Control (ESC) Levels 1, 2, and 3	Erosion and Sediment Control (ESC) Levels 1, 2, and 3	None

Additional Information

Expert panel report:

Clark, S., Grose, M., Greer, R., Jarrett, A., Kunkel, S., Lake, D., Law, N., McCutcheon, J., McLaughlin, R., Mumaw, K., & Young, B. 2014. Recommendations of the Expert Panel to Define Removal Rates for Erosion and Sediment Control Practices. Prepared by J. Hanson, Chesapeake Research Consortium, T. Schueler and C. Lane, Chesapeake Stormwater Network.
https://www.chesapeakebay.net/documents/WQGIT_APPROVED_ESC_EXPERT_PANEL_REPORT_LONG_04142014.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-7: Enhanced Erosion and Sediment Control Practices. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network, Archived (2014) webcast: Enhanced Erosion and Sediment Control Measures Webcast: http://chesapeakestormwater.net/events/webcast-ms4/

Chesapeake Stormwater Network, Final Recommended Guidance for Urban Stormwater BMP Verification: http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2013/01/USWG-Approved-Urban-BMP-Verification-Guidance-08112014.pdf

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This info sheet was first published on November 16, 2022 and reflects the BMP definitions and reductions approved by the WQGIT in April 2014.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-4. Dirt and Gravel Roads Erosion and Sediment Control

General Information

Figure D-4-1. "Resource Conservationist shows a water bar erosion control practice on a gravel road adjacent to an orchard. Grand Traverse County, Michigan." Source: USDA NRCS.

Improperly maintained dirt and gravel roads can have an adverse effect on the surrounding environment through increased erosion and the depositing of sediment to our streams and waterways. Dirt and gravel roads erosion and sediment control (ESC) practices, also known as environmentally sensitive road maintenance practices (ESMPs), reduce the amount of sediment runoff entering our streams from dirt and gravel roads. These practices can include driving surface aggregates (DSA), berm removal, additional drainage outlets, raising the road profile, and grade breaks.

CBP Definition(s)

Driving Surface Aggregate + Raising the Roadbed: Reducing the amount of sediment runoff from dirt and gravel roads through the use of driving surface aggregates (DSA) such as durable and erosion resistant road surface and raising road elevation to restore natural drainage patterns.

Driving Surface Aggregate with Outlets: Reducing the amount of sediment runoff from dirt and gravel roads through the use of driving surface aggregates (DSA) such as durable and erosion resistant road surface and through the use of additional Drainage Outlets.

Outlets Only: Reducing the amount of sediment runoff from dirt and gravel roads through the use of additional Drainage Outlets.

Driving Surface Aggregate: a well-graded, unbound mixture of aggregate designed for use as a wearing course on unpaved roads. DSA achieves sediment reductions by decreasing erosion and transport of fine material from the road surface.

Raising Road Elevation/Profile: Raising the road profile involves importing material to raise the elevation of an unpaved road. It is typically practiced on roads that have become entrenched (lower than surrounding terrain). Raising the road profile achieves sediment reduction by controlling and reducing the volume of road runoff.

Drainage Outlets: creating new outlets in ditchline to reduce channelized flow.

Specifications or Key Qualifying Conditions

Inspection and maintenance of these practices are required to ensure proper design implementation, performance values, and associated pollution reduction estimates. Consult the Simpson Weammert-Lane 2009 Report (see Additional Information) for further details.

Nitrogen, Phosphorus and Sediment Reductions

Total Nitrogen (TN) and Total Phosphorous (TP) reductions are minimal with dirt and gravel road erosion and sediment control. Sediment reduction factors for dirt and gravel road erosion and sediment controls are displayed below in Table D-4-1.

Table D-4-I. Sediment Reduction Factors for Dirt and Gravel Road Erosion and Sediment

Dirt and Gravel Road ESC	Sediment Reduction Factor (lbs/ft)
Driving Surface Aggregate + Raising the Roadbed	2.96
Driving Surface Aggregate with Outlets	3.60
Outlets Only	1.76

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Roads (Non-Regulated, MS4 and CSS)

It is recommended that states report these practices on the appropriate land use group, i.e., either "Nonregulated," "MS4" or "CSS." Alternatively, the combined group "Roads" can be used; this combined group is the default if one of the three is not specified.

Brief Description of BMP Simulation in the Model

All dirt and gravel road erosion and sediment control practices are *Load Reduction BMPs*, which means they are modeled as a simple removal of pounds of sediment from edge-of-stream load. Load Reduction BMPs cannot remove more pounds of sediment than are available in a watershed. Therefore, the Watershed Model does enforce maximum reductions that are described in Section 6.5.4.1 of the Watershed Model documentation.

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? Yes. However, the dirt and gravel roads ESC practices cannot be combined with one another.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - D&G Road – E&S Control and Outlets
    - D&G Road – Outlets Only
    - D&G Road – Surface Aggregate and Raised Roadbed
- *Measurement unit(s):* Length (feet).
- *Land Use:* Default is Roads. (Acceptable load source groups are Roads, CSS Roads, MS4 Roads, and Non-Regulated Roads)
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Date practice was installed.

Table D-4-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Dirt and Gravel Road Erosion and Sediment Control – Driving Surface Aggregate + Raising the Roadbed	D&G Road – Surface Aggregate and Raised Roadbed	Environmentally sensitive road maintenance practices (ESMPs), Driving surface aggregate (DSA), Raising the road profile, Grade breaks
Dirt and Gravel Road Erosion and Sediment Control – Driving Surface Aggregate with Outlets	D&G Road – E&S Control and Outlets	Environmentally sensitive road maintenance practices (ESMPs), Driving surface aggregate (DSA), Drainage outlets

Dirt and Gravel Road Erosion and Sediment Control – Outlets Only	D&G Road – Outlets Only	Environmentally sensitive road maintenance practices (ESMPs), Drainage outlets

Additional Information

T. Simpson and S. Weammert (Lane). 2009. Dirt and Gravel Road Erosion and Sediment Control – PENDING CBP APPROVAL. Definition and Nutrient and Sediment Reduction Effectiveness Estimates. T. Simpson and S. Weammert (Lane), eds. Final Report, December 2009. Pages 669-709. https://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

Version and History Statement

This info sheet was first published on November 16, 2022 and reflects the BMP definitions and reductions developed through Simpson and Weammert (Lane) and approved by the WQGIT in 2009.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-5. Urban Stream Restoration

General Information

New stream restoration techniques have been pioneered in the Chesapeake Bay watershed to restore urban streams. Approaches to stream restoration include natural channel design, legacy sediment removal, regenerative stream channel, and outfall and gully restoration practices. Stream restoration projects require state and federal permits and therefore involve extensive regulatory review. Projects often take multiple years from concept to construction, involving high costs and extensive effort from multiple stakeholders at the community, state, and federal level. Note: This BMP reference sheet is targeted for the Developed sector. See Sheets A-9: Stream Restoration (Ag) and N-1: Urban and Non-Urban Stream Restoration if interested in agricultural or general sectors, though the information is predominately similar.

Figure D-5-1. Stream restoration projects can improve the health of aquatic resources and can be one of the more cost-effective practices to reduce nutrient and sediment loads in urban watersheds. A stream in a residential area prior to restoration (top) that has an eroded stream bank and channel can be restored so that natural processes reduce the erosive energy of the stream flow during storm events. Small step pools and reconnecting the stream channel to the floodplain are two methods for restoring natural processes to a stream. The bottom picture is of the same stream three years after restoration. Photos: Arlington County (VA), Department of Environmental Services (https://projects.arlingtonva.us/projects/donaldson-run-stream-restoration-tributary-b/)

CBP Definition(s)

Natural Channel Design (NCD) applies the principles of stream geomorphology to maintain a state of dynamic equilibrium among water, sediment, and vegetation that creates a stable channel.

Legacy Sediment Removal (LSR) seeks to remove legacy sediments from the stream and its floodplain and thereby restore the natural potential of aquatic resources including a combination of streams, floodplains, and wetlands.

Regenerative Stream Channel (RSC, aka Regenerative Stormwater Conveyance) uses in-stream weirs in perennial streams to increase the interaction with the floodplain during smaller storm events. These projects may also include sand seepage wetlands and other habitats to increase the stream's connection with its floodplain. Only wet channel RSC practices are eligible as stream restoration projects. Dry channel RSC projects can be considered a runoff reduction retrofit practice (see Sheet D-2: Stormwater Retrofits) or an outfall and gully restoration practice.

Outfall and Gully Restoration Practices (OGSPs) are an engineering approach to design a stable channel to dissipate energy that extends from the upland source to the stream channel. The new channel is designed and constructed to achieve and equilibrium state where future sediment loss is minimized or eliminated altogether.

Stream Restoration refers to any NCD, RSC, LSR, OGSP or other restoration project that meets the qualifying conditions for credits, including environmental limitations and stream functional improvements.

Specifications or Key Qualifying Conditions

Protocol-specific qualifying criteria can be found in Section 3.1.3 of the Unified Guide for Crediting Stream and Floodplain Restoration Projects. All projects must meet the following criteria to be eligible for credit:

- The project MAY NOT be primarily designed to protect public infrastructure. Bank armoring and rip rap are not eligible for stream restoration credit (*Note:* the type of bank stabilization technique that is used can impact credit calculations under Protocol 1. For updated definitions on bank armoring, consult the Unified Guide linked in Additional Resources).
- Stream reach must be greater than 100 ft in length (*Note:* due to their unique location, Protocol 5 OGS practices are exempted from the 100-ft reach length restriction).
- Reach restored must be actively enlarging or degrading.
- Reach restored MAY NOT be tidally influenced.
- Restoration plan must utilize a comprehensive approach to stream restoration design addressing long-term stability of the channel, banks, and floodplain.
- Special consideration is given to projects explicitly designed to reconnect the stream with its floodplain or create wetlands and instream habitat features known to promote nutrient uptake or denitrification.
- Projects must meet post-construction monitoring requirements, exhibit successful vegetative establishment, and any initial project repairs required under construction permit.
- Must demonstrate that it will maintain or expand existing riparian vegetation in the stream corridor and compensate for any project-related riparian losses.
- Must have designated authority responsible for inspections, routine maintenance, long-term repairs, and credit verification.
- Must comply with all state and federal permitting requirements, including 404 and 401 permits.
- Must be intended to improve the hydrologic, hydraulic, geomorphic, water quality, and ecological condition of degraded urban streams.
- Stream restoration is a carefully designed intervention to improve the hydrologic, hydraulic, geomorphic, water quality, and biological condition of degraded urban streams, and must not be implemented for the sole purpose of nutrient or sediment reduction.
- Restoration projects should be developed through a functional assessment process, such as the stream functions pyramid (Harman et al., 2012) or functional equivalent.

Nitrogen, Phosphorus and Sediment Reductions

There are four general protocols to define the pollutant load reductions from stream restoration practices.

- Protocol 1. Credit for prevented sediment during storm flow.
- Protocol 2. Credit for in-stream nitrogen processing during base flow.
- Protocol 3. Credit for reconnection to the floodplain.
- Protocol 5. Credit for outfall and gully restoration.

For details on how to use the protocols, consult the resources listed under Additional Information.

Table D-5-1. Summary of stream restoration protocols for nitrogen, phosphorus, and sediment reductions.

Protocol	TN (lbs/ linear ft/ year)	TP (lbs/ linear ft/ year)	TSS (lbs/ linear ft/ year)
Protocol 1. Prevented sediment	Site-specific	Site-specific	Site-specific
Protocol 2. In-stream nitrogen processing	Site-specific	N/A	N/A
Protocol 3. Floodplain reconnection	Site-specific	Site-specific	Site-specific

Protocol 5. Outfall and gully restoration	Site-specific	Site-specific	Site-specific

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Stream Bed and Bank

The practice can only be applied to the "Stream Bed and Bank" load source, but it is recommended to distinguish the BMP based on its sector using the appropriate secondary BMP designation of either "Urban Stream Restoration" or "Non-Urban Stream Restoration."

Brief Description of BMP Simulation in the Model

All stream restoration practices are *Load Reduction BMPs,* which means they are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment from the edge-of-stream load. To calculate the pounds reduced for each protocol, follow the methods and examples described in the panel report and other resources listed under Additional Information. The protocols are additive; therefore, a project that reduces 100 lbs TN under Protocol 1, 25 lbs TN under Protocol 2, and 30 lbs TN under Protocol 3 has a net reduction of 155 lbs TN. Load reduction BMPs, such as urban stream restoration, cannot remove more pounds of nitrogen, phosphorus or sediment than are available in a watershed, meaning the Watershed Model does enforce maximum reductions, as described in Section 6.5.4.1 of the Watershed Model documentation. As per the guidance in the 2019-2020 urban stormwater memos (see Additional Resources below), there is no longer a default reduction rate eligible for credit.

Dry channel RSC practices installed in ephemeral stream channels can be credited as both a stormwater retrofit (Protocol 4 – See D-2: Stormwater Retrofits) and an OGSP (Protocol 5). Protocol 4 reductions are subtracted from the pollutant load generated from upland impervious cover, whereas the Protocol 5 reductions are subtracted from the urban stream bank load.

Annual or Cumulative? Cumulative (5-year credit duration for urban stream restoration).

Can this practice be combined with other BMPs? Yes. However, Protocol 5 cannot be combined with Protocol 1 (prevented sediment) within the same project reach. Protocol 5 can be combined with Protocols 2 and 3 in the same project reach if it meets the conditions for hyporheic exchange and/or floodplain reconnection.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Urban Stream Restoration Protocol 1, 2, 3 or 5.
- *Measurement unit(s):* Length restored (feet); Protocol 1 TN (lbs); Protocol 1 TP (lbs); Protocol 1 TSS (lbs); Protocol 2 TN (lbs); Protocol 3 TN (lbs); Protocol 3 TP (lbs); Protocol 3 TSS (lbs); Protocol 5 TN (lbs); Protocol 5 TP (lbs); Protocol 5 TSS (lbs)
- *Load Source:* Stream Bed and Bank.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the project was completed.

Table D-5-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Stream Restoration (Urban)	Urban Stream Restoration Protocol*	natural channel design, legacy sediment removal, regenerative stream channel or regenerative stormwater conveyance (wet channel only)

* Uses Protocols 1-5 summarized in Table D-5-1. Requires unit of feet in addition to the pounds reduced for each respective protocol.

Additional Information

2019 Protocol 1 Guidance:
Atland, D., Berg, J., Brown, B., Burch, J., Cook, R., Fraley-McNeal, L., Meyers, M., Running, J., Starr, R., Sweeney, J., Thompson, T., White, J., & A. Blair. 2019. Consensus Recommendations for Improving the Application of the Prevented Sediment Protocol for Urban Stream Restoration Projects Build for Pollutant Removal Credit. Prepared by D. Wood, Chesapeake Stormwater Network. Approved by the WQGIT December 9, 2019. Revised on February 27, 2020. https://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2020/03/PROTOCOL-1-MEMO_WQGIT-Approved_revised-2.27.20_clean_w-appendices.pdf

2020 Protocols 2 and 3 Guidance:
Atland, D., Becraft, C., Berg, J., Brown, T., Burch, J., Clearwater, D., Coleman, J., Crawford, S., Doll, B., Geratz, J., Hanson, J., Hartranft, J., Hottenstein, J., Kaushal, S., Lowe, S., Mayer, P., Noe, G., Oberholzer, W., Parola, A., Scott, D., Stack, B., Sweeney, J., & J. White. 2020. Consensus Recommendations to Improve Protocols 2 and 3 for Defining Stream Restoration Pollutant Removal Credits. Prepared by D. Wood and T. Schueler, Chesapeake Stormwater Network. Approved by the WQGIT on October 26, 2020. https://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2020/10/FINAL-Approved-Group-4-Memo_10.27.20.pdf

2019 Outfall (Protocol 5) Guidance:
Bahr, R., Blair, A., Brown, T., Coffman, K., Cole, R., Harmon, T., Michelsen, E., Noss, N., Ottinger, E., Reggi, B., Reiling, S., Santoro, A., Stone, C., Traver, C., & N. Weinstein. 2019. Recommendations for Crediting Outfall and Gully Stabilization Projects in the Chesapeake Bay Watershed. Approved by the WQGIT on October 15, 2019. https://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2019/10/FINAL-APPROVED-OUTFALL-RESTORATION-MEMO-101519.pdf

Verification Guidance:
Burch, J., Cox, S., Davis, S., Fellows, M., Hoverman, K., Law, N., Mumaw, K., Rauhofer, J., Schueler, J., & R. Starr. Recommended Methods to Verify Stream Restoration Practices Built for Pollutant Crediting in the Chesapeake Bay Watershed. Approved by the WQGIT on June 18, 2019. https://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2019/07/Approved-Verification-Memo-061819.pdf

Chesapeake Stormwater Network, A Unified Guide for Creating Stream and Floodplain Restoration Projects in the Chesapeake Bay Watershed. Available at https://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2021/10/Unified-Stream-Restoration-Guide_FINAL_9.17.21.pdf

Expert panel report (original – 2014):
Berg, J., Burch, J., Cappuccitti, D., Filoso, S., Fraley-McNeal, L., Goerman, D., Hardman, N., Kaushal, S., Medina, D., Meyers, M., Kerr, B., Stewart, S., Sullivan, B., R. Walter & J. Winters. 2013. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. Prepared by T. Schueler, Chesapeake Stormwater Network, and B. Stack, Center for Watershed Protection. Test-drive revisions approved by the WQGIT September 8, 2014. https://www.chesapeakebay.net/documents/Stream_Panel_Report_Final_08282014_Appendices_A_G.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-4: Urban Stream Restoration. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network. BMP Resources, Urban Stream Restoration: http://chesapeakestormwater.net/bmp-resources/urban-stream-restoration/

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs & C. Miller. 2012. A function-based framework for developing stream assessments, restoration goals, performance standards and standard operating procedures. U.S. Environmental Protection Agency. Office of Wetlands, Oceans and Watersheds. Washington, D.C. EPA 843-K-12-006. https://www.epa.gov/sites/production/files/2015-08/documents/a_function_based_framework_for_stream_assessment_3.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in May 2013, with test-drive revisions approved in September 2014. Updates to this reference sheet were published on November 14, 2022 to reflect the urban stormwater memos approved by the WQGIT in 2019-2020.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-6. Urban Nutrient Management

General Information

Turfgrass is everywhere in suburban and developed areas of the Chesapeake Bay Watershed, comprising roughly ten percent of the region's total land area. Therefore, the management of turfgrass – whether it is a private lawn, public park or golf course – affects local water quality. Three Bay States (Maryland, New York and Virginia) have passed laws that ban residential fertilizers from containing phosphorus, among other requirements.

Figure D-6-1. Fertilizers contain nutrients such as nitrogen, phosphorus and potassium that help grass and other plants grow. Excessive nitrogen and phosphorus can create water quality problems, however. Jurisdictions in the Chesapeake Bay Watershed have programs to educate homeowners and certify commercial applicators in best practices for nutrient management. Photo: Centers for Disease Control.

CBP Definition(s)

Urban Nutrient Management (UNM) is defined as the proper management of major nutrients for turf and landscape plants on a property to best protect water quality.

An *urban nutrient management plan (UNM plan)* is a written, site-specific plan which addresses how the major plant nutrients (nitrogen, phosphorus and potassium) are to be annually managed for expected turf and landscape plants and for the protection of water quality. The goal of an urban turf and landscape nutrient management plan is to minimize adverse environmental effects, primarily upon water quality, and avoid unnecessary nutrient applications. It should be recognized that some level of nutrient loss to surface and groundwater will occur even by following the recommendations in a nutrient management plan. The impacts of urban nutrient management plans will differ from lawn-to-lawn depending on nutrient export risk factors.

High risk areas: Pervious areas that are subject to one or more risk factors listed in Table D-6-2 (left-hand column).

Specifications or Key Qualifying Conditions

The technical support and qualifications needed to write a UNM plan varies in each Bay State. Localities should consult with State agencies to determine information requirements for UNM plans or if state regulations prevent reporting UNM plans as unique BMPs (see resources listed under Additional Information).

Nitrogen, Phosphorus and Sediment Reductions

There are no sediment reductions for UNM practices. The nutrient reductions are summarized in Table D-6-1.

Table D-6-1. Nitrogen and Phosphorus reductions for Urban Nutrient Management in the Phase 6 Watershed Model.

	TN reduction	**TP reduction**
Nutrient Management Maryland Commercial Applicators	9%	0%
Nutrient Management Maryland Do It Yourself	4.5%	0%
Nutrient Management Plan*	9%	4.5%
Nutrient Management Plan High Risk Lawn	20%	10%
Nutrient Management Plan Low Risk Lawn	6%	3%
* Default practice for lawns with unknown risk type.		

Table D-6-2. Lists of risk factors and core nutrient management practices for turf and lawns. Source: Nutrient Management Expert Panel (Aveni et al, 2013).

High Risk Export Factors for nutrients	Core Urban Nutrient Management Practices
1. Currently over-fertilized beyond state or extension recommendations	1. Consult with the local extension service, master gardener or certified applicator to get technical assistance to develop an effective urban nutrient management plan for the property
2. P-saturated soils as determined by a soil P test	2. Maintain a dense vegetative cover of turf grass to reduce runoff, prevent erosion, and retain nutrients
3. Newly established turf (i.e., less than three years old)	3. Choose not to fertilize, OR adopt a reduce rate/monitor approach OR the small fertilizer dose approach
4. Steep slopes	4. Retain clippings and mulched leaves on the yard and keep them out of streets and storm drains
5. Exposed soil	5. Do not apply fertilizers before spring green up or after grass becomes dormant
6. High water table	6. Maximize use of slow release N fertilizer during the active growing season
7. Over-irrigated lawns	7. Set mower height at 3 inches or taller
8. Soils that are sandy, shallow, compacted or have low water holding capacity	8. Do not apply fertilizer within 15 to 20 feet of a water feature (depending on applicable state regulations) and manage this zone as a perennial planting, meadow, grass buffer or a forested buffer
9. High use areas (e.g., athletic fields, golf courses)	9. Immediately sweep off any fertilizer that lands on a paved surface
10. Adjacent to stream, river or Bay	10. Employ lawn practices to increase soil porosity and infiltration capability, especially along portions of the lawn that convey or treat stormwater runoff.
11. Karst terrain	

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed pervious land uses (Non-Regulated, MS4 and CSS), which includes Turfgrass and Tree Canopy over Turfgrass
- Construction (Non-Regulated, MS4 and CSS)

The load source group “Pervious” can be used as a default, which includes all Turfgrass and Tree Canopy over Turfgrass (Non-Regulated, MS4 and CSS).

Brief Description of BMP Simulation in the Model

All UNM practices are *Efficiency Value BMPs*. Nutrient loads from pervious areas are reduced by the corresponding efficiency values listed in Table D-6-1. In the Phase 6 Watershed Model there is no more “state-wide” phosphorus credit because all P application rates are now adjusted to reflect non-agriculture fertilizer sales data.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Figure D-6-2. Soil tests by university extension or commercial professionals help determine optimal fertilizer application rates for UNM plans. Photo: USDA NRCS.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*

    - Nutrient Management Maryland Commercial Applicators
    - Nutrient Management Maryland Do It Yourself
    - Nutrient Management Plan
    - Nutrient Management Plan High Risk Lawn
    - Nutrient Management Plan Low Risk Lawn
- *Measurement unit(s):* Acres or percent
- *Land Use:* Approved NEIEN Developed load source groups (Non-Regulated, MS4, CSS) including Pervious and Construction; if none are reported the default load source group will be Pervious
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year UNM plan was active.

Table D-6-3. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
UNM, Maryland Commercial Applicator Lawn	Nutrient Management Maryland Commercial Applicators	None
UNM, Maryland Do It Yourself (DIY) Fertilized Lawn	Nutrient Management Maryland Do It Yourself	None
UNM [Blended]*	Nutrient Management Plan*	None
UNM High Risk	Nutrient Management Plan High Risk Lawn	None
UNM Low Risk	Nutrient Management Plan Low Risk Lawn	None
* Default practice for lawns with unknown risk type.		

Additional Information

Expert panel report:

Aveni, M., Berger, K., Champion, J., Felton, G., Goatley, M., Keeling, W., Law, N., & S. Schwartz. 2013. Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management. Prepared by T. Schueler and C. Lane, Chesapeake Stormwater Network. Approved by the WQGIT March 2013. https://www.chesapeakebay.net/documents/Final_CBP_Approved_Expert_Panel_Report_on_Urban_Nutrient_Management--short.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-5: Urban Nutrient Management. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network, Archived (2014) webcast: Crediting BMPs used for New and Redevelopment Webcast: http://chesapeakestormwater.net/events/webcast-urban-nutrient-management/

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in March 2013.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-7. Urban Tree Planting BMPs

General Information

Trees in urban and suburban areas provide a host of environmental benefits. They reduce stormwater runoff and improve local water quality, mitigate the urban heat island effect in highly developed settings, provide habitat for wildlife and trap air pollution, among other benefits. Planting new trees is one way to increase those benefits in developed areas, but it is vital to conserve and maintain existing trees to protect the services they offer. The BMPs described here relate to planting new trees in developed areas (for Forest Buffers in agricultural settings see A-12 and A-13; for tree planting in agricultural areas, see A-22).

CBP Definition(s)

To understand tree planting BMPs for developed areas, it helps to understand the three different land uses that represent tree cover in the Watershed Model:

- *Tree Canopy over Impervious* includes trees over roads and non-road impervious surfaces such as buildings and parking lots.
- *Tree Canopy over Turfgrass* includes trees within 30'-80' of non-road impervious surfaces where the understory is assumed to be turf grass or otherwise altered through compaction, removal of surface organic material and/or fertilization.
- *Forest* includes trees farther than 30'-80' from non-road impervious surfaces and forming contiguous patches greater than one-acre in extent.

Urban Tree Canopy Expansion: The planting of trees in an urban area that are not part of a riparian forest buffer, structural BMP (e.g., bioretention, tree planter) or do not conform to the definition of the Urban Forest Planting BMP. The land use area conversion factor is based on the panel's recommendation of 144 square foot average of canopy per tree planted. Thus, 300 newly planted trees are equivalent to one acre of tree canopy land use; however, this is not a planting density requirement and each tree converts 1/300 of an acre of either pervious or impervious developed area to tree canopy land uses. This BMP does not require trees to be planted in a contiguous area.

Figure D-7-1. Trees in developed areas yield many benefits, but they provide the greatest environmental uplift when they form areas of forest as seen (top) in Rock Creek Park, Washington, D.C. Trees over managed turfgrass or near road corridors provide important environmental benefits but are considered "tree canopy over turfgrass" (middle) or "tree canopy over impervious" (bottom) to distinguish these trees from higher-functioning areas of forest. Photos: Chesapeake Bay Program.

Urban Forest Planting: Tree planting projects in urban or suburban areas that are not part of a riparian buffer, structural BMP or Urban Tree Canopy Expansion BMP, with the intent of establishing forest ecosystem processes and function. This requires urban forest plantings to be documented in a planting and maintenance plan that meets state planting density and associated standards for establishing forest conditions, including no fertilization and minimal mowing as needed to aid tree and understory establishment. Under this BMP, trees are planted in a contiguous area as documented in the planting plan and the acreage of this BMP is converted from the developed turfgrass land use into forest in the modeling tools.

Urban Forest Buffer: Forest buffers are linear wooded areas that help filter nutrients, sediment and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width is 100 feet, with a 35 feet minimum width required.

Specifications or Key Qualifying Conditions

Trees planted for mitigation or as part of other BMPs or not eligible under these practices; an area of planted trees can only be counted towards one BMP. For example, if an acre of trees is planted along a stream as a forest buffer in a developed area it can be reported as an Urban Forest Buffer, but that same acre of trees cannot also be reported as Urban Forest Planting or Urban Tree Canopy Expansion.

Nitrogen, Phosphorus and Sediment Reductions

Each pollutant (nitrogen, phosphorus and sediment) is reduced according to the area of trees planted, with buffers reducing the load from upland developed acres. Average per-acre reduction estimates are provided in Table D-7-1 to illustrate the significant expected benefits for these practices, but actual estimates can be calculated using CAST.

Table D-7-1. Baywide average nitrogen, phosphorus and sediment reductions per acre of implementation. Pounds reduced edge-of-tide (EOT). TN and TP rounded to nearest hundredth of a pound; TSS rounded to nearest whole pound. Values derived in Phase 6 version of CAST and available by county or state. These values provided as useful estimates but the actual reductions for specific BMPs will be different from these average estimates. Source: BMP Pounds Reduced and Cost by State, July 13, 2018 version, available under "Cost Effectiveness" section at [http://cast.chesapeakebay.net/Documentation/DevelopPlans.](http://cast.chesapeakebay.net/Documentation/DevelopPlans)

Jurisdiction	BMP	Nitrogen Average reduction per acre, Edge of tide (lbs/ac)	Phosphorus Average reduction per acre, Edge of tide (lbs/ac)	Sediment Average reduction per acre, Edge of tide (lbs/ac)
Delaware	Forest buffer	35.25	0.95	113
	Forest planting	32.47	0.67	63
	Tree planting - canopy	15.91	0.10	15
District of Columbia	Forest buffer	5.86	1.07	915
	Forest planting	4.08	0.80	414
	Tree planting - canopy	-	0.03	18
Maryland	Forest buffer	8.06	1.10	729
	Forest planting	6.15	0.77	381
	Tree planting - canopy	0.62	0.10	64
New York	Forest buffer	5.85	0.37	730
	Forest planting	4.40	0.24	363
	Tree planting - canopy	0.60	0.04	267
Pennsylvania	Forest buffer	9.69	0.48	661
	Forest planting	7.33	0.32	341
	Tree planting - canopy	0.83	0.05	92
Virginia	Forest buffer	8.77	1.61	854
	Forest planting	7.33	1.16	451
	Tree planting - canopy	1.82	0.15	223
West Virginia	Forest buffer	7.52	0.56	1491
	Forest planting	5.77	0.36	847
	Tree planting - canopy	0.77	0.06	236

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

All Developed Turfgrass Land Uses (Non-Regulated, MS4 and CSS); Tree Canopy is also applicable to all Developed impervious land uses (Roads; Buildings and Other)

It is recommended that states report these practices on the appropriate version of Turfgrass, i.e., either "Nonregulated," "MS4" or "CSS." Alternatively, the combined group "Turfgrass" can be used; this combined group is the default if one of the three is not specified.

Brief Description of BMP Simulation in the Model

Urban Tree Canopy Expansion and Urban Forest Planting are *Load Source Change BMPs*, whose reductions are determined by the difference in nitrogen, phosphorus and sediment loading rates between the previous and the new land use (e.g., the difference in loads between Roads and Tree Canopy over Impervious). Urban Forest Buffers are a *Load Source Change with Efficiency Value BMP*. Each acre reported under the Urban Forest Buffer BMP is converted to the Forest load source, and then there is an additional treatment of upland load sources (25% TN, 50% TP and 50% sediment). For example, if one acre of trees is planted as a buffer along a stream, it converts one acre of Turfgrass into Forest, and reduces the load from an additional acre of Developed land by 25% for TN and 50% for TP and Sediment.

Annual or Cumulative? Cumulative (15-year credit duration for urban tree canopy expansion, urban forest buffer and urban forest planting)

Can this practice be combined with other BMPs? Yes. However, land converted to Forest by the Urban Forest Planting or Urban Forest Buffer BMPs cannot receive other developed BMPs in the model.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Tree Planting – Canopy
  - Urban Forest Planting
  - Urban Forest Buffer
- *Measurement unit(s):* Acres (of the forested buffer or planted with trees)
- *Land Use:* Approved NEIEN Developed load source groups (Non-Regulated, MS4, CSS);
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year trees were planted, or year forest buffer was established.

Table D-7-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Urban Tree Canopy Expansion	Tree Planting – Canopy	Street trees; landscape or individual tree planting
Urban Forest Planting	Urban Forest Planting	None
Urban Forest Buffer	Urban Forest Buffer	None

Additional Information

Expert panel report for urban tree canopy and forest planting BMPs:

Law, N., Cappiella, K., Claggett, S., Cline, K., Day, S., Galvin, M., MacDonagh, P., Sanders, J., Whitlow, T. & Q. Xiao. 2016. Recommendations of the Expert Panel to Define BMP Effectiveness for Urban Tree Canopy Expansion. Prepared by N.

Law, Center for Watershed Protection and J. Hanson, Virginia Tech.
https://www.chesapeakebay.net/documents/Urban_Tree_Canopy_EP_Report_WQGIT_approved_final.pdf

Center for Watershed Protection. 2017. *Making Urban Trees Count.* Report and other supporting materials available at*:* https://www.cwp.org/making-urban-trees-count/

Chesapeake Stormwater Network, Archived (2016) webcast: Urban Tree Canopy and Forest Planting: http://chesapeakestormwater.net/2016/09/webcast-urban-tree-canopy/

Chesapeake Tree Canopy Network: http://chesapeaketrees.net/

Trees and Stormwater: http://treesandstormwater.org/

Chesapeake Bay Program Forestry Workgroup Phase 3 WIP packet:
https://www.chesapeakebay.net/what/publications/25951

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in September 2016 for the urban tree canopy and urban forest planting BMPs. The urban forest buffer BMP definition and benefits have remained in use since review and approval by the CBP partnership's source sector workgroups for tributary strategy development. Updates to this reference sheet were published on November 14, 2022.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-8. Reducing Nutrients from Grey Infrastructure

General Information

Figure D-8-1. Visual Inspections and Outfall Screening are used to look for any signs of flow discharges in storm drain manholes or outfalls. If found, samples are taken to measure flow, color, odor, oils, floatables, and water quality parameters. Source: Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet U-6.

Grey infrastructure is defined as the underground network of sewer, water, and storm drain pipes that transport drinking water, sewage, and stormwater runoff where it needs to go. Many segments of this infrastructure are prone to leakage and overflows, causing their flows to interact with streams, and ultimately produce high nutrient discharges. Two potential practices that reduce nutrient discharge generated from gray infrastructure include: 1) Implementing Advanced MS4 Nutrient Discovery Programs and 2) Eliminating Individual Nutrient Discharges that are discovered in the field.

CBP Definition(s)

Advanced MS4 Nutrient Discovery Programs: The credit is defined as being equivalent to a maximum of 1% of the dry weather nutrient load within the jurisdiction, which is defined as 20% of the total annual nitrogen and phosphorus load discharged from the urban pervious land in which advanced nutrient discovery programs are targeted.

Advanced Grey Infrastructure Nutrient Discovery Program (IDDE): A local program to detect and eliminate illicit discharges from the storm drain system. IDDE programs are mandated as one of the six minimum stormwater control measures that must be addressed by communities regulated under Phase 1 or Phase 2 MS4 NPDES stormwater permits. Illicit discharge detection and elimination credits are only available to localities that show empirical monitoring for each eligible individual discharge.

Nutrient Discharges: the complex range of non-stormwater flows that export nutrients and other pollutants into urban receiving waters during dry weather conditions due to spills, leaks, and overflows from grey infrastructure. These discharges are created by the interaction of pollutant generating activities/sources with aging grey infrastructure (sanitary sewers, drinking water pipes, and storm sewers) via stormwater runoff and groundwater migration.

Discovered Nutrient Discharge refers to an existing nutrient discharge that is found through systematic assessment of a catchment, sewershed or stream corridor by the designated MS4 permittee or local sewer utility, using the screening, tracing and analysis methods described in this report. Nutrient discharges that are discovered using these methods may be eligible for a credit if they lead to the prevention or elimination of the discharge.

Specifications or Key Qualifying Conditions

For *Option 1: Advanced MS4 Nutrient Discovery Program* credit, localities must provide documentation that they possess advanced program elements to target, screen, detect, and correct the nutrient discharges with the highest nutrient loading risks. For a full list of these qualifications, consult Table 7 in the expert panel report (see Additional Information below).

For *Option 2: Elimination of Individual Nutrient Discharges* credit, the BMP only qualifies for credit if:

- They are detected and physically eliminated from 2005 or later.
- On-site sampling of the discharged that has been eliminated to define one or more of the following parameters – nutrient concentration, flow rate, and duration.
- Subsequent inspections and/or monitoring verify or otherwise confirm that discharge no longer exists.

For a full list of specifications and key qualifying conditions for this BMP, consult the expert panel report (see Additional Information below).

Nitrogen, Phosphorus and Sediment Reductions

For *Option 1: Advanced MS4 Nutrient Discovery Programs*, the reductions for qualifying programs will be applied as a 0.2 percent reduction in annual nutrient load discharged from urban pervious land targeted by the programs. This option has a retirement date of 6/30/2021, as indicated in the expert panel report and confirmed by the Urban Stormwater Workgroup, meaning projects implemented past that date are not eligible for credit in the model.

Table D-8-I. Nutrient Removal Rates for Advanced Grey Infrastructure Nutrient Discovery Program (IDDE) Practices.

Practice	TN Efficiency	TP Efficiency
Advanced Grey Infrastructure Nutrient Discovery Program (IDDE)	0.2%	0.2%

For *Option 2: Elimination of Individual Nutrient Discharges*, any nutrient reduction credit must be empirically based for each individual discharge that is removed, using a calculation of its unique nutrient concentration, flow rate, and discharge duration over the year. There are three general protocols that are used to define the pollutant load reductions. See expert panel report for more information.

- Protocol 1: The Prevented Load Calculation
- Protocol 2: The Before and After Load Approach
- Protocol 3: The Overflow Reduction Tracking Method

Table D-8-2. Data Requirements and Protocols to Compute Elimination of Individual Nutrient Discharge Reduction Credits.

No.	Discharge Type	Method	Nutrients	Flow Volume	Flow Duration
N-1	Laundry Wash Water	Protocol 1	S or D	E or M	E
N-2	Commercial Car Wash	Protocol 1	S	E or M	E
N-3	Floor Drains	Protocol 1	S	E or M	E
N-4	Misc. High Nutrient Discharges	Protocol 1	S	E or M	E
N-5	Sanitary Direct Connection	Protocol 1	S or D	E or M	E
N-6	Sewer Pipe Exfiltration	Protocol 2	S or D	M	E
N-7	Drinking Water Transmission Loss	Protocol 2	S or D	M	E
N-8	Dry Weather Sanitary Sewer Overflows (SSOs)	Protocol 3	S or D	E	M
KEY: S = Sample; D = Use Default Value; E = Estimate; M = Measure					

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Non-Regulated (Turf Grass, Tree Canopy over Turf Grass)
- MS4 (Turf Grass, Tree Canopy over Turf Grass)
- CSS (Turf Grass, Tree Canopy over Turf Grass)

Brief Description of BMP Simulation in the Model

Practices that fall under Option 1: Advanced MS4 Nutrient Discovery Program are *Efficiency Value BMPs*. Runoff from applicable load sources is reduced by the efficiency values in Table D-8-1.

Practices that fall under Option 2: Elimination of Individual Nutrient Discharges are *Load Reduction BMPs*. The reductions are calculated in the watershed model using the aggregate nutrient load (in pounds) associated with the elimination of individual nutrient discharges within the river basin segment for that year by the MS4.

Annual or Cumulative? Option 1: Advanced MS4 Nutrient Discharge BMP is annual (1-year credit duration). Option 2: Elimination of Individual Nutrient Discharges is cumulative (10-year credit duration) and cannot be renewed with an inspection or maintenance date.

Can this practice be combined with other BMPs? Yes. However, jurisdictions may claim the advanced MS4 program credit OR calculate individual credits, but not both.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - *Option 1:* Advanced Nutrient Discovery Program.
    - *Option 2:* Type of discharge eliminated (e.g., Grey Infrastructure Discharge Elimination Laundry Washwater, Commercial Car Washing, etc.).
- *Measurement unit(s):*
    - *Option 1:* Number of pervious acres in targeted catchments and/or sewersheds being treated by the advanced program.
    - *Option 2:* Pounds of TN and TP eliminated using the appropriate protocol.
- *Land Use:* Previous urban land.
- *Geographic location:* Latitude and Longitude, HUC 12 watershed code or other geographic data so that the pervious acres can be assigned to the appropriate river basin segment. No more specific NEIEN geographic resolution is needed per the more flexible reporting standards for this class of urban BMPs, as outlined in USWG memo (2014).
- *Date of implementation:*
    - *Option 1:* The first year in which the advanced MS4 nutrient discharge discovery program fully meets the qualifying criteria outlined in Table 7 in expert panel report.
    - *Option 2:* First year in which elimination of the discharge is confirmed.

Table D-8-3. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Advanced Grey Infrastructure Nutrient Discovery Program (IDDE)	Advanced Nutrient Discovery Program	Advanced MS4 Nutrient Discovery Program; Illicit Discharge Detection and Elimination (IDDE) Program
Grey Infrastructure Discharge Elimination Laundry Washwater		None
Grey Infrastructure Discharge Elimination Commercial Car Washing		None
Grey Infrastructure Discharge Elimination Floor Drains		None
Grey Infrastructure Discharge Elimination Misc. High Nutrient Non-Sanitary Discharge		None
Grey Infrastructure Discharge Elimination Sanitary Direct Connections		None

Grey Infrastructure Discharge Elimination Sewage Pipe Exfiltration
Grey Infrastructure Discharge Elimination Drinking Water Transmission Loss
Grey Infrastructure Discharge Elimination Dry Weather Sanitary Sewer Overflows

Additional Information

Expert panel report:

Walch, M., Brosh, M., Lilly, L., Tribo, J., Whitehurst, J., Brumbaugh, B., Handy, D., Hoskins, M., Utt, K., Pitt, R., Spano, T., & Katchmark, W. 2014. Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards. Prepared by T. Schueler and C. Lane, Chesapeake Stormwater Network, and B. Stack, Center for Watershed Protection.
https://www.chesapeakebay.net/documents/grey_infrastructure_expert_panel_report_102714.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-6: Elimination of Individual Nutrient Discharges from Gray Infrastructure. Available at: http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2017/02/U6.-Elimination-of-Discovered-Nutrient-Discharges-from-Grey-Infrastructure_final-draft.pdf

Chesapeake Stormwater Network, Profile Sheets for Crediting Nutrient Reductions from Gray Infrastructure. Available at: http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2016/01/Appendix-A.-Profile-Sheets.pdf

Chesapeake Stormwater Network, Archived (2015) webcast: Nutrient Discharges from Grey Infrastructure: https://chesapeakestormwater.net/events/nutrient-discharges-from-grey-infrastructure/

Chesapeake Stormwater Network, Archived (2015) webcast: Discharge Discovery Techniques: https://chesapeakestormwater.net/events/webcast-discharge-discovery-techniques/

Chesapeake Stormwater Network, Archived (2017) webcast: Tracking and Eliminating Illicit Discharges: https://chesapeakestormwater.net/events/webcast-tracking-and-eliminating-illicit-discharges/

Urban Stormwater Workgroup (USWG). 2014. Final Recommended Guidance for Verification of Urban Stormwater BMPs. Approved 01/21/2014. Chesapeake Bay Program Partnership. Available at https://www.chesapeakebay.net/channel_files/21146/attachment_c--uswg_urban_bmp_verification_guidance_011214_review_draft.pdf

Urban Stormwater Workgroup (USWG). Meeting Minutes, May 17, 2022. Available at: https://www.chesapeakebay.net/channel_files/44160/uswg_may_minutes_draft.pdf

Version and History Statement

This info sheet was first published on November 16, 2022 and reflects the BMP definitions and reductions approved by the WQGIT in October 2014.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-9. Street Cleaning (Street Sweeping)

General Information

Streets comprise a significant portion of impervious cover in the Chesapeake Bay watershed. Most communities operate some kind of street sweeping program, using vehicles to clean their roads along curbside gutters where debris and dirt accumulate. Street sweeping provides a number of benefits to the community by removing trash, debris, sand, road salt and other solids. This prevents pollution from entering local waterways while creating a more attractive streetscape. The accumulated materials may also contain toxic pollutants or pose other risks to the local environment. The effectiveness of street sweeping is greatest when cleaning high-use roadways free of parked cars which block access to curbs and gutters where materials accumulate.

Figure D-9-1. There are different types of street sweeping vehicles, but the most common technology are mechanical broom sweepers, like the one pictured here. More advanced and effective, but expensive, options include vacuum-assisted and regenerative air sweepers (not pictured). Photo: Mississippi Watershed Management Organization.

CBP Definition(s)

The CBP has two categories of street cleaning practices (SCPs) based on the type of sweeper technology.

Mechanical broom technology sweepers: Researchers have found that while mechanical sweepers are effective in picking up coarse-grained particles, they leave behind fine-grained particles, which are then subject to future wash-off. Therefore, mechanical broom sweepers are useful in removing gross solids, trash and litter from streets but have very limited capabilities to reduce nutrients and fine sediment.

Advanced sweeping technology: Technologies with greater demonstrated ability to remove solids and even finer particles from street surfaces.

Regenerative air sweepers are equipped with a sweeping head which creates suction and uses forced air to transfer street debris into the hopper.

Vacuum-assisted sweepers are sweepers equipped with a high power vacuum to suction debris from street surface.

The practices are further divided into eleven BMPs based on the frequency of sweeping (see Table D-9-1), since more frequent sweeping increases the likelihood that sweepers will remove accumulated material before precipitation washes it into storm drains or waterways.

Specifications or Key Qualifying Conditions

Mechanical broom sweepers are only eligible for SCP-9, SCP-10 or SCP-11 based on the frequency of sweeping a given route. The other eight SCPs require an advanced sweeper, either vacuum-assisted or regenerative air. Localities should check with their state stormwater agency for specific data reporting or tracking requirements.

Nitrogen, Phosphorus and Sediment Reductions

Advanced sweeper technologies (SCP-1 through SCP-8) have efficiency values for nitrogen, phosphorus and sediment, summarized in Table D-9-1. Mechanical broom sweepers (SCP-1 through SCP-3) only have efficiency values for sediment. The efficiency values are applied to an area of roads or impervious surfaces; generally, one curb-lane mile equals one acre in terms of area swept.

Table D-9-1. Street cleaning practices' sediment, nitrogen and phosphorus efficiency values in the Phase 6 Watershed Model.

Type	Practice	Description of passes by sweeper; approx. # of passes per year	Sediment (%)	Nitrogen (%)	Phosphorus (%)
Advanced	SCP-1	2 passes per week; ~100 per year	21	4	10
Advanced	SCP-2	1 pass per week; ~50 per year	16	3	8
Advanced	SCP-3	1 pass every 2 weeks; ~25 per year	11	2	5
Advanced	SCP-4	1 pass every 4 weeks; ~10 per year	6	1	3
Advanced	SCP-5	1 pass every 8 weeks; ~6 per year	4	0.7	2
Advanced	SCP-6	1 pass every 12 weeks; ~4 per year	2	0	1
Advanced	SCP-7*	Seasonal scenario 1 or 2; ~15 per year	7	1	4
Advanced	SCP-8*	Seasonal scenario 3 or 4; ~20 per year	10	2	5
Mech. Broom	SCP-9	2 passes per week; ~100 per year	1	N/A	N/A
Mech. Broom	SCP-10	1 pass per week; ~50 per year	0.5	N/A	N/A
Mech. Broom	SCP-11	1 pass every 4 weeks; ~10 per year	0.1	N/A	N/A

*Seasonal scenarios for SCP-7 and SCP-8 are defined as follows:

- Seasonal scenario 1: Spring – One pass every week from March to April. Monthly otherwise
- Seasonal scenario 2: Spring – One pass every other week from March to April. Monthly otherwise
- Seasonal scenario 3: Spring and fall – One pass every week (March to April, October to November). Monthly otherwise
- Seasonal scenario 4: Spring and fall – One pass every other week during the season. Monthly otherwise

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed Roads and Impervious Land Uses (Non-Regulated, MS4 and CSS)

If a land use is not specified the default is "Roads."

Brief Description of BMP Simulation in the Model

All street sweeping practices are *Efficiency Value BMPs*. Pollutant loads from roads or other treated impervious surfaces are reduced by the percentage values in Table D-9-1. For example, a community that sweeps 10 curb lane miles twice a week for a whole year with an advanced street sweeper (SCP-1) will have loads from that area of road reduced by 21 percent for sediment, four percent for nitrogen and 10 percent for phosphorus; if they used a mechanical broom sweeper (SCP-11) they will reduce sediment loads from that area of roads by one percent.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Street Sweeping
  - Street Cleaning Practice (SCP-1 through SCP-11)
- *Measurement unit(s):* Runoff storage volume; impervious acres; acres treated
- *Land Use:* Approved NEIEN Developed load source groups for Roads and Impervious cover (Non-Regulated, MS4, CSS); if none are reported the default load source group will be Roads.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year sweeping was performed.

Table D-9-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Advanced sweeping technology sweepers	Street Cleaning Practice 1 (SCP1); Street Cleaning Practice 2 (SCP2); Street Cleaning Practice 3 (SCP3); Street Cleaning Practice 4 (SCP4); Street Cleaning Practice 5 (SCP5); Street Cleaning Practice 6 (SCP6); Street Cleaning Practice 7 (SCP7); Street Cleaning Practice 8 (SCP8)	Vacuum-assisted sweepers and/or regenerative air sweepers, with variable sweeping frequency for respective routes
Mechanical broom technology sweepers	Street Cleaning Practice 9 (SCP9); Street Cleaning Practice 10 (SCP10); Street Cleaning Practice 11 (SCP11); Street Sweeping (equal to SCP11)	Mechanical broom sweepers with variable sweeping frequency for respective routes

Additional Information

Expert panel report:

Donner, S., Frost, B., Goulet, N., Hurd, M., Law, N., Maguire, T., Selbig, B., Shafer, J., Stewart, S., and J. Tribo. 2016. Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices. Prepared by T. Schueler, E. Giese, J. Hanson and D. Wood. https://www.chesapeakebay.net/documents/FINAL_APPROVED_Street_and_Storm_Drain_Cleaning_Expert_Panel_Report_--_Complete2.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-8: Street Cleaning Practices Fact Sheet. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network, Archived (2016) webcast: Crediting Street Sweeping and Storm Drain Cleaning in the Bay Watershed. Webcast: http://chesapeakestormwater.net/events/webcast-street-sweeping/

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the Management Board in May 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-10. Storm Drain Cleaning

General Information

Areas such as roads and parking lots are designed for water to quickly flow into large networks on underground storm sewers whenever it rains. To enter the storm sewer system, the stormwater first flows through a storm drain, which includes an area known as the catch basin. Stormwater carries pollutants like sediment or other debris, and over time these materials can fill up or even clog the catch basin or storm drain. When these materials are removed from storm drain systems through storm drain cleaning, a community can help protect its waterways while also protecting roads or other infrastructure from ponding water during storms.

Figure D-10-1. Storm Drain Cleaning in Anne Arundel County. Work is completed on a rotating basis using a vactor (vacuum) truck to reduce sediment traveling to the Bay. Source: Anne Arundel County, Department of Public Works. https://www.aacounty.org/departments/public-works/highways/road-maintenance/Drainage_Maintenance/storm-drain-cleaning

CBP Definition(s)

Storm Drain Cleaning is the removal of sediment and organic matter from catch basins in a targeted manner that focuses on water quality improvements. The storm drain cleaning program should 1) focus on catch basins trapping the greatest organic matter loads, streets with the greatest adjacent tree canopy and/or outfalls with higher sediment or debris loads; 2) be verified using a field protocol to measure the mass or volume of solids collected with the storm drainpipe system; and 3) properly dispose of removed material so that it cannot migrate back through the watershed.

Specifications or Key Qualifying Conditions

There are three qualifying conditions to ensure that storm drain cleaning efforts have a strong water quality focus:

- Efforts should be targeted to catch basins that trap the greatest organic matter loads, streets with the greatest overhead tree canopy and/or outfalls that generate higher sediment or debris loads.
- The loads removed must be verified using a field protocol to measure the mass or volume of solids collected within the storm drainpipe system. This may also entail periodic sub-sampling of the carbon/nutrient content of the solids that are captured.
- Material must be properly disposed so that it cannot migrate back into the watershed.

For more detailed information on specifications and qualifying conditions, consult the Expert Panel report (see Additional Information below).

Nitrogen, Phosphorus and Sediment Reductions

The credit is computed in three steps:

- *Step 1:* Measure the mass of solids/organic matter that is effectively captured and properly disposed by the storm drain cleaning practice on an annual basis.

- *Step 2:* Convert the initial wet mass captured into dry weight. The following default factors can be used to convert wet mass to dry weight in the absence of local data. The conversion factors are 0.7 for wet sediments (CSN, 2011) and 0.2 for wet organic matter (Stack et al, 2013).

- *Step 3:* Multiply the dry weight mass by a default nutrient enrichment factor depending on whether the material captured is sediment or organic in nature (see Table D-10-1). Note: Locals may substitute their own enrichment factor if they sample the nutrient and carbon content of the materials they physically remove from the storm drain.

The aggregate load captured over the course of a year is reported for credit and is expressed in terms of pounds of sediment and nutrients.

Table D-10-1. Mean Nutrient Enrichment Factor to Apply to Dry Weight Mass of Solids Physically Removed From Storm Drains. Source: BMP Expert Panel Report on Street and Storm Drain Cleaning, 2016.

Nutrient Enrichment Factor	% P	% N	Notes
BMP and Catch Basin Sediments*	0.06	0.27	See Table B-4 in Expert Panel Report.
Organic Matter/Leaf Litter	0.12	1.11	See Table 11 in Expert Panel Report.
* Multiply the mass of sediment removed from the storm drain (in pounds by a factor of 0.0006 and 0.0027, for total phosphorus and total nitrogen, respectively.			

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

The following load sources are applicable for the storm drain cleaning BMP:

- All Developed Land Uses (Non-Regulated, MS4, CSS) except construction.

Brief Description of BMP Simulation in the Model

Storm drain cleaning practices are *Load Reduction BMPs*.

Storm drain cleaning practices will be treated in the same way as stream restoration practices in the model. This means that storm drain cleaning reductions will apply to loads exiting upslope acres after they have filtered through upslope BMPs. The pounds reduced for each project within a land-river segment will be added together and applied as a reduction at the watershed outlet for each segment. The model simulates further reductions to nutrients between the watershed outlet and the Chesapeake Bay.

Figure D-10-2. Storm Drain Cleaning in Anne Arundel County, Maryland. Source: Anne Arundel County, Department of Public Works.

Annual or Cumulative? Annual (one-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Storm Drain Cleaning.
- *Measurement unit(s):* Lbs. total suspended solids; Lbs. total nitrogen; Lbs. total phosphorus.
- *Land Use:* Approved NEIEN land uses; the default land use group for Storm Drain cleaning BMPs will be UrbanWithCSS.
- *Geographic location:* Qualifying NEIEN geographies including: Latitude/Longitude (preferred as the coordinates of the centroid of the street cleaning rout); or County; or County (CBWS Only); or Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4, State (CBWS Only).

- *Date of implementation:* Date the storm drain cleaning was done.

Table D-10-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Storm Drain Cleaning	Storm Drain Cleaning	Catch basin clean-out; storm sewer inlet cleaning

Additional Information

Expert panel report:

Donner, S., Frost, B., Goulet, N., Hurd, M., Law, N., Maguire, T., Selbig, B., Shafer, J., Stewart, S., & Tribo, J. 2016. Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices. Prepared by T. Schueler, Chesapeake Stormwater Network, E. Giese, Chesapeake Research Consortium, J. Hanson, Virginia Tech, and D. Wood, Chesapeake Research Consortium.
https://www.chesapeakebay.net/documents/FINAL_APPROVED_Street_and_Storm_Drain_Cleaning_Expert_Panel_Report_--_Complete2.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-10: Storm Drain Cleaning. Available at: http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2017/04/U10.-Storm-Drain-Cleaning_4.6.17_final.pdf

Chesapeake Stormwater Network, Archived (2016) webcast: Crediting Street Sweeping and Storm Drain Cleaning in the Bay Watershed. Webcast: http://chesapeakestormwater.net/events/webcast-street-sweeping/

Version and History Statement

This info sheet was first published on November 14, 2022, and reflects the BMP definitions and reductions approved by the WQGIT in May 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-11. Floating Treatment Wetlands

General Information

Floating Treatment Wetlands (FTW) are buoyant rafts that hold aquatic plants whose roots extend below the surface of pond water. FTWs enhance the natural processes that occur between water, plants, and microorganisms to remove contaminants from wastewater and stormwater. FTWs provide a porous structure for plants to grow upon, creating a vast underwater root network that allows for microbes and bacteria to flourish. In turn, these microorganisms trap sediment and uptake nutrients, improving the overall water quality of the pond. Beyond improving water quality, FTWs can also provide benefits by enhancing wetland habitat and aesthetic qualities for existing stormwater wet ponds, as well as providing habitat refuge for birds and waterfowl away from the shoreline or aquatic benches.

Figure D-11-1. A Floating Treatment Wetland (FTW) in an existing wet pond. Source: Bill Hunt, NCSU (see Expert Panel Report).

CBP Definition(s)

Floating Treatment Wetlands are a variant of the BMP enhancement retrofit category. A more specific definition of the practice is below.

Floating Treatment Wetlands: Rafts of wetland vegetation that are deployed in existing wet ponds with a drainage area of greater than 400 acres. They are a proprietary or non-proprietary floating island design that incorporates the following general elements:

- A buoyant artificial raft that floats on the surface.
- Constructed from non-toxic materials such as, but not limited to, high density polyethylene (HDPE) plastic, marine grade polystyrene foam and PVC pipe.
- Containing growing media planted with macrophytes (aquatic plants) whose roots extend well below the water surface.

Wet Pond (aka stormwater retention pond, wet extended detention pond): An existing stormwater retention pond with a permanent pool of water that has an average depth of 3.5 to 8 feet and meets performance criteria for an effective FTW retrofit application. Wet ponds designed to treat runoff from impervious surfaces associated with the farmstead, covered storage areas and barn rooftops in rural areas are also eligible for the retrofit.

Specifications or Key Qualifying Conditions

The FTW application within an existing wet pond must:

- Achieve a minimum pond surface coverage of 10% and a maximum cover of no more than 50%.
- Have an initial planting density of two plugs per square foot and attain 80% plant coverage on the raft by the end of the growing season.
- The raft should be placed perpendicular to the stormwater flow path and be at least 3.5 feet above the bottom of the pond.
- Utilize FTW units within a large surface area.
- Possess a suitable method for reaeration to prevent anoxic discharges from the pond during the summer months.
- Be adequately anchored or tethered in the pond to protect its flood control function during major storms, as well as enable retrieval for periodic maintenance. Anchoring should not be too taut to inundate the surface and flood the raft.

- Should not be infested with invasive plants and should initially be covered with netting, to be protected from geese and turtles during plant establishment.
- Use native wetland plant species that are appropriate for the ecosystem.

Floating treatment wetlands deployed in tidal or open water settings are currently not eligible for credit. For additional qualifying conditions and practice limitations, consult the Expert Panel Report (see Additional Information below).

Nitrogen, Phosphorus and Sediment Reductions

A series of curves were used to define the incremental total suspended solids, total phosphorus and total nitrogen removal rate associated with the FTW retrofit based on the amount of FTW coverage over the surface area of the existing wet pond. The removal rates are displayed in Table D-11-1.

Table D-11-1. Pollutant Removal Rates for Floating Treatment Wetland Pond Retrofits.

Practice Name	Raft Coverage in Pond	Pollutant removal estimates		
		TN	TP	TSS
FTW-1	10%	0.8%	1.6%	2.3%
FTW-2	11-20%	1.7%	3.3%	4.7%
FTW-3	21-30%	2.5%	4.9%	7.0%
FTW-4	31-40%	3.3%	6.5%	9.2%
FTW-5	51-50%	4.1%	8.0%	11.5%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

In the Phase 6 Watershed Model, reductions from FTWs can be applied to all of the urban land uses within the contributing draining area of the existing wet stormwater pond that meets the qualifying criteria.

- All Developed Land Uses (Non-Regulated, MS4, CSS) except construction.

If not specified, the default land use will be “MS4CSSNonRegulated”.

Brief Description of BMP Simulation in the Model

All floating treatment wetlands are *Efficiency Value BMPs*. Runoff from applicable land use types is reduced by the efficiency values list in Table D-11-1, based on the amount of FTW surface area coverage.

Annual or Cumulative? Cumulative (three-year credit duration).

Can this practice be combined with other BMPs? Yes. The wet pond practice where the floating treatment wetland is installed should be reported separately according to the Stormwater Performance Standards Expert Panel report (see D-1: Stormwater Performance Standards).

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - *FTW-1.*
    - *FTW-2*
    - *FTW-3.*
    - *FTW-4.*
    - *FTW-5.*
- *Measurement unit(s):* Total Acres Treated (Acres) by the wet pond in which the FTW is located.
- *Land Use:* Urban. Default Land Use will be MS4CSSNonregulated.

- *Geographic location:* Qualifying NEIEN geographies including: Latitude/Longitude; or County; or Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); or State.
- *Date of implementation:* Date practice was installed.

Table D-11-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Floating Treatment Wetlands	Floating Treatment Wetlands	None

Additional Information

Expert panel report:

Lane, S., Sample, D., Lazur, A., Winston, R., Streb, C., Ferrier, D., Linker, L., & Brittingham, K. 2016. Recommendations of the Expert Panel to Define Removal Rates for Floating Treatment Wetlands in Existing Wet Ponds. Prepared by T. Schueler and C. Lane, Chesapeake Stormwater Network, and D. Wood, Chesapeake Research Consortium. https://www.chesapeakebay.net/documents/FINAL-FTW-EXPERT-PANEL-REPORT-072716-LONG.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-12: Floating Treatment Wetlands. Available at: http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2017/09/U-12-Floating-Treatment-Wetland-Fact-Sheet_final.pdf

Chesapeake Stormwater Network, Archived (2016) webcast: Crediting Floating Treatment Wetlands in the Chesapeake Bay Webcast: http://chesapeakestormwater.net/events/webcast-floating-treatment-wetlands/

Chesapeake Stormwater Network, Archived (2016) webcast: The Pond Protocol: http://chesapeakestormwater.net/events/webcast-pond-protocol/

Version and History Statement

This info sheet was first published on November 14, 2022, and reflects the BMP definitions and reductions approved by the WQGIT in July 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-12. Impervious Area Disconnection and Soil Amendments

General Information

Impervious area disconnection is a practice used to redirect stormwater from impervious areas, such as rooftops and pavement, towards pervious areas with amended soils. Conditioners and fertilizers, such as compost, are used to modify these soils to increase its infiltration capacity. In doing so, the soil provides filtering and infiltration capabilities, which can reduce the volume and flows associated with stormwater runoff.

CBP Definition(s)

Impervious Disconnection to Amended Soils: Disconnecting existing impervious area runoff from stormwater drainage systems such as directing rooftops and/or on-lot impervious surfaces to pervious areas with amended soils. Report the disconnect to unamended soils as Urban Filter Strip.

Soil Amendment: Conditioners and fertilizers that are added to a soil to increase its infiltration capacity. Compost is one of the most commonly used amendments. Others include zeolite, gypsum and liquid amendments such as ammonium laurel sulfate.

Specifications or Key Qualifying Conditions

The definition of this BMP includes impervious surface disconnection to amended soils and treatment within the conveyance system, however, only impervious disconnections to amended soils may be reported for credit in the Watershed Model. Additional qualifying conditions and assumptions for impervious surface disconnection to amended soils are outlined in Section 2 of the Expert Panel report (see Additional Information below).

Impervious surface disconnection to untreated soils is considered an Urban Filter Strip and follows the recommendations for that specific BMP.

This practice is separate from Impervious Cover Removal (ICR)/Impervious Surface Removal (ISR). ISR reduces the pollutant loading rate generated on an area of land and is credited based on the actual area that is converted. In contrast, impervious surface disconnection treats runoff received from an adjacent impervious area and is credited based on the acres or runoff volume treated.

Nitrogen, Phosphorus and Sediment Reductions

Impervious disconnections to amended soils exists as a BMP in the Watershed Model but is a default efficiency reduction. This practice should only be used for planning purposes or be reported when runoff from an impervious surface is redirected to a pervious surface with amended soils, but the treatment volume is unknown.

Table D-12-I. Default Nutrient and Sediment Removal Rates for Impervious Area Disconnection Coupled with Soil Amendments.

Practice	Total Nitrogen (TN)	Total Phosphorus (TP)	Total Suspended Solids (TSS)
Impervious Area Disconnection + Soil Amendments	12.3%	14.6%	15.6%

Impervious surface disconnection can stand alone as a single BMP or be part of a “treatment-train” of other practices. If it is a stand-alone practice where runoff from impervious cover is redirected to amended soil and the runoff treatment volume is known, then the practice should be reported as a Runoff Reduction (RR) using the Stormwater Performance Stands BMP Expert Panel Report (in Additional Resources below). If the practice is part of a “treatment-train” of other BMPs, the dominant practice should be reported along with the volume treated, total impervious acres treated and total site acres, per the Stormwater Performance Standards BMP Expert Panel Report (in Additional Resources below).

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed Land Uses (Non-Regulated, MS4, CSS) except construction.

Brief Description of BMP Simulation in the Model

Impervious disconnection to amended soils are *Efficiency Value BMPs.* The default nutrient and sediment removal rates are displayed in Table D-12-1 above.

Annual or Cumulative? Cumulative (five-year credit duration). The Expert Panel recommends that heavily utilized areas have surface compost amendments applied annually and inspected more frequently. The credit can be extended if a field inspection verifies the BMP(s) are still performing.

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Impervious disconnection to amended soils.
- *Measurement unit(s):* Impervious Area (acres).
- *Land Use:* Urban Impervious.
- *Geographic location:* Qualifying NEIEN geographies: Latitude/Longitude; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Date practice was installed.

Table D-12-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Impervious disconnection to amended soils	Impervious disconnection to amended soils	Impervious cover disconnections (ICD)

Additional Information

ICD expert panel report:
Evanylo, G., Montalto, F., Papacosma, J., Sample, D., Shafer, J., Stack, B., & Winston, R. 2016. Recommendations of the Expert Panel to Define Removal Rates for Disconnecting Runoff from Impervious Areas onto Amended Soils or Treatment in the Stormwater Conveyance System. Prepared by R. Christianson, L. Fraley-McNeal, J. Hanson, B. Benham, G. Sandi, L. Ottinger, S. Stewart, and J. Sweeney.
https://www.chesapeakebay.net/documents/Impervious_Disconnection_Expert_Panel_Report_WQGIT_approved_December_2016.pdf

Stormwater performance standards expert panel report:
Comstock, S., Crafton, S., Greer, R., Hill, P., Hirschman, D., Karimpour, S., Murin, K., Orr, J., Rose, F., & S. Wilkins. 2012. Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards. Prepared by T. Schueler and C. Lane, Chesapeake Stormwater Network. Revised with updated curves January 2015.
http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2012/10/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Performance-Standards-SHORT_0120151.pdf

Chesapeake Stormwater Network, Archived (2017) webcast: New Crediting Approaches: Impervious Cover Disconnection and CMAC Webcast: http://chesapeakestormwater.net/events/webcast-new-crediting-approaches-impervious-cover-disconnection-and-cmac/

Cleanup of Removal Rate Crediting for Impervious Cover Disconnection (ICD) and Removal (ICR) BMPs in the Watershed Model Memo (January 2021): https://chesapeakestormwater.net/download/10955/

Version and History Statement

This info sheet was first published on November 14, 2022 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-13. Dry Detention Ponds

General Information

Figure D-13-1. Small dry detention basin near Harvest Circle, Village of Oregon, Wisconsin, USA. Water ponds in this area during heavy rainstorms, and slowly drains out through a pipe in the berm on the far side of the basin. Source: Aaron Volkening, Flickr (https://flic.kr/p/dreYBM).

Dry detention ponds are stormwater BMPs that are designed to store surface runoff water and gradually release it over time to moderate the influence of peak flows and drains completely between storm events. By decreasing the water velocity, these BMPs remove suspended solids via settling, which, in turn, improves the overall water quality. The surface of the dry detention pond can consist of concrete or grass, shown in Figure D-13-1, which may improve the trapping of sediments. These basins can also consist of underground tanks that temporarily store stormwater, as well as hydrodynamic structures, which are designed to remove sediment and contaminants from urban runoff.

CBP Definition(s)

Dry Detention Ponds are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms.

Hydrodynamic Structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.

Specifications or Key Qualifying Conditions

There are no specifications or key qualifying conditions for CBP purposes beyond the definitions above, aside from the fact that hydrodynamic structures are not considered a stand-alone BMP. They act similar to a dry detention pond and therefore are included in this group.

Nitrogen, Phosphorus and Sediment Reductions

The removal efficiencies for dry detention basins and hydrodynamic structures used in the Chesapeake Bay watershed model are displayed in Table D-13-1. For more information on how these efficiencies were determined, consult the Simpson and Weammert-Lane report (see Additional Information below).

Table D-13-I. Nutrient and Sediment Reduction Effectiveness Efficiencies for Dry Detention Ponds.

Practice Type	TN	TP	TSS
Dry Detention Ponds/Basins and Hydrodynamic Structures	5%	10%	10%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed Land Uses (Non-regulated, MS4, CSS) except construction

Brief Description of BMP Simulation in the Model

Dry detention pond practices are *Efficiency Value BMPs.* Runoff from applicable load sources is reduced by the efficiency values displayed in Table D-13-1 for nitrogen, phosphorus, and sediment.

Annual or Cumulative? Cumulative (10-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Dry Detention Ponds
    - Dry Detention Ponds and Hydrodynamic Structures
- *Measurement unit(s):* Area treated, Drainage Area, Acres.
- *Land Use:* Approved NEIEN Developed load source groups (Non-Regulated, MS4, CSS); if none are reported the default load source group will be combination of all three (MS4CSSNonRegulated).
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Date practice was installed.

Figure D-13-2. Dry detention basin. Source: Simpson and Weammert-Lane Report (p. 201).

Table D-13-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Dry detention ponds	Dry detention ponds	Dry detention basins, Dry ponds
Hydrodynamic structures	Hydrodynamic structures	Stormceptor®, StormVault®, and Vortechs®

Additional Information

T. Simpson and S. Weammert (Lane). 2009. Dry Detention Ponds and Hydrodynamic Structures Best Management Practice. Definition and Nutrient and Sediment Reduction Effectiveness Estimates. T. Simpson and S. Weammert (Lane), eds. Final Report, December 2009. Pages 198-263. https://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

Chesapeake Stormwater Network, The Pond Protocol: Appendix A. Available at http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2016/10/APPENDIX-A-VISUAL-INDICATORS.pdf

Chesapeake Stormwater Network, Archived (2016) webcast: The Pond Protocol: http://chesapeakestormwater.net/events/webcast-pond-protocol/#resources

Version and History Statement

This info sheet was first published on November 16, 2022 and reflects the BMP definition and benefits that have remained in use since review and approval by the CBP partnership's source sector workgroups for tributary strategy development. All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-14. Urban Filter Strips

General Information

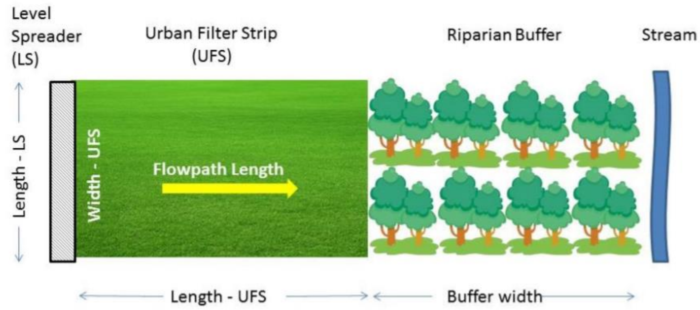

Figure D-14-1. Dimensional elements of an urban filter strip. Source: Expert Panel Report.

Urban filter strips (UFS) are areas of vegetation located between source of pollution and a body of water that recieves runoff. They are also referred to as vegetated filter strips (VFS) or grass filter strips. These practices are designed to filter out sediment, organic matter, and pollutants carried in runoff before it reaches a body of water. Urban filter strips can also reduce erosion, as the vegetation covers an area of soil that may otherwise be a source of erosion.

CBP Definition(s)

UFS Runoff Reduction: stable areas with vegetated cover on flat or gently sloping land. Runoff entering the filter strip must be in the form of sheetflow and must enter at a non-erosive rate for the sit-specific soil conditions. A 0.4 design ratio of filter strip length to impervious flow length is recommended for runoff reduction urban filter strips.

UFS Stormwater Treatment: stable areas with vegetated cover on flat or gently sloping land. Runoff entering the filter strip must be in the form of sheetflow and must enter at a non-erosive rate for the sit-specific soil conditions. A 0.2 design ratio of filter strip length to impervious flow length is recommended for runoff reduction urban filter strips. Additional qualifying conditions for both practices can be found on pp. 4-5 of the Expert Panel report.

Specifications or Key Qualifying Conditions

Figure D-14-2. An urban filter strip hard at work. Source: Chesapeake Stormwater Network.

An urban filter strip may receive pollutant load reduction credits when used as a stand-along practice to treat relatively small impervious areas (e.g., 5000 ft² or less) for new a development, redevelopment, or retrofit site. Pollutant load reductions may also be applied to UFS if it were implemented as a pre-treatment practice as part of a retrofit.

This practice should be designed and maintained in accordance with the qualifying conditions to receive pollutant removal credits and excludes the use of conservation landscaping as part of the definition for this BMP. Manicured lawns, athletic fields, and other managed turf or pervious area (that do not meet these conditions) cannot be used as UFS, however, other BMPs may be considered, such as Urban Fertilizer Management (UNM, 2013).

- UFS Runoff Reduction: a 0.4 design ratio of filter strip length to impervious flow length is recommended for runoff reduction urban filter strips.
- UFS Stormwater Treatment: a 0.2 design ratio of filter strip length to impervious flow length is recommended for runoff reduction urban filter strips.

Consult the expert panel report (see Additional Information below) for a full list of qualifying conditions for this BMP, as well as your state stormwater reporting agency for state-specific design and hydraulic standards.

Nitrogen, Phosphorus and Sediment Reductions

The nitrogen, phosphorus, and sediment reductions for urban filter strips are displayed in Table D-14-1. More details about the percent reductions can be found in Section 6 of the expert panel report (see Additional Information below).

Table D-14-1. Estimated nutrient and sediment removal for urban filter strips as a runoff reduction and stormwater treatment practice. Source: Expert Panel, 2014.

Practice Type	Total Nitrogen (TN[1])	Total Phosphorus (TP[2])	Total Sediment (TS[2])
Runoff Reduction	20%	54%	56%
Stormwater Treatment	n/a	n/a	22%
[1] TN removal is based on particulate-N only and assumes that particulate N removed is not converted to nitrate and leached to groundwater. No credit is provided for dissolved N. [2] The percent pollutant removal is estimated using the 0.5" rainfall depth capture for the TP and TS performance adjustor curves provided in SPS EP (2013a).			

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed Land Uses (Non-Regulated, MS4 and CSS) except construction

It is recommended that states report these practices on the appropriate land use group, i.e., either "Nonregulated," "MS4" or "CSS." Alternatively, the combined group "MS4CSSNonRegulated" can be used; this combined group is the default if one of the three is not specified.

Brief Description of BMP Simulation in the Model

Urban filter strips are *Efficiency Value BMPs.* Runoff from applicable load sources is reduced by the efficiency values displayed in Table D-14-2.

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? No. UFS practices are typically designed as stand-along practices to treat sheetflow runoff. As such, acres treated by UFS practices cannot also be treated by other urban practices. Additionally, an acre cannot be treated by two separate UFS practices.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Urban Filter Strip RR
    - Urban Filter Strip ST
- *Measurement unit(s):* Acres treated
- *Land Use:* Approved NEIEN land uses; impervious or pervious urban lands (impervious urban with CSS will be the default land use group)
- *Geographic location:* Latitude and longitude, the coordinates for the center of the practice.
- *Date of implementation: Date* practice was installed.

Table D-14-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Urban Filter Strips (UFS)	Urban Filter Strip RR (Runoff Reduction); Urban Filter Strip ST (Stormwater Treatment)	Vegetated Filter Strips (VFS), Grass Filter Strips

Additional Information

Expert panel report:

Battiata, J., Claggett, S., Crafton, S., Follansebee, D., Gasper, D., Greer, R., Hardman, C., Jordan, T., Stewart, S., Todd, A., Winston, R., Zielinski, J. 2014. Recommendations of the Expert Panel to Define Removal Rates for Urban Filter Strips and Stream Buffer Upgrade Practices. Prepared by N. Law, Center for Watershed Protection, Inc. https://www.chesapeakebay.net/documents/UFS_SBU_Expert_Panel_Draft_Report_Decision_Draft_FINAL_WQ_GIT_APPROVED_JUNE_9_2014.pdf

Chesapeake Stormwater Network, Urban Filter Strips. Available at: https://chesapeakestormwater.net/bmp-resources/urban-filter-strips/

Chesapeake Stormwater Network, Archived (2014) webcast: Accounting for Urban Stormwater Retrofits and Urban Filter Strips. Available at: http://chesapeakestormwater.net/events/webcast-ms4-implementers-and-the-bay-tmdl-retrofits/

Version and History Statement

This info sheet was first published on November 16, 2022, and reflects the BMP definitions and reductions approved by the WQGIT in June 2014.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-1. Urban and Non-Urban Stream Restoration

General Information

New stream restoration techniques have been pioneered in the Chesapeake Bay watershed to restore streams in urban and non-urban settings. Approaches to stream restoration include natural channel design, regenerative stream channel and legacy sediment removal. Stream restoration projects require state and federal permits and thus extensive regulatory review. Projects often take multiple years from concept to construction, involving high costs and extensive effort from multiple stakeholders at the community, state and federal level. Note: This BMP reference sheet is not targeted to a particular sector. See Sheets A-9: Stream Restoration (Ag) and D-5: Urban Stream Restoration if interested in agricultural or developed sectors, respectively, though the information is the same.

Figure N-1-1. Stream restoration projects can improve the health of aquatic resources and can be one of the more cost-effective practices to reduce nutrient and sediment loads in urban watersheds. A stream in a residential area prior to restoration (top) that has an eroded stream bank and channel can be restored so that natural processes reduce the erosive energy of the stream flow during storm events. Small step pools and reconnecting the stream channel to the floodplain are two methods for restoring natural processes to a stream. The bottom picture is of the same stream three years after restoration. Photos: Arlington County (VA), Department of Environmental Services (https://projects.arlingtonva.us/projects/donaldson-run-stream-restoration-tributary-b/)

CBP Definition(s)

Natural Channel Design (NCD) applies the principles of stream geomorphology to maintain a state of dynamic equilibrium among water, sediment, and vegetation that creates a stable channel.

Legacy Sediment Removal (LSR) seeks to remove legacy sediments from the stream and its floodplain and thereby restore the natural potential of aquatic resources including a combination of streams, floodplains, and wetlands.

Regenerative Stream Channel (RSC, aka Regenerative Stormwater Conveyance) uses in-stream weirs in perennial streams to increase the interaction with the floodplain during smaller storm events. These projects may also include sand seepage wetlands and other habitats to increase the stream's connection with its floodplain. Only wet channel RSC practices are eligible as stream restoration projects. Dry channel RSC projects are considered a runoff reduction retrofit practice, which is not applicable to agricultural load sources (see Sheet D-2: Stormwater Retrofits).

Stream Restoration refers to any NCD, RSC, LSR or other restoration project that meets the qualifying conditions for credits, including environmental limitations and stream functional improvements.

Specifications or Key Qualifying Conditions

There are further protocol-specific qualifying criteria detailed in other resources listed under Additional Information below. All projects must meet the following criteria to be eligible for credit:

- Reach restored must be greater than 100ft in length.

- Reach restored must be actively enlarging or degrading.
- Reach restored MAY NOT be tidally influenced.
- The project MAY NOT be primarily designed to protect public infrastructure. Bank armoring and rip rap are not eligible for stream restoration credit.
- Restoration plan must utilize a comprehensive approach to stream restoration design, addressing long-term stability of the channel, banks, and floodplain.
- Must comply with all state and federal permitting requirements, including 404 and 401 permits.

Stream restoration is a carefully designed intervention to improve the hydrologic, hydraulic, geomorphic, water quality, and biological condition of degraded urban streams, and must not be implemented for the sole purpose of nutrient or sediment reduction. Restoration projects should be developed through a functional assessment process, such as the stream functions pyramid (Harman et al., 2012) or functional equivalent.

Figure N-1-2. A stream prior to restoration (top). The bottom picture is the same stream shortly after completion of the project. Photos: US Fish and Wildlife Service.

Nitrogen, Phosphorus and Sediment Reductions

There are three general protocols to define the pollutant load reductions from stream restoration practices. There is also a default rate for historic projects and new projects that cannot conform to the recommended reporting requirements.

- Protocol 1. Credit for prevented sediment during storm flow
- Protocol 2. Credit for in-stream nitrogen processing during base flow
- Protocol 3. Credit for reconnection to the floodplain

For details on how to use the protocols consult the resources listed under Additional Information.

Table N-1-1. Summary of stream restoration protocols for nitrogen, phosphorus, and sediment reductions.

Protocol	**TN (lbs/ linear ft/ year)**	**TP (lbs/ linear ft/ year)**	**TSS (lbs/ linear ft/ year)**
Protocol 1. Prevented sediment	Site-specific	Site-specific	Site-specific
Protocol 2. In-stream nitrogen processing	Site-specific	N/A	N/A
Protocol 3. Floodplain reconnection	Site-specific	Site-specific	Site-specific
Default for existing/non-conforming projects*	0.075	0.068	248**
*The existing/non-conforming rates were adjusted following a test drive period. These adjustments are explained in Appendix G of the expert panel report. **Because small stream loads are explicitly modeled in the Phase 6 tools, no sediment delivery factors are needed to reduce the default edge-of-field rate of 248 lbs of TSS/linear ft/year published by the panel.			

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Stream Bed and Bank

The practice can only be applied to the "Stream Bed and Bank" load source, but it is recommended to distinguish the BMP based on its sector using the appropriate secondary BMP designation of either "Urban Stream Restoration" or "Non-Urban Stream Restoration."

Brief Description of BMP Simulation in the Model

All stream restoration practices are *Load Reduction BMPs,* which means they are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment from the edge-of-stream load. To calculate the pounds reduced for each protocol, follow the methods and examples described in the panel report and other resources listed under Additional Information. The protocols are additive. So, a project that reduces 100 lbs TN under Protocol 1, 25 lbs TN under Protocol 2, and 30 lbs TN under Protocol 3 has a net reduction of 155 lbs TN. As another example, pretend the project design is unknown for a project planned to restore 1,000 linear feet of a degraded stream. Using the default rate for that project yields reductions of 7.5 lbs TN, 6.8 lbs TP and 24,800 lbs TSS, which would be removed from the edge-of-stream load in the Watershed Model. Load reduction BMPs such as stream restoration cannot remove more pounds of nitrogen, phosphorus or sediment than are available in a watershed, however. So, the Watershed Model does enforce maximum reductions that are described in Section 6.5.4.1 of the Watershed Model documentation.

Annual or Cumulative? Cumulative (5-year credit duration for urban stream restoration; 10-year credit duration for non-urban stream restoration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Urban Stream Restoration Protocol
    - Urban Stream Restoration
    - Non-Urban Stream Restoration Protocol
    - Non-Urban Stream Restoration
- *Measurement unit(s): Length restored (feet); Protocol 1 TN (lbs); Protocol 1 TP (lbs); Protocol 1 TSS (lbs); Protocol 2 TN (lbs); Protocol 3 TN (lbs); Protocol 3 TP (Lbs); Protocol 3 TSS (lbs)*
- *Load Source:* Stream Bed and Bank
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the project was completed.

Table N-1-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Stream Restoration (Urban)	Urban Stream Restoration Protocol*	natural channel design, legacy sediment removal, regenerative stream channel or regenerative stormwater conveyance (wet channel only)
Stream Restoration (Urban)	Urban Stream Restoration**	
Stream Restoration (Ag)	Non-Urban Stream Restoration Protocol*	
Stream Restoration (Ag)	Non-Urban Stream Restoration**	
* Uses protocols 1-3 summarized in Table N-1-1. Requires unit of feet in addition to the pounds reduced for each respective protocol. ** For use when specific project design is not known. Requires unit of feet.		

Additional Information

Expert panel report:

Berg, J., Burch, J., Cappuccitti, D., Filoso, S., Fraley-McNeal, L., Goerman, D., Hardman, N., Kaushal, S., Medina, D., Meyers, M., Kerr, B., Stewart, S., Sullivan, B., R. Walter & J. Winters. 2013. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. Prepared by T. Schueler, Chesapeake Stormwater Network, and B. Stack, Center for Watershed Protection. Test-drive revisions approved by the WQGIT September 8, 2014. https://www.chesapeakebay.net/documents/Stream_Panel_Report_Final_08282014_Appendices_A_G.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-4: Urban Stream Restoration. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network. BMP Resources, Urban Stream Restoration: http://chesapeakestormwater.net/bmp-resources/urban-stream-restoration/

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs & C. Miller. 2012. A function-based framework for developing stream assessments, restoration goals, performance standards and standard operating procedures. U.S. Environmental Protection Agency. Office of Wetlands, Oceans and Watersheds. Washington, D.C. EPA 843-K-12-006. https://www.epa.gov/sites/production/files/2015-08/documents/a_function_based_framework_for_stream_assessment_3.pdf

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This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in May 2013, with test-drive revisions approved in September 2014.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-2. Shoreline Management (Urban and Non-Urban)

General Information

There are a range of practices that can limit tidal shoreline erosion and protect property. Many states encourage practices that use natural habitats such as vegetation, sometimes with the addition of hard structures, to create living shorelines.

CBP Definition(s)

Shoreline management is any tidal shoreline practice that prevents and/or reduces tidal sediments to the Bay. Shoreline management practices can include living shorelines, revetments and/or breakwater systems, bulkheads and seawalls.

The particular definition varies by state, but for CBP purposes a *living shoreline* refers to a shoreline management practice or suite of stabilization and erosion control measures that preserve natural shoreline, minimize shoreline eorsion, maintains coastal processes and provides aquatic habitat. Living shoreline can be non-structural with only vegetated and natural elements, or hybrid with vegetation plus some hard structures such as stone sills or breakwaters.

(Urban or Non-Urban) Shoreline Erosion Control Non-Vegetated are shoreline management practices without a vegetated area along an urban- or agriculturally dominated tidal shoreline that prevent and/or reduces tidal sediments to the Bay.

(Urban or Non-Urban) Shoreline Erosion Control Vegetated are shoreline management practices with a vegetated area along an urban- or agriculturally dominated tidal shoreline that prevent and/or reduces tidal sediments to the Bay.

Specifications or Key Qualifying Conditions

These BMPs are only applicable along tidal shorelines. They should be implemented in areas with a demonstrated need to control erosion based on the jurisdiction's respective thresholds and qualifying conditions for shoreline management projects. Only projects with vegetated areas can receive credit for Protocols 2-4 of this BMP. Any shoreline practices implemented prior to 2008 are automatically credited in the model and should not be reported.

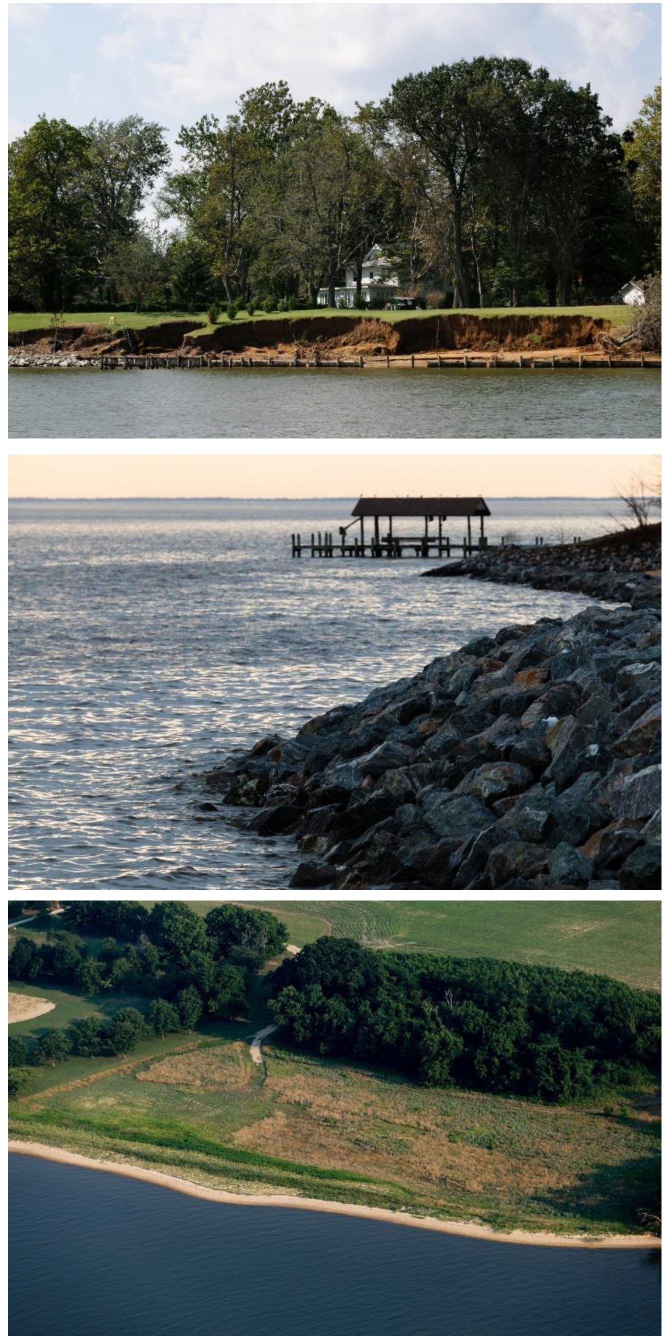

Figure N-2-1. Erosion is a natural process, but sometimes it is necessary to protect property from excessive erosion, like occurred (top) with Hurricane Isabel in 2003. Often the shoreline in or near developed areas is hardened – or "armored" – against erosion using bulkheads, revetments or riprap (middle). The use of softer approaches – such as the living shoreline (bottom) seen from the air – are becoming more common. Living shorelines protect against excessive erosion while providing ecological functions like habitat. Photos: Chesapeake Bay Program.

Nitrogen, Phosphorus and Sediment Reductions

There are four general protocols to define the pollutant load reductions from shoreline management practices. There is also a default rate for historic projects and new projects that cannot conform to the recommended reporting requirements.

- Protocol 1. Credit for prevented sediment
- Protocol 2. Denitrification in vegetated areas
- Protocol 3. Sedimentation in vegetated areas
- Protocol 4. Marsh redfield ratio for vegetated areas

Table N-2-1. Summary of protocols for nitrogen, phosphorus and sediment reductions of shoreline management BMPs.

Protocol		**TN (lbs. per unit)**	**TP (lbs. per unit)**	**TSS (lbs. per unit)**
Protocol 1. Prevented sediment	Linear feet	Project-specific	Project-specific	Project-specific
Protocol 2. Denitrification	Acres of re-vegetation	85	N/A	N/A
Protocol 3. Sedimentation	Acres of re-vegetation	N/A	5.289	6,959
Protocol 4. Marsh Redfield Ratio	Acres of re-vegetation	6.83	0.3	N/A
Non-conforming/existing practices	Linear feet	0.04756 / 0.01218*	0.03362 / 0.00861*	164 / 42 **

* Analysis by Modeling Workgroup indicated that an average of 0.00029 lbs. TN per lb. of TSS and 0.000205 lbs. TP per lb. of TSS. These values can be used directly by jurisdictions for their calculations in Protocol 1, and were adapted for non-conforming/existing practices by multiplying by the default TSS reduction for non-conforming projects by the average nutrient concentrations in sediment. The first number applies to MD, DE and DC (i.e., 0.04756 for TN and 0.03362 for TP) and the second number applies to VA.
** The default rate is based on fine sediment erosion estimates from the expert panel report (Table 3) and a 50% reduction factor applied. The first number applies to Maryland, Delaware and Washington, D.C., and the second number applies to Virginia.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Shoreline

The practice can only be applied to the "Shoreline" load source, but the BMP can be distinguished based on sector using the appropriate secondary BMP designation of either "Urban Shoreline Management" or "Non-Urban Shoreline Management."

Brief Description of BMP Simulation in the Model

All shoreline management practices are *Load Reduction BMPs,* which means they are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment. However, the shoreline load source is only at the edge-of-tide in the model. Therefore, the load reductions from shoreline management practices are removed at the edge-of-tide and not the edge-of-stream as is done for stream restoration.

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:* Shoreline Management
    - Urban Shoreline Management*
    - Urban Shoreline Erosion Control Vegetated**
    - Urban Shoreline Erosion Control Non-Vegetated
    - Non-Urban Shoreline Management*
    - Non-Urban Shoreline Erosion Control Vegetated**
    - Non-Urban Shoreline Erosion Control Non-Vegetated
- *Measurement unit(s): Length restored (feet); Acres planted**; Protocol 1 TN (lbs); Protocol 1 TP (lbs); Protocol 1 TSS (lbs)*
- *Load Source:* Shoreline
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the project was completed.

* These BMPs provide default load reductions based on length restored (feet) of shoreline, which can be used for non-conforming projects or planning purposes.
** These BMPs are for practices with some vegetated area, i.e. non-structural or hybrid living shoreline. Acres planted or the vegetated area is needed for load reductions based on Protocols 2-4. Eligible hybrid practices can also report reductions for Protocol 1.

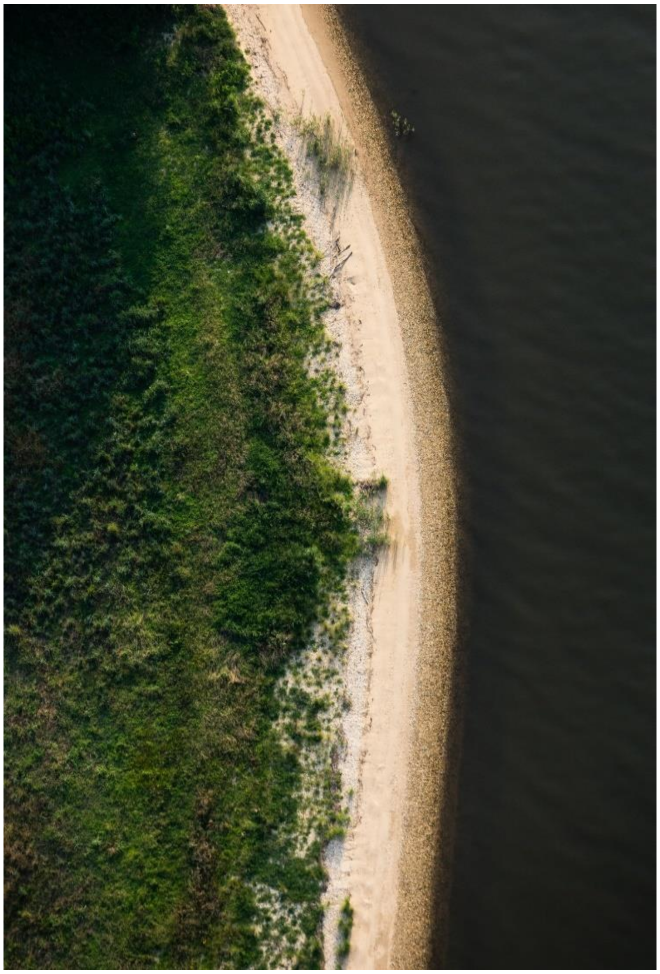

Figure N-2-2. Living shorelines can use a variety of natural design elements to create or restore vegetated areas to reduce shoreline erosion while protecting near-shore aquatic habitat important for young blue crabs and fish. Photo:

Table N-2-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Urban Shoreline Management*	Urban Shoreline Management	None
Urban Shoreline Erosion Control Non-Vegetated	Urban Shoreline Non-Vegetated	None
Urban Shoreline Erosion Control Vegetated	Urban Shoreline Vegetated	Living shoreline
Non-Urban Shoreline Management*	Ag Shoreline Management	None
Non-Urban Shoreline Erosion Control Non-Vegetated	Ag Shoreline Non-Vegetated	None
Non-Urban Shoreline Erosion Control Vegetated	Ag Shoreline Vegetated	Living shoreline
* Default BMPs for planning purposes or for non-conforming existing practices.		

Additional Information

Expert panel report:

Forand, F., DuBois, K., Halka, J., Hardaway, S., Janek, G., Karrh, L., Koch, E., Linker, L., Mason, P., Morgereth, E., Proctor, D., Smith, K., Stack, B., Stewart, S. & B. Wolinski. 2015. Recommendations of the Expert Panel to Define Removal Rates for Shoreline Management Projects. Prepared by S. Drescher and B. Stack, Center for Watershed Protection. Approved by the WQGIT July 13, 2015, with revised credits approved June 26, 2017. Amended November 2019.
https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Final_Shoreline-Management_RPT__APPENDICES_12-18-19.pdf

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All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-3. Algal Flow-way Technologies

Figure N-3-1. Looking down the Maryland Port's Algal Turf Scrubber flow-way – the 2014 winner for the Most Innovative BMP in the Bay Award. Source: Chesapeake Stormwater Network.

General Information

In the Chesapeake Bay's tidal waters, the growth of algae is fueled by excess nutrients and the death of algae can deplete waters of oxygen and negatively impact aquatic life. In controlled circumstances, the growth of algae can be used as an innovative approach to remove nutrients and sediment from waterways while disposing of the algae, or possibly using it to generate biofuel.

CBP Definition(s)

Algal Flow-way Technologies (AFTs) are systems designed to grow and harvest algal in a controlled environment with the end purpose of improving water quality. The process works by using a continuous flow of nutrient-laden water over an inclined raceway structure to provide water coverage and produce algal growth over the entire surface area. The process must continue throughout the entire growing season (at least 240 days per year) to be eligible for credit. The natural algal assemblages that accumulate must be harvested, properly stored in a manner that prevents nutrient runoff, and have an end use such that algal nutrients are not applied onsite unless applications are made under a qualifying nutrient management plan.

Non-tidal Ambient Waters AFT: Any AFT designed to provide treatment of continuously, ambient, nontidal surface waters including perennial ponds, lakes, reservoirs, wetlands, streams and rivers.

Tidal Ambient Waters AFT: Any AFT designed to provide treatment of continuously flowing, ambient, tidal waters.

Specifications or Key Qualifying Conditions

There are further protocol-specific qualifying criteria detailed in the expert panel report, listed under Additional Information below. All projects must have the following criteria to be eligible for credit:

- a continuous flow (subject to normal maintenance and harvesting activities) of nutrient-laden water over an inclined raceway structure that provides water coverage and algal growth over the entire surface area*
- adequate shade-free light for photosynthesis throughout the growing season
- a harvesting process for the algae
- proper storage of harvested biomass to eliminate runoff of nutrients from the site year-round
- an end use for harvested algae (algal nutrients must not be applied onsite unless applications are made under a qualifying nutrient management plan)
- an operating system for the duration of the growing season (most commonly 240 days throughout the Chesapeake Bay watershed); if it is less than 240 days, operators cannot claim a default credit and must report more detailed biomass harvest information.

*For a range of typical algal production based on various flow rates, see Kangas and Mulbry, 2014; Figure B1 in Appendix B of the expert panel report.

Nitrogen, Phosphorus and Sediment Reductions

To qualify for nutrient and sediment reduction credit, jurisdictions have the option to submit results from nutrient concentration analyses or inorganic dry weight ash concentration analysis of biomass produced by an AFT project, along with the dry algal weight of biomass produced. This would result in a more accurate accounting of nutrients removed by these systems. A more detailed description of the submittal procedures and credit calculations can be found in Section 5 of the expert panel report (see Additional Information below). These procedures are considered sufficient to apply to multiple variants of the AFTs. Consult the expert panel report for the equations used to calculate the annual nutrient and sediment removal.

For planning scenarios and for those operations or jurisdictions that do not have access to regularly sampled algal production weights and nutrient concentration analyses of algae produced, a jurisdiction may claim a default reduction value based upon conservative algal production and nutrient concentration estimates of systems in operation around the Chesapeake Bay Watershed.

The default nutrient and sediment reductions are outlined in Table N-3-1.

Table N-3-1. Default Nutrient and Sediment Reductions Associated with Algal Flow Way Technology BMPs.

Practice	TSS Removal (lbs)	TN Removal (lbs)	TP Removal (lbs)
Algal Flow-way Technologies (AFTs)	3,219	545	45

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Stream Bed and Bank
- Shoreline

All urban and agricultural land use categories are eligible to receive nutrient and sediment reduction credit from AFT BMPs. The assumption will be that all non-tidal AFTs treat runoff from urban land uses unless otherwise specified by the state. The assumption will be that all tidal AFTs treat tidal water and thus can reduce loads from all land uses adjacent to the tidal water.

Brief Description of BMP Simulation in the Model

All algal flow-way practices are *Load Reduction BMPs.* The modeling tools estimate the load reductions differently depending on whether the AFT is tidal or non-tidal. Non-tidal AFTs are treated similarly to stream restoration BMPs in the Phase 5.3.2 Model in that the practices treat runoff that has already filtered through upstream BMPs. The model mimics this upland treatment by simulating non-tidal AFT practices at a watershed outlet. The pounds reduced for each pollutant will be added together and applied as a reduction at the watershed outlet for each model segment. The model simulates further reductions to nutrients between the watershed outlet and the Chesapeake Bay.

Tidal AFTs are treated similarly to shoreline erosion control BMPs in the Phase 5.3.2 Watershed Model. The Watershed Model domain ends at the tidal shoreline, and shoreline erosion loads are actually simulated by the estuarine Water Quality Sediment Transport Model (WQSTM). However, the Watershed Model is the accounting tool used to credit reductions to nutrients and sediments delivered to the Bay by all best management practices. For this reason, the WTWG recommended that reductions from tidal AFTs be counted as reductions in delivered nutrients and sediment from each Watershed Model land-river segment within which the practices are implemented. This will have an identical effect to reducing the nutrient and sediment loads within the WQSTM but will allow the practices to remain within the accounting and crediting framework.

Annual or Cumulative? Annual (1-year credit duration)

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - AFT (either tidal or non-tidal)
- *Measurement unit(s):*
    - To receive default credits: Total number of acres of AFT install
    - To receive direct sampling credit: Mass of annual TN, TP, and sediment collected each year

- *Load Source:*
    - Tidal – N/A; this BMP will be simulated adjacent to or within surface waters.
    - Non-tidal – the default will be UrbanwithCSS, but jurisdictions may report more specific land use groups if appropriate.
- *Geographic location:* Approved NEIEN geographies: Latitude/Longitude (preferred); County; County (CBWS Only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4), State (CBWS Only)
- *Date of implementation:* Date of sampling (for monitored direct sampling).

If reported in this manner, jurisdictions reporting default credits will receive reductions of 545 lbs TN/acre/year, 45 lbs TP/acre/year, and 3,219 lbs sediment/acre/year. Jurisdictions reporting direct sampling credits should use the procedures and equations in Section 5 of the expert panel report to calculate the annual mass of TN, TP, and sediment collected.

Table N-3-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Algal Flow-way Technologies (AFTs)	Algal Flow-way Technologies (AFTs)	May be referred to by proprietary trade names such as algal turf scrubbers®

Additional Information

Expert panel report:

Bott, C., Brush, M., Canuel, E., Johnston, M., Kangas, P., Lane, S., May, P., Mulbry, W., Mulholland, M., Sample, D., Sellner, K., & Stephenson, K. 2015. Nutrient and Sediment Reductions from Algal Flow-way Technologies: Recommendations to the Chesapeake Bay Program's Water Quality Goal Implementation Team from the Algal Flow-way Technologies BMP Expert Panel. https://www.chesapeakebay.net/documents/AFT_Report_Final_Approved.pdf

Chesapeake Stormwater Network, Archived (2016) webcast: Algal Flo-way Technologies: https://chesapeakestormwater.net/events/webcast-algal-flow-way-technologies/

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All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-4. Forest Harvesting Practices

General Information

Forest management activities – such as road, trail, and land construction and use; harvesting and log removal activities; and site preparation or within-rotation treatments – can contribute to sediment and nutrient pollution in water bodies. Forest harvesting practices are a group of practices that help improve water quality by reducing the sediment and nutrient pollution in runoff that is associated with forest management.

Figure N-4-1. NRCS Practice Code 384: Forest Slash Treatment – a practice that reduces or otherwise addresses woody plant residues created during forestry, agroforestry, and horticultural activities to achieve management objectives. Source: NRCS (https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_026619.doc)

CBP Definition(s)

Forest Harvesting Practices are a suite of BMPs that minimize the environmental impacts of road building, log removal, site preparation and forest management. These practices help reduce suspended sediments and associated nutrients that can result from forest operations.

Specifications or Key Qualifying Conditions

For more details on specifications and key qualifying conditions of this BMP, consult the criteria standards under the USDA-NRCS National Handbook of Conservation Practices and associated Field Office and Technical Guides for each state (see Additional Information below).

BMPs associated with the Forest Harvesting Practices include, but are not limited to, the following USDA-HRCS conservation practices:

- Forest Trails and Landings (655)
- Forest Slash Treatment (384)

Nitrogen, Phosphorus and Sediment Reductions

The nutrient and sediment effectiveness estimates for forest harvesting practices are displayed in Table N-4-1.

Table N-4-1. Nutrient and Sediment Effectiveness Estimates for Forest Harvesting Practices.

BMP Practice	TN (%)	TP (%)	TSS (%)
Forest Harvesting Practices	50	60	60

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Harvested Forest

Brief Description of BMP Simulation in the Model

All forest harvesting practices are *Efficiency BMPs.* Runoff from applicable load sources is reduced by the efficiency values listed in Table N-8-1 for nitrogen, phosphorus, and sediment.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? This is the only BMP for this load source.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Forest Harvesting Practices
- *Measurement unit(s):* Acres.
- *Load Source:* Harvested Forest
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Date of implementation.

Table N-4-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Forested Harvesting Practices	Forest Harvesting Practices	Forest Trails and Landings, Forest Slash Treatment.

Additional Information

USDA-NRCS National Handbook of Conservation Practices (NHCP):
http://www.nrcs.usda.gov/technical/standards/nhcp.html

Locate and consult your state and county USDA Field Office Technical Guide (FOTG) for details on conservation practices:
http://www.nrcs.usda.gov/technical/efotg/

T. Simpson and S. Weammert (Lane). 2009. Forest Harvesting Practices. Definition and Nutrient and Sediment Reduction Effectiveness Estimates. T. Simpson and S. Weammert (Lane), eds. Final Report, December 2009. Pages 300-342. https://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

Version and History Statement

This info sheet was first published on November 14, 2022 and reflects the BMP definitions and reductions developed through Simpson and Weammert (Lane) and approved by the WQGIT in 2009.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-5. Abandoned Mine Reclamation

General Information

Coal mining within the Chesapeake Bay watershed, before the Surface Mining Control and Reclamation Act (SMCRA) of 1977 was passed, has resulted in lasting adverse environmental impacts. Abandoned mine lands can contaminant groundwater and have toxic impacts on water quality of nearby streams, wildlife, and human health. Re-establishing forest on mine lands, a practice known as abandoned mine reclamation (AMR), can improve water quality and enhance stream habitat for many aquatic species.

Figure N-5-1. A strip-mining operation is seen above Shamokin Creek, a tributary of the Susquehanna River, in Shamokin, Pa., on Sept. 17, 2019. Photo by: Will Parson, Chesapeake Bay Program. Source: [https://flic.kr/p/2kyE7xT.](https://flic.kr/p/2kyE7xT)

CBP Definition(s)

Abandoned mine reclamation (AMR) is the planting of forests to stabilize the soil on lands mined for coal or affected by mining, such as wastebanks, coal processing, or other coal mining processes. Enter units of acre or percent.

Specifications or Key Qualifying Conditions

There are no key qualifying conditions for abandoned mine reclamation.

Nitrogen, Phosphorus and Sediment Reductions

The abandoned mine reclamation BMP converts land from a higher loading land use (Mixed Open) to a lower loading land use (Forest). The specific loading rate varies by year.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Mixed Open

Brief Description of BMP Simulation in the Model

Abandoned mine reclamation is a *Load Source Change BMP.* Each acre reported under this BMP gets converted from Mixed Open load source into True Forest.

Annual or Cumulative? Cumulative (10-year credit duration).

Can this practice be combined with other BMPs? No. An area converted to the Forest load source by this BMP is no longer eligible for application of other BMPs.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:* Abandoned Mine Reclamation.
- *Measurement unit(s):* acres.
- *Load Source:* Mixed open.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Year the project was completed.

Table N-5-1. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Abandoned Mine Reclamation (AMR)	Land Reclamation, Abandoned Mined Land	None.

Additional Information

U.S. Dept of Interior, Natural Resource Revenue Data. Abandoned Mine Land Reclamation Program: https://revenuedata.doi.gov/how-revenue-works/aml-reclamation-program/

Pennsylvania Department of Environmental Protection (PA DEP)'s AML Fact Sheet: Pennsylvania's Surface Mining Control and Reclamation Act (SMCRA) Funded Abandoned Mine Lands Program: Past, Present, and Future. https://files.dep.state.pa.us/Mining/Abandoned%20Mine%20Reclamation/AbandonedMinePortalFiles/AML_Fact_Sheet_Final_2019_03_11.pdf

PA DEP, Frequently Asked Questions (FAQ) about the SMCRA Funded Abandoned Mine Land Program: https://files.dep.state.pa.us/Mining/Abandoned%20Mine%20Reclamation/AbandonedMinePortalFiles/SMCRA_Funded_AML_Program_FAQ.pdf

PA DEP, Abandoned Mine Land Related Technical Papers: https://www.dep.pa.gov/Business/Land/Mining/AbandonedMineReclamation/Publications-Links-Other-Resources/Pages/AML-Related-Technical-Papers.aspx

West Virginia Department of Environmental Protection (WV DEP). Abandoned Mines and Reclamation: https://dep.wv.gov/dlr/aml/Pages/default.aspx

Water Quality Goal Implementation Team (WQGIT) Meeting Minutes. May 9, 2016. https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/wqgit_meeting_minutes_5_9_16.pdf

Version and History Statement

This info sheet was first published on November 16, 2022 and reflects the BMP definitions and benefits that have remained in use since review and approval by the CBP partnership's source sector workgroups for tributary strategy development and most recently affirmed by the WQGIT in May 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-6. Oyster Aquaculture Practices

General Information

Oysters can improve water quality by removing nitrogen and phosphorus from the water column. Oysters consume algae and other organic matter through filter feeding, a process by which nutrients are absorbed into the oyster's tissue and shell. When oysters are removed from the water column, the nutrients stored in their shells and tissue are removed as well.

There are various ways to establish oyster populations in the Chesapeake Bay, including private oyster aquaculture, public fisheries, and oyster reef restoration. This reference sheet will only cover BMPs associated with private oyster aquaculture. Specifically, three aquaculture methods: off-bottom using hatchery produced oysters, on-bottom using hatchery produced oysters, and on-bottom using substrate addition.

Figure N-6-1. Oystering in the Upper Tangier Sound on the Delmarva Peninsula. Source: Steve Droter, Chesapeake Bay Program. https://flic.kr/p/bQCqmK

CBP Definition(s)

Oyster Aquaculture: Private oyster aquaculture that is on- or off-bottom using hatchery-produced oysters or on-bottom using substrate addition.

Diploid Oyster: Wild or hatchery-produced oysters containing two complete sets of chromosomes, one from each parent and capable of sexual reproduction.

Triploid Oyster: Hatchery-produced oysters containing three sets of chromosomes, typically a result of hybridizing a diploid oyster with a tetraploid oyster (4-set chromosome individual) via human manipulation. The resulting triploid oyster lacks reproduction capabilities.

Site-specific Monitored Oyster Aquaculture: Private oyster aquaculture that is on- or off-bottom using hatchery-produced oysters or on-bottom using substrate addition. When reporting this practice to receive credit, report the finishing location if moved when shell < 2 inches; otherwise report the initial location. Operators must provide the state with the average tissue dry weight of subsample of 50 oysters per oyster size class category within two seasons that are at least six months apart. These dry tissue estimates can then be multiplied by a default nitrogen content of 8.2% and a default phosphorus content of 0.9%, and averaged to determine the total nutrients reduced by the harvested oysters. Enter units of number of oysters harvested and the pounds of Total Nitrogen (TN) and Total Phosphorus (TP).

Off-bottom private oyster aquaculture using hatchery produced oysters: Hatchery-produced diploid or triploid oysters grown off the bottom in the water column using some sort of gear (e.g., floating rafts near the surface or cages near the bottom) in an area designated for oyster aquaculture where public fishing is not allowed (e.g., State-permitted oyster aquaculture leases to oyster aqua-culturists) for eventual removal from the water.

On-bottom private oyster aquaculture using hatchery produced oysters: Hatchery-produced diploid or triploid oysters (e.g., spat-on-shell) grown directly on bottom using no gear in an area designated for oyster aquaculture where public fishing is not allowed (e.g., State-permitted oyster aquaculture leases to oyster aqua-culturists) for eventual removal from the water.

On-bottom private oyster aquaculture using substrate addition: Placing oyster shell or alternative hard substrate, such as granite, to the bottom sediment surface to attract recruitment of wild (diploid) oysters in an area designated for oyster aquaculture where public fishing is not allowed (e.g., State-permitted oyster aquaculture leases to private oyster aqua-culturists) for eventual removal from the water.

Specifications or Key Qualifying Conditions

To be eligible for credit, practices must include the following criteria (the qualifying conditions described below apply to both the default and site-specific estimates):

- Only includes oysters that are removed from the water after the BMP is approved/implemented for the TMDL reduction effectiveness credit.
- Oysters had to have been grown from initial sizes < 2.0 inches shell height.
- Oysters must be alive when removed to count toward reduction effectiveness.

Figure N-6-2. Oyster planting on the Tred Avon River in Talbot County, Maryland. Source: Ethan Weston, Chesapeake Bay Program. https://flic.kr/p/2m9G71h

Nitrogen, Phosphorus and Sediment Reductions

Private oyster aquaculture BMPs receive reduction credits based upon the average size and type of oyster harvested at an operation. Table N-6-1 provides the BMP names and lbs of nutrient reduction related to maximum size and type of oysters harvested. If the type or average size is not known, then the diploid estimate will be used based on the State's minimum legal harvest size.

Table N-6-1. Nutrient Reductions per 1,000,000 Oysters Harvested by BMP.

BMP Name	N reduced (lbs/1,000,000 oysters harvested)	P reduced (lbs/1,000,000 oysters harvested)
Diploid Oyster Aquaculture 2.25 inches	110	22
Diploid Oyster Aquaculture 3.0 inches	198	22
Diploid Oyster Aquaculture 4.0 inches	331	44
Diploid Oyster Aquaculture 5.0 inches	485	44
Diploid Oyster Aquaculture ≥ 5.0 inches	683	66
Triploid Oyster Aquaculture 2.25 inches	132	22
Triploid Oyster Aquaculture 3.0 inches	287	22
Triploid Oyster Aquaculture 4.0 inches	573	66
Triploid Oyster Aquaculture 5.0 inches	970	110
Triploid Oyster Aquaculture ≥ 5.0 inches	1,477	154
Site-specific Monitored Oyster Aquaculture	NA	NA

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Shoreline

Brief Description of BMP Simulation in the Model

All oyster harvesting practices are *Load Reduction BMPs,* meaning they are modeled as a simple removal of pounds of nitrogen and phosphorus. The reductions from this practice will be credited towards the nutrient loads at the nearest shoreline segments to the practice location. If latitude and longitude are not submitted, then the practice benefits will be distributed amongst all shoreline segments in the geography submitted.

Annual or Cumulative? Annual (1-year credit duration).

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Select from column "BMP Name" in Table N-6-1 above.
- *Measurement unit(s):* Oysters harvested.
    - For site-specific monitored oyster aquaculture: Lbs TN; Lbs TP
- *Load Source:* Shoreline.
- *Geographic location:* Approved NEIEN geographies: Latitude, Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year oysters were harvested.

Table N-5-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Diploid Oyster Aquaculture Triploid Oyster Aquaculture	Diploid Oyster Aquaculture 2.25, 3.0, 4.0, 5.0, >5.0 inch Triploid Oyster Aquaculture 2.25, 3.0, 4.0, 5.0, > 5.0 inch	None
Site Specific Monitoring Oyster Aquaculture	Site specific monitoring oyster aquaculture	None

Additional Information

Expert panel report:

Cornwell, J., Rose, J., Kellogg, L., Luckenbach, M., Bricker, S., Paynter, K., Moore, C., Parker, M., Sanford, L., Wolinski, B., Lacatell, A., Fegley, L., & K. Hudson. 2016. Panel Recommendations on the Oyster BMP Nutrient and Suspended Sediment Reduction Effectiveness Determination Decision Framework and Nitrogen and Phosphorus Assimilation in Oyster Tissue Reduction Effectiveness for Oyster Aquaculture Practice. Prepared by J. Reichert-Nguyen, E. French, and W. Slacum, Oyster Recovery Partnership. Approved by the WQGIT in coordination with the Fisheries and Habitat GITs: December 19, 2016. https://www.chesapeakebay.net/documents/Oyster_BMP_1st_Report_Final_Approved_2016-12-19.pdf

Version and History Statement

This info sheet was first published on November 16, 2022 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-7. Licensed Oyster Harvest

General Information

Oysters can improve water quality by removing nitrogen and phosphorus from the water column. Oysters consume algae and other organic matter through filter feeding, a process by which nutrients are absorbed into the oyster's tissue and shell. When oysters are removed from the water column, the nutrients stored in their shells and tissue are removed as well.

Figure N-7-1. Butch Walters of Deal Island, Md., harvests oysters using a power dredge in the waters north of Deal Island, Md., on March 31, 2017. Source: Will Parson/Chesapeake Bay Program. https://flic.kr/p/25aGqCZ

There are various ways to establish oyster populations in the Chesapeake Bay, including private oyster aquaculture, enhancing areas open to commercial fishing and oyster reef restoration. This BMP sheet focuses specifically on licensed oyster harvest. While this practice is similar to private oyster aquaculture (see BMP Sheet N-6), the fundamental difference is that licensed oyster harvest only applies to areas where hatchery produced oysters are planted in public harvest areas. Because this practice occurs in public areas where activities are implemented by a larger group of people, additional verification requirements will be needed to ensure the practices are functioning as intended.

CBP Definition(s)

Licensed Oyster Harvest: Planting oysters (e.g., spat-on-shell, single oysters) produced from hatchery techniques directly on the bottom to enhance the stock in State-designated fishing areas (e.g., public shellfish fishing grounds) for eventual removal (harvest) from the water by individuals holding the proper licenses.

Specifications or Key Qualifying Conditions

For harvest assimilation practices to be eligible for credit, practices must include the following criteria. The qualifying conditions described below apply to both the default and site-specific estimates. The subchapters cited below refer to the corresponding information in the Expert Panel report.

- A qualifying enhancement activity using hatchery-produced oysters (Subchapter 6.2.2) must have occurred throughout the BMP site area (Subchapter 6.2.1).
- The BMP site area must lie within an area open to licensed oyster harvest (Subchapter 6.2.2).
- At the time of planting, the shell height of hatchery-produced oysters must be <2.0 inches (<50.8mm; Subchapter 6.2.2).
- At the time of harvest, all oysters must be live (Subchapter 6.2.2), of legal harvest size (Subchapter 6.2.5.1) and harvested from within the BMP site (Subchapter 6.2.1).
- All oysters must be harvested within the harvest crediting timeframe (Subchapter 6.2.4). Credit can be received annually for oysters harvested 2-5 years after the enhancement activity. Only up to 3% of planted hatchery produced oysters are eligible for credit when harvested.

Nitrogen, Phosphorus and Sediment Reductions

For harvest assimilation practices, there are two options for determining the amount of nitrogen and phosphorus reduction available for credit: the default approach or the site-specific approach. The default estimates for nitrogen and phosphorus assimilation represent typical conditions across the entire Bay and the entire suite of environmental conditions that influence oyster growth. In contrast, site-specific estimates represent the nitrogen and phosphorus contained in the tissue of oysters at a single BMP site. Site-specific estimates can potentially be higher than the default estimate but require collection of considerably more data from the BMP site. To calculate the total nitrogen (TN) and phosphorus (TP) reductions, the Expert Panel recommends the following:

- Step 1. Identify the BMP site location and determine the BMP site area.
- Step 2. Document the qualifying enhancement activity and the date it occurred.
- Step 3. Determine the maximum harvest allowance using either the default (3%) or an approved site-specific survival rate.
- Step 4. Determine the harvest crediting timeframe.
- Step 5. Determine the TN and TP harvested from the BMP site during the harvest crediting timeframe based on the numbers and sizes of oyster harvested and either the default (Table N-7-1) or an approved site-specific estimate of tissue nutrient contents per oyster.

Table N-7-1. Default nutrient reductions in pounds per one million harvested hatchery-produced oysters. Oyster size class based on shell height measurements.

BMP Name	Oyster size class (inches)	N reduced (lbs/1,000,000 oysters harvested)	P reduced (lbs/1,000,000 oysters harvested)
Diploid Licensed Oyster Harvest, Hatchery Produced 3.0 inches	3.00 – 3.49*	198	22
Diploid Licensed Oyster Harvest, Hatchery Produced 4.0 inches	3.50 – 4.49*	331	44
Diploid Licensed Oyster Harvest, Hatchery Produced 5.0 inches	4.50 – 5.49*	485	44
Diploid Licensed Oyster Harvest, Hatchery Produced >5.0 inches	≥5.50**	683	66
*adjusted from 2.50 – 3.59. See Section 6.5 in Expert Panel (linked below) for details. **based on a midpoint of 6.0 inches.			

To establish site-specific tissue nutrient contents, the Panel recommends the implementer work with the reporting jurisdiction, CBP Partnership, and expert(s) in oyster sampling and sample processing to:

- Define specific oyster size classes if they differ from the size classes used for default tissue nutrient contents.
- Identify at least two evenly distributed sampling periods to ensure sampling reflects seasonal differences within the allowed harvesting timeframe set by state regulations.
- Assess the average tissue dry weight for each size class based on 50 randomly selected oysters per size class and sampling period. Oyster samples must be processed at a lab that uses standardized methods to acquire the tissue dry weight in grams (e.g., tissue heated at 60°C until samples reach constant weight; Mo & Neilson 1994, Carmichael et al. 2012).
- Multiply the average tissue dry weight for each size class by the default nitrogen percentage (8.2%) and phosphorus percentage (0.9%) in oyster tissue to determine the site-specific nitrogen and phosphorus content per oyster.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Shoreline

Brief Description of BMP Simulation in the Model

These oyster practices are *Load Reduction BMPs,* meaning they are modeled as a simple removal of pounds of nitrogen and phosphorus. The Phase 6 Model estimates nutrient loads in shoreline segments that can be reduced by shoreline and tidal water practices. Credit for the pounds of nutrients reduced by licensed oyster harvest and oyster restoration practices will go to the shoreline segments closest to the harvest location. If geographic coordinates are not submitted, then the credit will be distributed amongst all shoreline segments in the reported geographic area.

Annual or Cumulative? Annual (1-year credit duration). Credit can be received annually for oysters harvested 2-5 years after the enhancement activity. Only up to 3% of planted hatchery produced oysters are eligible for credit when harvested.

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Select from column "BMP Name" in Table N-7-1 above.
- *Measurement unit(s):* Oysters harvested (or millions of oysters harvested, unit = count. Both measurements are available in NEIEN).
    - For site-specific licensed oyster harvest: Lbs TN; Lbs TP
- *Load Source:* Shoreline.
- *Geographic location:* Approved NEIEN geographies: Latitude, Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Date eligible oysters were harvested.

Table N-7-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Diploid Licensed Oyster Harvest	Diploid Licensed Oyster Harvest, Hatchery Produced 3.0, 4.0, 5.0, or > 5.0 inches	None.

Additional Information

Expert panel report:

Cornwell, J., S. Bricker, A. Lacatell, M. Luckenbach, F. Marenghi, C. Moore, M. Parker, K. Paynter, J. Rose, L. Sanford, W. Wolinski, O.N. Caretti, J. Reichert-Nguyen, & H.W. Slacum. 2023. Nitrogen and phosphorus reduction associated with harvest of hatchery-produced oysters and reef restoration: Assimilation and enhanced denitrification: Panel recommendations. Report submitted to the Chesapeake Bay Program Partnership Water Quality Goal Implementation Team January 27, 2023. Approved by the WQGIT June 26, 2023. https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Oyster-BMP-Second-Report_Approved_with_Minutes.pdf

Oyster BMP Expert Panel Recommendations Roll-out Webinar Part 2: Oyster Assimilation Protocols. https://www.chesapeakebay.net/what/event/oyster-bmp-expert-panel-recommendation-roll-out-webinar-part-2-oyster-assimilation-protocol

Technical Appendix (approved by the WTWG in May 2023): https://d18lev1ok5leia.cloudfront.net/chesapeakebay/Oyster-BMP-Expert-Panel-Second-Report_Technical-Appendix_3May2023.pdf

Carmichael RH, Walton W, Clark H, (2012) Bivalve-enhanced nitrogen removal from coastal estuaries. Can J Fish Aquat Sci 69:1131–1149.

Mo C, Neilson B (1994). Standardization of oyster soft tissue dry weight measurements. Water Resources 28: 243-246.

Version and History Statement

This info sheet was first published on April 3, 2024 and reflects the BMP definitions and reductions approved by the WQGIT in June 2023.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-8. Oyster Reef Restoration

General Information

Oysters can improve water quality by removing nitrogen and phosphorus from the water column through a filtering process. As oysters consume algae and other organic matter, nutrients are absorbed into their tissues and shells. Within oyster reefs, oyster-associated microbial communities remove nutrients through a biogeochemical processes. In addition to improving water quality, oysters also provide habitat for fish, crabs and other living resources.

Figure N-8-1. The Chesapeake Bay Foundation's Maryland Oyster Restoration Center is seen in Shady Side, Md., on June 6, 2015. Source: Will Parson/Chesapeake Bay Program. https://flic.kr/p/QJTvxM.

Oyster populations in the Chesapeake Bay have degraded due to overfishing, disease and poor water quality. To address this, restoration techniques are used to enhance their habitat and filtering capabilities and create self-sustaining oyster populations. This reference sheet will only cover oyster BMPs associated with restoration.

CBP Definition(s)

Oyster Reef Restoration Nutrient Assimilation: The estimated assimilation of nitrogen and phosphorus in live oyster tissue and shell that is gained through the restoration of oyster reefs in tidal areas of the Chesapeake Bay or its tributaries.

Oyster Reef Restoration Enhanced Denitrification: The estimated positive net increase in overall microbial denitrification associated with the restoration of oyster reefs in tidal areas of the Chesapeake Bay or its tributaries.

Figure N-8-2. From left, Sean Corson, Acting Director of the NOAA Chesapeake Bay Office, Rep. Bobby Scott of Virginia's third congressional district, congressional aide Ryan Jackson, Virginia Sec. of Natural Resources Molly Ward, and Phil Stedfast of the Elizabeth River Project board of directors dump baby oysters overboard while Jackie Shannon, right, of Chesapeake Bay Foundation, watches at the site of a restored reef on the Lafayette River during an event celebrating the tributary's restoration in Norfolk, Va. Source: Will Parson/Chesapeake Bay Program. https://flic.kr/p/YKHdhD

Specifications or Key Qualifying Conditions

For restoration assimilation practices, the following criteria must be met to be considered eligible for credit. The subchapters cited below refer to the corresponding information in the Expert Panel report.

- *A qualifying enhancement activity (Subchapter 7.2.2) using hatchery produced oysters and/or substrate addition must have occurred throughout the BMP site area (Subchapter 7.2.1).
- *BMP site must lie within an area protected from harvest.
- At the time of planting, the shell height of any hatchery-produced oysters should be <1.0 inch (<25.4mm; Subchapter 7.2.2).
- *Baseline oyster biomass must be determined using an appropriate approach and adhere to baseline conditions (Subchapter 7.2.4)
  - For projects using the representative site approach for determining baseline oyster biomass (Subchapter 7.2.4):

        - The representative site must be within the same basin as the BMP site and be representative of conditions at the BMP site before restoration occurred.
        - Data from a non-restored representative site must be collected within the same year and season as the first post-restoration biomass measurement at the BMP site.
    - For projects using the pre-restoration approach for determining baseline oyster biomass (Subchapter 7.2.4):
        - Pre-restoration biomass data must have been collected within two years prior to the start of restoration.
        - For baseline surveys using the pre-restoration approach and for all post-restoration surveys, all data used to estimate oyster biomass must be collected from within the BMP site.
- *All biomass estimates (Subchapter 7.2.5) must:
    - *Be based on field surveys of live *Crassostrea virginica*
    - *Be based on data collected using a survey design that ensures estimates are representative of the entire BMP site.
    - *Include enough data points to allow calculation of mean biomass and its variance. If multiple strata are included in the sampling design, data must be sufficient to calculate means and variances for all strata.
    - Be collected within 12 months prior to application for crediting.
- Biomass must be extrapolated appropriately to the scale of the BMP site (Subchapter 7.2.6).
- Only nutrients associated with eligible appreciated biomass (Subchapter 7.2.7) may be credited.

For restoration denitrification practices, most of the qualifying criteria is identical to the restoration assimilation protocols (see above). Along with the starred criteria above, the following protocols must be met to be considered eligible for credit:

- If using the default approach to estimating enhanced denitrification, the reef must be in a subtidal habitat and restoration activities must have utilized only small substrates (Subchapter 8.2.2)
- Only live oyster tissue biomass is eligible for credit.
- The post-restoration oyster tissue biomass must be greater than the baseline oyster tissue biomass.

Nitrogen, Phosphorus and Sediment Reductions

For restoration assimilation practices, calculating the nutrient reductions requires the baseline oyster tissue and shell biomass per unit area, post-restoration oyster tissue and shell biomass per unit area, and the BMP site area. To calculate the total nitrogen (TN) and phosphorus (TP) reductions, the Expert Panel recommends the following:

- Step 1: Identify the BMP site location and determine the BMP site area.
- Step 2: Document the qualifying enhancement activity and its date, the type(s) of substrate used for restoration, and the baseline approach.
- Step 3: Assess baseline and post-restoration tissue and shell biomass and extrapolate it to determine total tissue and shell biomass estimates for the BMP site.
- Step 4: Determine the eligible appreciated tissue and shell biomass at the BMP site.
- Step 5: Convert eligible appreciated tissue and shell biomass to total nitrogen and phosphorus removed.

An implementer would receive reduction credit for nutrient assimilation practices if oyster tissue and/or shell biomass increased above the previously credited oyster tissue and/or shell biomass after the creation of the TMDL in 2009.

There are no bay-wide default estimates for restoration assimilation practices. If the baseline is not known, no credit will be given for these practices. However, for small substrates the Expert Panel does provide a regression-based approach to simplify calculation of estimates for applicable projects. In addition, if the baseline is not known, the oyster restoration-assimilation BMP can be used in a planning scenario within CAST based on the planned areas of restoration activity.

Enhanced Nitrogen Removal (lbs acre^{-1} yr^{-1})	Post-restoration Oyster Biomass Range (g DW m^{-2})												
Baseline Oyster Biomass Range (g DW m^{-2})	15 - 24.9	25 - 34.9	35 - 44.9	45 - 54.9	55 - 64.9	65 - 74.9	75 - 84.9	85 - 94.9	95 - 104.9	105 - 114.9	115 - 124.9	125 - 134.9	135 - 144.9
0 - 14.9	29	51	74	97	120	143	165	169	172	176	179	183	186
15 - 24.9		23	46	68	91	114	137	140	144	147	151	154	158
25 - 34.9			23	46	68	91	114	118	121	124	128	131	135
35 - 44.9				23	46	68	91	95	98	102	105	109	112
45 - 54.9					23	46	68	72	75	79	82	86	89
55 - 64.9						23	46	49	53	56	59	63	66
65 - 74.9							23	26	30	33	37	40	44
75 - 84.9								3	7	10	14	17	21
85 - 94.9									3	7	10	14	17
95 - 104.9										3	7	10	14
105 - 114.9											3	7	10
115 - 124.9												3	7
125 - 134.9													3

Figure N-8-3. (Table 8.6 in Expert Panel Report). Partial lookup table for use in determining the annual enhanced denitrification rates. For full lookup table, see Appendix G in Expert Panel Report.

For restoration denitrification practices, calculating the nutrient reductions requires the baseline oyster tissue biomass per unit area, post-restoration oyster tissue biomass per unit area, the Expert Panel's default lookup table to estimate enhanced nitrogen removal per unit area per year (Figure N-8-3), and the BMP site area. To calculate the total nitrogen (TN) reductions, the Expert panel recommends the following:

- Step 1. Identify the BMP site location and determine the BMP site area.
- Step 2. Document the qualifying enhancement activity and the date it occurred.
- Step 3. Determine the appropriate baseline approach.
- Step 4. Assess baseline and post-restoration tissue biomass.
- Step 5. Determine denitrification enhancement per unit area using either the biomass-based default denitrification rates per unit area or site-specific measured denitrification rates.
- Step 6. Determine the total nitrogen removal attributable to enhanced denitrification using the estimated denitrification enhancement per unit area and the BMP site area.

An implementer will receive reduction credit for enhanced denitrification if oyster tissue biomass increased above the baseline oyster tissue biomass. There are no bay-wide default estimates for restoration denitrification practices. If the baseline is not known, no credit will be given for these practices for progress scenarios; however, they can be used in a planning scenario within CAST based on planned acres of restoration activity.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Shoreline

Brief Description of BMP Simulation in the Model

These oyster practices are *Load Reduction BMPs,* meaning they are modeled as a simple removal of pounds of nitrogen and phosphorus. The Phase 6 Model estimates nutrient loads in shoreline segments that can be reduced by shoreline and tidal water practices. These practices are not eligible for non-tidal waters. Credit for the pounds of nutrients reduced by oyster restoration practices will go to the shoreline segments closest to the harvest location. If geographic coordinates are not submitted, then the credit will be distributed amongst all shoreline segments in the reported geographic area.

Annual or Cumulative? Annual (1-year credit duration).

For restoration assimilation, credit for appreciated oyster tissue and shell biomass must be applied within 12 months of the most recent post-restoration biomass assessment. Credit for newly appreciated biomass can only be applied one time.

For restoration denitrification, credits can be applied annually for up to 3 years after the most recent post-restoration biomass assessment.

Can this practice be combined with other BMPs? Yes. Both oyster restoration assimilation and restoration denitrification BMPs can be applied in scenarios within CAST.

Key Elements for State BMP Reporting through NEIEN

For restoration assimilation practices:

- *BMP Name:*
    - Oyster reef restoration - assimilation
- *Measurement unit(s):*
    - Required (parent) - site area or restoration area, Unit = acres, both measurements will be available in NEIEN
    - Required (child) – lbs TN, unit = lbs
    - Required (child) – lbs TP, unit = lbs
    - Optional(child) - appreciated oyster tissue and shell biomass, unit = lbs
    - Optional(child) – no. of structures, unit = count
- *Load Source:* Shoreline.
- *Geographic location:* Approved NEIEN geographies: Latitude, Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Date of post-restoration biomass assessment in which oyster tissue and shell biomass appreciated above previously credited biomass.

For restoration denitrification practices:

- *BMP Name:*
    - Oyster reef restoration – enhanced denitrification
- *Measurement unit(s):*
    - Required (parent) - site area or restoration area, Unit = acres, both measurements will be available in NEIEN
    - Required (child) – lbs TN, unit = lbs
    - Optional(child) – annual reduction from enhanced denitrification, unit = lbs
- *Load Source:* Shoreline.
- *Geographic location:* Approved NEIEN geographies: Latitude, Longitude; County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only).
- *Date of implementation:* Date the annual enhanced denitrification occurred.

Table N-8-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Oyster Reef Restoration Nutrient Assimilation	Oyster Reef Restoration – Assimilation	None
Oyster Reef Restoration Enhanced Denitrification	Oyster Reef Restoration – Denitrification	None

Additional Information

Expert panel report:
Cornwell, J., S. Bricker, A. Lacatell, M. Luckenbach, F. Marenghi, C. Moore, M. Parker, K. Paynter, J. Rose, L. Sanford, W. Wolinski, O.N. Caretti, J. Reichert-Nguyen, & H.W. Slacum. 2023. Nitrogen and phosphorus reduction associated with harvest of hatchery-produced oysters and reef restoration: Assimilation and enhanced denitrification: Panel recommendations. Report submitted to the Chesapeake Bay Program Partnership Water Quality Goal Implementation Team January 27, 2023. Approved by the WQGIT June 2023.
https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Oyster-BMP-Second-Report_Approved_with_Minutes.pdf

Oyster BMP Expert Panel Recommendation Roll-out Webinar Part 1: Oyster Reef Enhanced Denitrification Protocols.
https://www.chesapeakebay.net/what/event/oyster-bmp-expert-panel-recommendation-roll-out-webinar-part-1-oyster-reef-enhanced-denitrification-protocols

Oyster BMP Expert Panel Recommendations Roll-out Webinar Part 2: Oyster Assimilation Protocols.
https://www.chesapeakebay.net/what/event/oyster-bmp-expert-panel-recommendation-roll-out-webinar-part-2-oyster-assimilation-protocol

Technical Appendix (approved by the WTWG in May 2023):
https://d18lev1ok5leia.cloudfront.net/chesapeakebay/Oyster-BMP-Expert-Panel-Second-Report_Technical-Appendix_3May2023.pdf

Version and History Statement

This info sheet was first published on April 3, 2024 and reflects the BMP definitions and reductions approved by the WQGIT in June 2023.

S-1. Septic Connection and Pumping

General Information

Septic connection and pumping are two BMPs that can be applied to private septic systems. Septic pumping is used to remove solids from the septic systems to prevent clogging and failure of the systems. System failure can lead to the inability to adequeately filter and treat wastewater, which can result in sewage discharge into ground and surface water sources.

Another practice applied to septic systems is known as septic connection, which involves connecting private septic tanks to public sewer systems. This transfers the nutrient load to a wastewater treatment plant where the water can then be treated and the nutrient load reduced.

Figure S-1-1. Pumping sludge out of a septic tank, a routine part of septic system maintenance. Source: MCPA Flickr. (https://flic.kr/p/UScorM).

CBP Definition(s)

Septic Connection: This is when septic systems get converted to public sewer. This reduces the number of septic systems because the waste is sent into the sewer and treated at a wastewater treatment plant. Enter units of number or percent of systems.

Sepctic Pumping: Septic systems achieve nutrient reductions through several types of management practices, including frequent maintenance and pumping. On average, septic tanks need to be pumped once every three to five years to maintain effectiveness. The pumping of septic tanks is one of several measures that can be implemented to protect soil absorption systems from failure. Enter units of number or percent of systems.

Specifications or Key Qualifying Conditions

There are no key qualifying conditions for septic connections or pumping.

Nitrogen, Phosphorus and Sediment Reductions

The nitrogen reduction efficiency for septic pumping is displayed in Table S-1-1 below. Phosphorus and sediment reduction credits are not available for this practice. The reductions associated with septic connection dependent upon the number of septic systems that get converted.

Table S-1-1. Percent Nitrogen Reduction for Septic Pumping BMPs.

BMP NEIEN Name	Nitrogen Reduction (%)
Septic Pumping	5%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Septic

Brief Description of BMP Simulation in the Model

Septic connection is a *Load Source Change BMP.* This BMP reduces the number of septic systems in the model, eliminating the loads associated with those systems.

Septic pumping is an *Efficiency Value BMP.* The efficiency value listed in Table S-1-1 will be applied to conventional septic systems within the modeling tools.

Annual or Cumulative? Cumulative (5-year credit duration).

Can this practice be combined with other BMPs? The septic pumping BMP is mutually exclusive with each of the advanced on-site wastewater treatment BMPs (see S-2: Advanced On-site Wastewater Treatment BMPs) and should not be reported in conjunction with these practices. The septic connection BMP removes the septic systems altogether.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Septic Connection.
  - Septic Pumping.
- *Measurement unit(s):* Number of systems.
- *Load Source:* Septic.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the project was completed.

Table S-1-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Septic Connection	Septic Connection	None
Septic Pumping	Septic Pumping	None

Additional Information

Expert panel report (see Appendix C for septic pumping):
Adler, R., Aschenbach, E., Baumgartner, J., Conta, J., Degen, M., Goo, R., Hudsen, J., Moeller, J., Montali, D., Piluk, R., & Prager, J. 2014. Recommendations of the On-Site Wastewater Treatment Systems Nitrogen Reduction Technology Expert Review Panel. Report and Appendix G approved by the WQGIT July 14, 2014. https://www.chesapeakebay.net/documents/Final_OWTS_Expert_Panel_WQGIT_approved_07142014_w_Apdx_G.pdf

Technical Appendix G: Requirements to Enter Advanced On-Site Wastewater Treatment Practices into Scenario Builder and the Phase 5.3.2 Watershed Model. http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2014/10/Onsite_Wastewater_Treatment_Technical_Appendix_07232014.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-13: Enhanced Septic Systems. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network. Archived Webcast: Crediting On-Site Wastewater Treatment Systems in the Bay Watershed. http://chesapeakestormwater.net/events/crediting-on-site-wastewater-treatment-systems-bay-tmdl/

Palace, M.W., J.e. Hannawald, L..C. Linker, G.W. Shenk, J.M. Storrick, and M.L Clipper. 1998. *Chesapeake Bay Watershed Model Application and Calculation of Nutrient and Sediment Loadings.* Appendix H: Tracking Best Management Practice Nutrient Reductions in the Chesapeake Bay Program. Chesapeake Bay Program. Modeling Subcommittee, Annapolis, MD. https://www.chesapeakebay.net/documents/3689/8_777.pdf

Version and History Statement

This info sheet was first published on November 16, 2022 and reflects the BMP definitions and reductions approved by the WQGIT in July 2014. All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

S-2. Advanced On-site Wastewater Treatment Systems

General Information

Typical septic systems treat waste in two steps: first, within the septic tank and, second, in the drainfield. Certain types of systems or technologies can increase nitrogen removal by using pre-treatment within the septic tank (ex situ BMPs), and soil-based technologies in the drainfield (in situ BMPs), as shown in Figure S-2-1. There are many different types of enhanced septic systems that work to remove nitrogen. A combination of both pre-treatment (ex situ) and soil-based technologies (in situ) is the most effective way to maximize nitrogen removal performance. Installing advanced on-site wastewater treatment systems can provide several benefits beyond improved nitrogen removal, including improving bacterial removal, reducing septic system overflows and leaks, and improving property values.

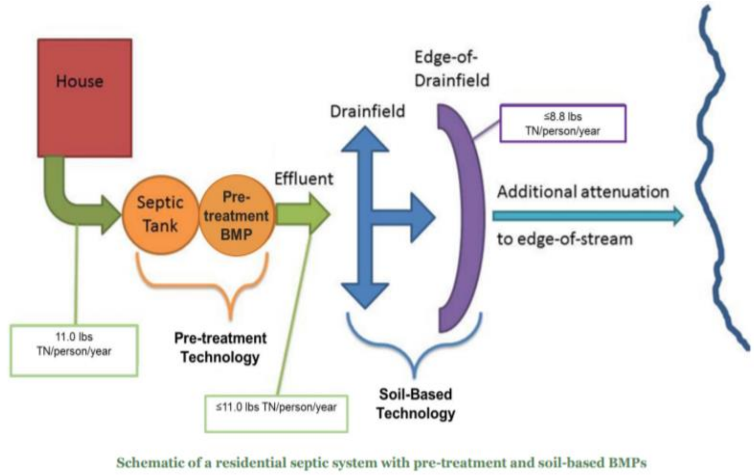

Figure S-2-1. Schematic of a residential septic system with pre-treatment and soil based BMPs. Source: Chesapeake Stormwater Network, U-13 Enhanced Septic Systems Fact Sheet.

CBP Definition(s)

Septic Denitrification – Conventional: The septic system should employ a 50% denitrification unit for pre-treatment of waste with no enhanced in situ treatment system within the soil treatment unit. This BMP should be used only for systems that employ recirculating media filters (RMF) or integrated fixed-film activated sludge (IFAS) pre-treatment technologies, but do not employ enhanced in situ treatment systems. Use this BMP where the specific system design is unknown.

Septic Denitrification – Enhanced: The septic system should employ both a 50% denitrification unit for pre-treatment of waste and an enhanced in situ treatment system within the soil treatment unit. This BMP should be used only for systems that employ recirculating media filters (RMF) or integrated fixed-film activated sludge (IFAS) pre-treatment technologies. The system must also employ shallow-placed, pressure-dosed dispersal units or elevated sand mounds with pressure-dosed dispersal for in situ treatment within the soil treatment unit

Septic Denitrification – Advanced: The septic system should employ both a 50% denitrification unit for pre-treatment of waste and an enhanced in situ treatment system within the soil treatment unit. This BMP should be used only for systems that employ integrated fixed-film activated sludge (IFAS) pre-treatment technologies with advanced drip dispersal units for in situ treatment within the soil treatment unit.

Septic Effluent – Enhanced: The septic system must be designed to reduce 38% TN by employing an enhanced in situ treatment system within the soil treatment unit with no secondary treatment or enhanced denitrification technology. This system must employ shallow-placed, pressure-dosed dispersal units or elevated sand mounds with pressure-dosed dispersal for in situ treatment within the soil treatment unit.

Septic Effluent – Advanced: The septic system must be designed to reduce 50% of TN by employing an enhanced in situ treatment system within the soil treatment unit with advanced drip dispersal units for in situ treatment within the soil treatment unit. This system must also employ shallow-placed, pressure-dosed dispersal units or elevated sand mounds with pressure-dosed dispersal for in situ treatment within the soil treatment unit.

Secondary Treatment: Pre-treatment practices are those occurring prior to dispersing effluent into the soil treatment unit. Secondary ex situ systems include certified, NFS 40 Class I or equivalent systems; intermittent media filters (IMF); and constructed wetlands.

Septic Secondary Treatment – Conventional: The septic system should employ a technology for pre-treatment of waste with no enhanced in situ treatment system within the soil treatment unit. This BMP should be used only for systems that employ certified, NFS 40 Class I or equivalent technologies, intermittent media filters (IMF) or constructed wetlands for pre-treatment designed to produce a gross 20% TN reduction.

Septic Secondary Treatment – Enhanced: The septic system should employ both technologies for pre-treatment of waste and an enhanced in situ treatment systems within the soil treatment unit. This BMP should be used only for systems that employ certified, NFS 40 Class I or equivalent technologies, intermittent media filters (IMF) or constructed wetlands for pre-treatment designed to produce a gross 50% TN reduction. The system must also employ shallow-placed, pressure-dosed dispersal units or elevated sand mounds with pressure-dosed dispersal for in situ treatment within the soil treatment unit.

Septic Secondary Treatment – Advanced: Processes occurring within the soil treatment unit, including drip dispersal systems designed to produce a gross 60% TN reduction and designed in accordance with the details provided in the 2018 expert panel report (see Additional Information below).

Enhanced In-Situ: – In situ processes are those occurring after ex situ treatment, within the soil treatment unit. These practices include shallow-placed, pressure-dosed dispersal units and elevated sand mounds with pressure-dosed dispersal.

Proprietary Systems are those developed, marketed, and constructed by a manufacturer. Proprietary technologies exhibiting a reduction of total nitrogen greater than 50% will be assigned a total nitrogen reduction credit of 50% in the watershed model. It is up to each jurisdiction to determine which systems exhibit a reduction of 50% or greater based upon third-party monitoring.

Nonproprietary systems are those designed on a case-by-base basis for each site.

Specifications or Key Qualifying Conditions

The associated nitrogen reduction credits of advanced on-site wastewater treatment systems are linked to the planning, design, installation, and operational elements of these systems. For a full list of specifications and key qualifying conditions for this BMP, consult the expert panel report (p.11-13).

Nitrogen, Phosphorus and Sediment Reductions

The efficiency reductions listed in Table S-2-1 will be applied to septic systems within the modeling tools. No phosphorus credit is available because research shows that soils are very effective at retaining phosphorus from septic systems.

Jurisdictions may request a reduction efficiency of greater than 50% for a particular type of system based upon third-party monitoring. The jurisdiction must submit the results of the third-party monitoring data and design specifications to the Wastewater Treatment Workgroup (WWTWG) for consideration. Per the CBP's BMP Protocol, the Wastewater Treatment Workgroup will then have the discretion to refer the system to an Expert Panel to determine if it should receive greater than 50% reduction in the modeling tools. Further details about third-party monitoring protocols can be found in Section 3.2.1 of the expert panel report (see Additional Information below).

Table S-2-1. Percent Nitrogen Reductions for Septic System Treatment BMPs.

BMP NEIEN Name	CAST Name	Nitrogen Reduction (%)
Septic Effluent with Shallow Pressure	Septic Effluent with Enhanced In Situ	38%
Septic Effluent with Elevated Mound	Septic Effluent with Enhanced In Situ	38%
Septic Effluent with Advanced Drip Dispersal	Septic Effluent with Advanced In Situ	50%

NSF 40 with Elevated Mound	Secondary Treatment with Enhanced In Situ	50%
NSF 40 with Advanced Drip Dispersal	Secondary Treatment with Advanced In Situ	60%
IMF	Secondary Treatment with Conventional In Situ	20%
IMF with Shallow Pressure	Secondary Treatment with Enhanced In Situ	50%
IMF with Elevated Mound	Secondary Treatment with Enhanced In Situ	50%
IMF with Advanced Drip Dispersal	Secondary Treatment with Advanced In Situ	60%
Constructed Wetland	Secondary Treatment with Conventional In Situ	20%
Constructed Wetland with Shallow Pressure	Secondary Treatment with Enhanced In Situ	50%
Constructed Wetland with Elevated Mound	Secondary Treatment with Enhanced In Situ	50%
Constructed Wetland with Advanced Drip Dispersal	Secondary Treatment with Advanced In Situ	60%
RMF	Denitrification Unit with Conventional In Situ	50%
RMF with Shallow Pressure	Denitrification Unit with Enhanced In Situ	69%
RMF with Elevated Mound	50% Denitrification Unit with Enhanced In Situ	69%
RMF with Advanced Drip Dispersal	50% Denitrification Unit with Advanced In Situ	75%
IFAS	50% Denitrification Unit with Conventional In Situ	50%
IFAS with Shallow Pressure	50% Denitrification Unit with Enhanced In Situ	69%
IFAS with Elevated Mound	50% Denitrification Unit with Enhanced In Situ	69%
IFAS with Advanced Drip Dispersal	50% Denitrification Unit with Advanced In Situ	75%
Proprietary Ex Situ	50% Denitrification Unit with Conventional In Situ	50%
Proprietary Ex Situ with Shallow Pressure	50% Denitrification Unit with Enhanced In Situ	69%
Proprietary Ex Situ with Elevated Mound	50% Denitrification Unit with Enhanced In Situ	69%
Proprietary Ex Situ with Advanced Drip Dispersal	50% Denitrification Unit with Advanced In Situ	75%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Septic

Brief Description of BMP Simulation in the Model

All advanced on-site wastewater treatment systems are *Efficiency Value BMPs.* The efficiency values listed in Table S-2-1 will be applied to conventional septic systems within the modeling tools. These reductions will result in lower edge-of-stream nitrogen loads from the modeled, conventional septic systems.

Annual or Cumulative? Cumulative (10-year credit duration).

Can this practice be combined with other BMPs? No. Each of the system types are mutually exclusive, meaning that a jurisdiction should only report one practice type per septic system. Please also note that septic pump-outs and the current septic de-nitrification practices are also mutually exclusive with each of the system types and should not be reported in conjunction with these new BMPs.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - See above in Table S-2-1 under Column "BMP NEIEN Name"
- *Measurement unit(s):* Systems, Count.
- *Load Source:* Septic
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Date the project was completed.

Table S-2-2. Synonymous BMP names for Watershed Model, NEIEN and other sources.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Septic Effluent with Enhanced In-Situ	Septic Effluent with Shallow Pressure Septic Effluent with Elevated Mound	None
Septic Effluent with Advanced In-Situ	Septic Effluent with Advanced Drip Dispersal	None
Secondary Treatment with Conventional In-Situ	NSF 40 IMF Constructed Wetland	None
Secondary Treatment with Enhanced In-Situ	NSF 40 with Shallow Pressure NSF 40 with Elevated Mound IMF with Shallow Pressure IMF with Elevated Mound Constructed Wetland with Shallow Pressure Constructed Wetland with Elevated Mound	None
Secondary Treatment with Advanced In-Situ	NSF 40 with Advanced Drip Dispersal IMF with Advanced Drip Dispersal Constructed Wetland with Advanced Drip Dispersal	None
50% Denitrification Unit with Conventional In Situ	RMF IFAS Proprietary Ex Situ	None
50% Denitrification Unit with Enhanced In Situ	RMF with Shallow Pressure RMF with Elevated Mound IFAS with Shallow Pressure IFAS with Elevated Mound Proprietary Ex Situ with Shallow Pressure Proprietary Ex Situ with Elevated Mound	None
50% Denitrification with Advanced In Situ	RMF with Advanced Drip Dispersal IFAS with Advanced Drip Dispersal Proprietary Ex Situ with Advanced Drip Dispersal	None

Additional Information

Expert panel report:

Baumgartner, J., Berkowitz, S., Boekeloo, T., Buchanan, J., Conta, J., Degen, M., Diehl, J., Eichholz, S., Goo, R., Hayes, J., Heger, S., Hepner, L., Lindbo, D., Lowe, K., Prager, J., Roeder, E., & E. Severson. 2018. Drip Irrigation and Peat Treatment System On-site Wastewater Nutrient Removal BMP Expert Panel Report. Prepared by N. Zhou and D. Wood, Chesapeake

Bay Program Office. Report and Appendix approved by the WQGIT August 2018. https://www.chesapeakebay.net/documents/Advanced_OWTS_Drip_Peat_BMP_Panel_2018.pdf

Expert panel report:
Adler, R., Aschenbach, E., Baumgartner, J., Conta, J., Degen, M., Goo, R., Hudsen, J., Moeller, J., Montali, D., Piluk, R., & Prager, J. 2014. Recommendations of the On-Site Wastewater Treatment Systems Nitrogen Reduction Technology Expert Review Panel. Report and Appendix G approved by the WQGIT July 14, 2014. https://www.chesapeakebay.net/documents/Final_OWTS_Expert_Panel_WQGIT_approved_07142014_w_Apdx_G.pdf

Technical Appendix G: Requirements to Enter Advanced On-Site Wastewater Treatment Practices into Scenario Builder and the Phase 5.3.2 Watershed Model. http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2014/10/Onsite_Wastewater_Treatment_Technical_Appendix_07232014.pdf

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Version and History Statement

This info sheet was first published on November 16, 2022 and reflects the BMP definitions and reductions approved by the WQGIT in July 2014 and July 2018.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.