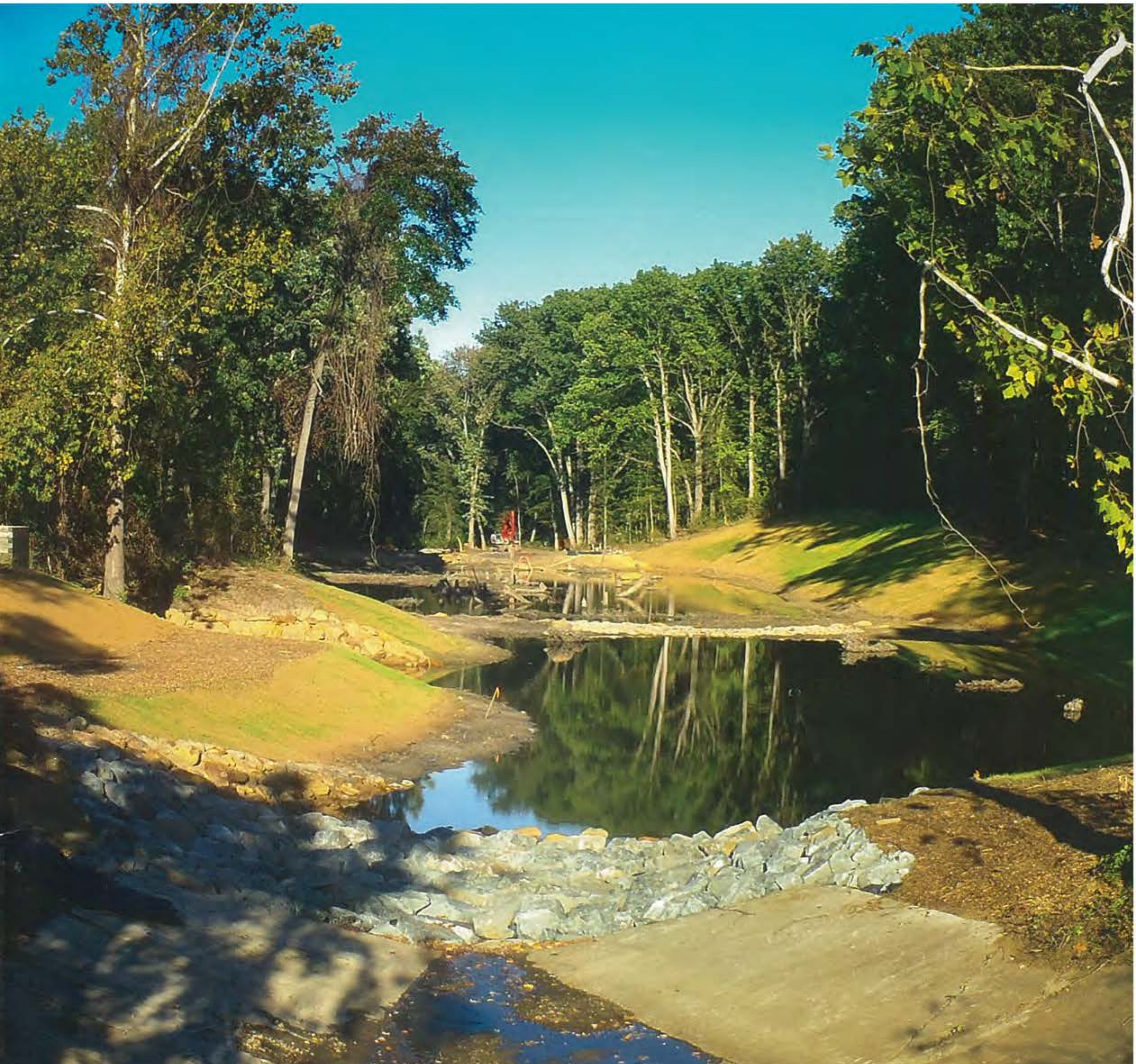
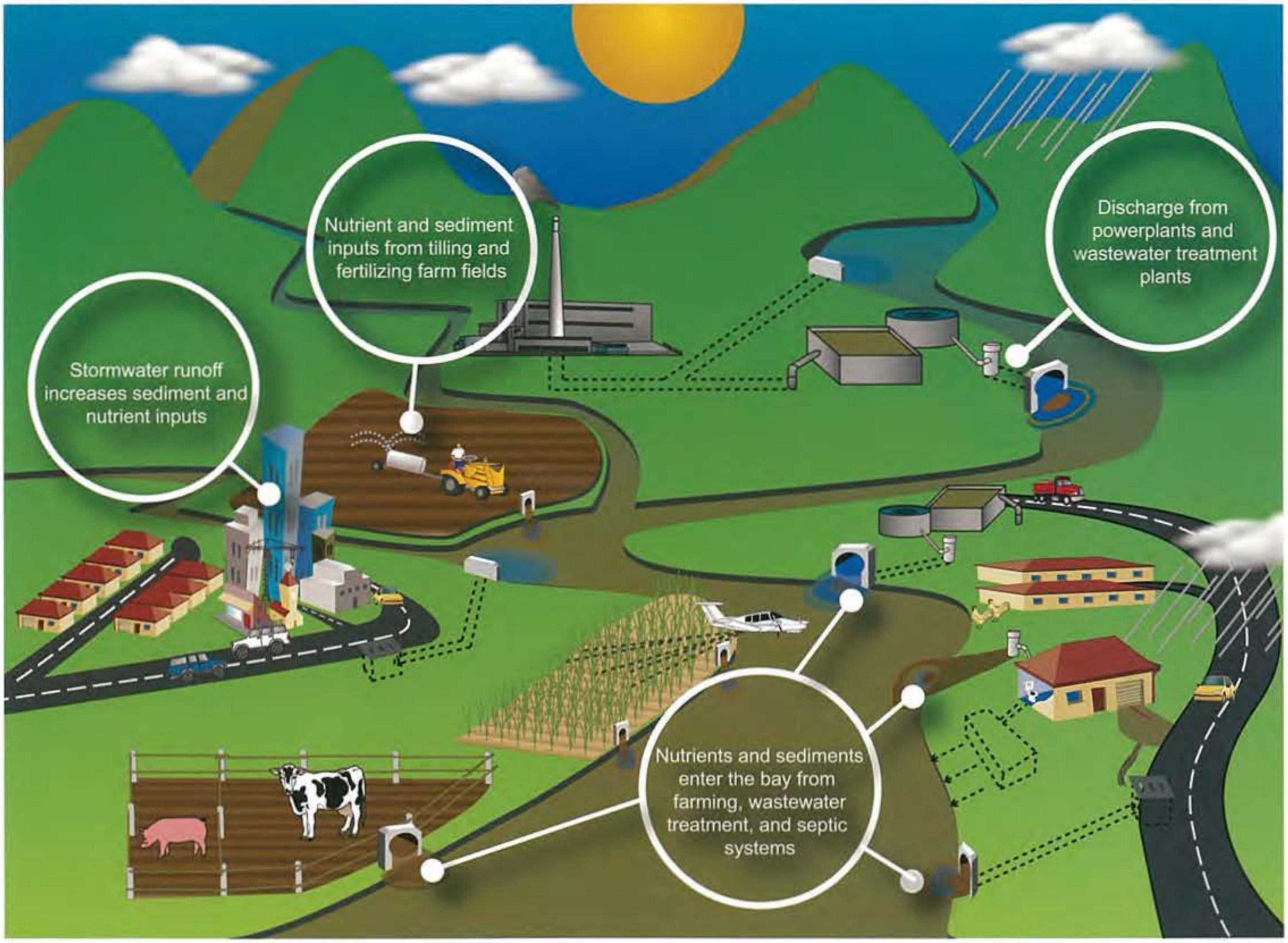


Measuring effectiveness of
Best Management Practices

CHESAPEAKE AND ATLANTIC COASTAL BAYS TRUST FUND

Challenges facing Chesapeake and Atlantic Coastal Bays

As early as the 1960s, there has been a growing awareness that the resources of the Chesapeake and Atlantic Coastal Bay watersheds were declining, largely due to the tremendous pressure placed upon sensitive resources by a rapidly expanding population. A key pressure identified was excess nutrients (particularly nitrogen and phosphorus) and sediments entering the bays, originating from agriculture, urban/suburban runoff, vehicle emissions and many other sources throughout their watersheds. Excess nutrients in the bays have led to deterioration of water quality and a decline of those organisms that depend on clean, clear and oxygenated water.



Reversing this trend of ecological deterioration is a significant challenge for us as a community. In an effort to reduce nutrient and sediment pollution to these bays, the Chesapeake and Atlantic Coastal Bays Trust Fund was created in 2007, with a focus to fund the implementation of effective non-point (i.e., diffuse) source pollution control projects using best management practices (BMPs) in high priority watersheds.

Trust Fund recipients are required to demonstrate nutrient and/or sediment load reductions per restoration dollar awarded. This is a significant challenge for recipients and this document was developed to help achieve this requirement. This includes measuring the success of individual pollution control practices at the sub-basin level, and a more comprehensive assessment of an entire system (e.g., the effect of multiple or larger-scale implementation projects on downstream receiving waters such as rivers and estuaries).

Focused Actions to Reach Solutions

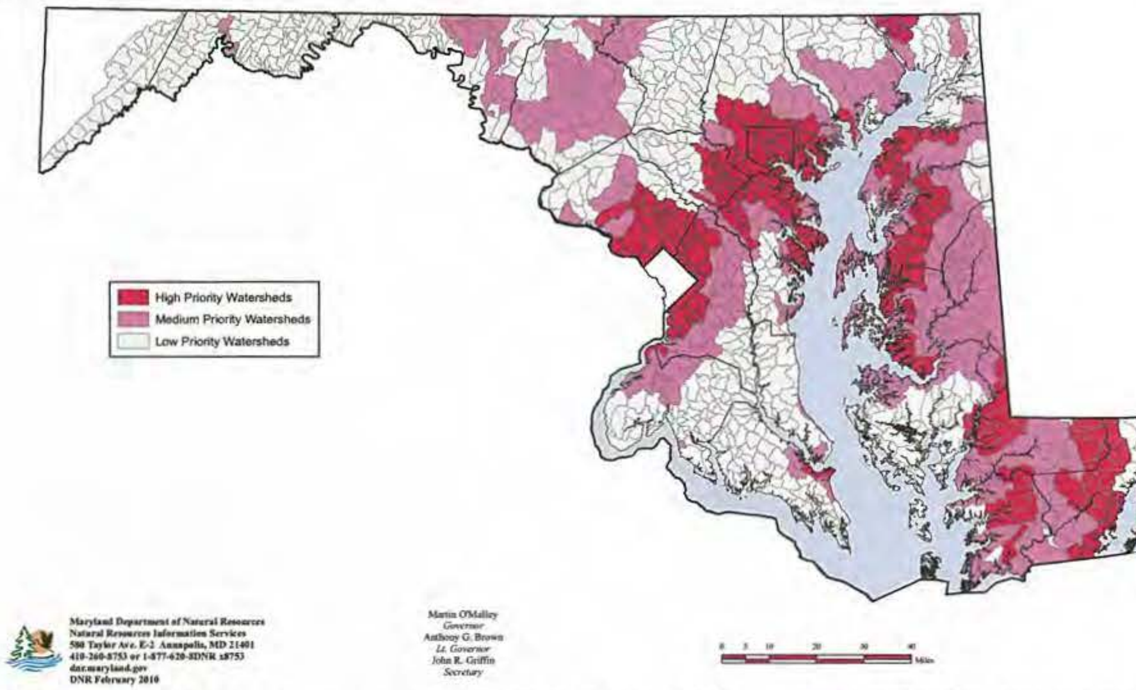
Targeting action on watersheds that are deemed to have tributaries with the worst water quality, and highest levels of nutrient pollution, offers the best opportunity to demonstrate success. These watersheds are described as high-priority watersheds and are responsible for proportionally more nutrient and sediment inputs to receiving waters than other watersheds.

Priority funding areas were developed using information from the USGS SPARROW model and local knowledge and expertise. Coastal Bays watersheds were prioritized based on the expertise of scientists in that region. Agricultural and urbanized watersheds were evaluated separately to identify the highest nutrient loading areas. For urban watersheds developed lands were analyzed, while agricultural watersheds were separated into cropland and animal production systems.

High priority watersheds with the top 10% delivered yields for both nitrogen and phosphorus were selected using the U.S. Geological Survey's SPARROW model. The top 10% delivered yielding areas for developed land, top 10% for fertilizer and top 10% for manure were combined to represent the high priority watersheds for urban, cropland and animal production, respectively. Medium priority watersheds have the top 25% delivered yields for nitrogen and phosphorus to the Chesapeake Bay. The top 25% delivered yielding areas for developed land, top 25% for fertilizer, and top 25% for manure were combined to represent the medium priority watersheds for urban, cropland and animal production, respectively. Low priority watersheds are the lowest 75% delivered nitrogen and phosphorus, in the Chesapeake Bay drainage area.

The Atlantic Coastal Bay watersheds were selected based on the pattern of trajectories of the water quality index (dissolved oxygen, chlorophyll a, total nitrogen, total phosphorus) between 2001-2006. Improving or stable trajectories are occurring north of the Ocean City inlet and degrading trajectories are occurring south of the Ocean City inlet. Seagrass abundance has rapidly declined in Chincoteague Bay and water turbidity has increased. Based on the trajectories and the expertise of scientists in that region, Chincoteague Bay is designated as a high priority area while the remaining Coastal Bays watersheds are low priority areas.

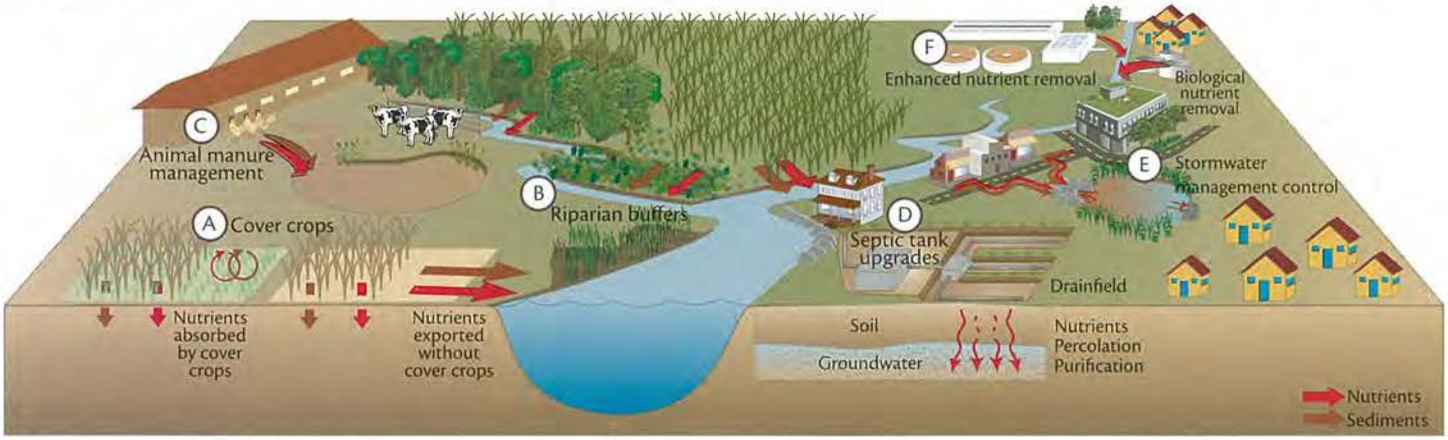
These tools allowed scientists to create a map indicating where Trust Fund grants should be targeted to achieve the largest reduction of non-point nutrient and sediment inputs to receiving waters per restoration dollar. It is anticipated that the cumulative effect of multiple projects in priority areas will ultimately have a measurable, positive effect on the health of the bays.



Watersheds in Maryland were grouped into priority areas based on nutrient loads by landuse type. High priority watersheds are where Trust Fund projects will be targeted first.

Best Management Practices around the Bays

There are a suite of Best Management Practices (BMPs), with many more being developed, that reduce nutrient and sediment loads to the Chesapeake Bay. These may be as simple as individuals not fertilizing their lawn, or only during the recommended time of the year (fall), to large and expensive construction projects such as upgrading municipal wastewater treatment plants. Here are some of the most important and some of the new BMPs being undertaken in agriculture and urban areas.



Agricultural BMPs

A. Cover crops

Non-harvested cereal cover crop specifically planted in fall for nutrient removal. Cereal cover crops reduce erosion and the leaching of nutrients to groundwater by maintaining a vegetative cover on cropland and holding nutrients within the root zone during the winter crop season.

B. Riparian buffers

Up to 100-foot-wide buffer of grass, non-woody, or woody (forest) vegetation between crop and waterway. A 100-foot-wide strip of grass buffer can significantly reduce sediment inputs to waterways.

C. Animal manure management

Animal farming uses directed flows to better contain waste products from animal houses. Lagoons, ponds, steel or concrete tanks, and storage sheds are used for the treatment and/or storage of wastes.

BMPs

Urban BMPs

D. Septic upgrades

Septic denitrification represents the replacement of traditional septic systems with more advanced systems that have additional nitrogen removal capabilities.

E. Stormwater management control

Includes rain gardens, green roofs and riparian buffers. Filtering practices capture and temporarily store the water and pass it through a filter of sand, organic matter, and vegetation, promoting pollutant treatment and recharge.

F. Enhanced nutrient removal

Wastewater treatment plants are being upgraded to enhanced nutrient removal, which uses the most efficient removal process available before the water is discharged into local waterways.

Not all BMPs will show rapid change downstream

It has been difficult to document the reductions in non-point source nutrient loads from best management practices (BMPs) in the Chesapeake Bay watershed. This may be due to: i) over-estimation of the effectiveness of individual BMPs; ii) lag time between implementation and when the effects become apparent in water quality; and iii) natural variability in water quality being greater than actual reductions, masking detectable change.

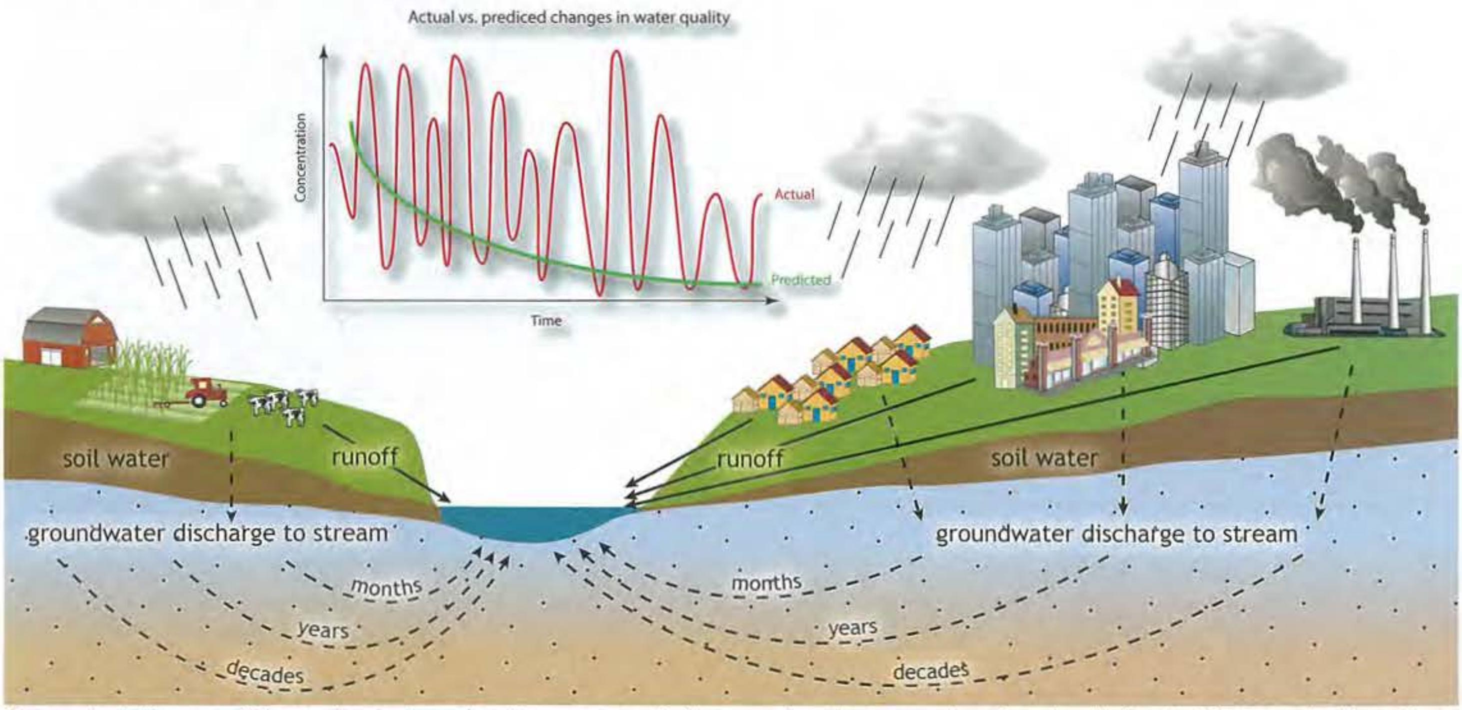
These issues are particularly relevant in the Maryland Coastal Plain region of the Chesapeake Bay watershed, where high-priority watersheds are located. On average, there is a lag time of 10 years for nitrogen in groundwater to travel to streams in the Chesapeake Bay watershed, and long flow paths allow for considerable pollutant dilution. This combined with variable water quality, caused in part by annual fluctuations in rainfall, can make detecting improvements in water quality difficult (see figure below).

Where monitoring is less likely to succeed, standardized nutrient reduction efficiencies can be used to estimate the potential effectiveness of implementation activities.

Given Trust Fund project goals of demonstrating water quality response to BMP implementation within a 3-year time period, it is important that monitoring be done only when there is a reasonable chance that it will be possible to observe water quality change over several years.

Assume that > 30% reduction in ambient loading is required to achieve a measurable effect on downstream receiving waters[1]

If it is determined that the Trust Fund project does not reduce nutrient sediment pollution by >30%, but does augment existing additional efforts to reduce nutrient and sediment pollution in the watershed (e.g. stormwater projects; restoration projects) to an amount collectively >30%, then monitoring is justified and additional funding can be sought.



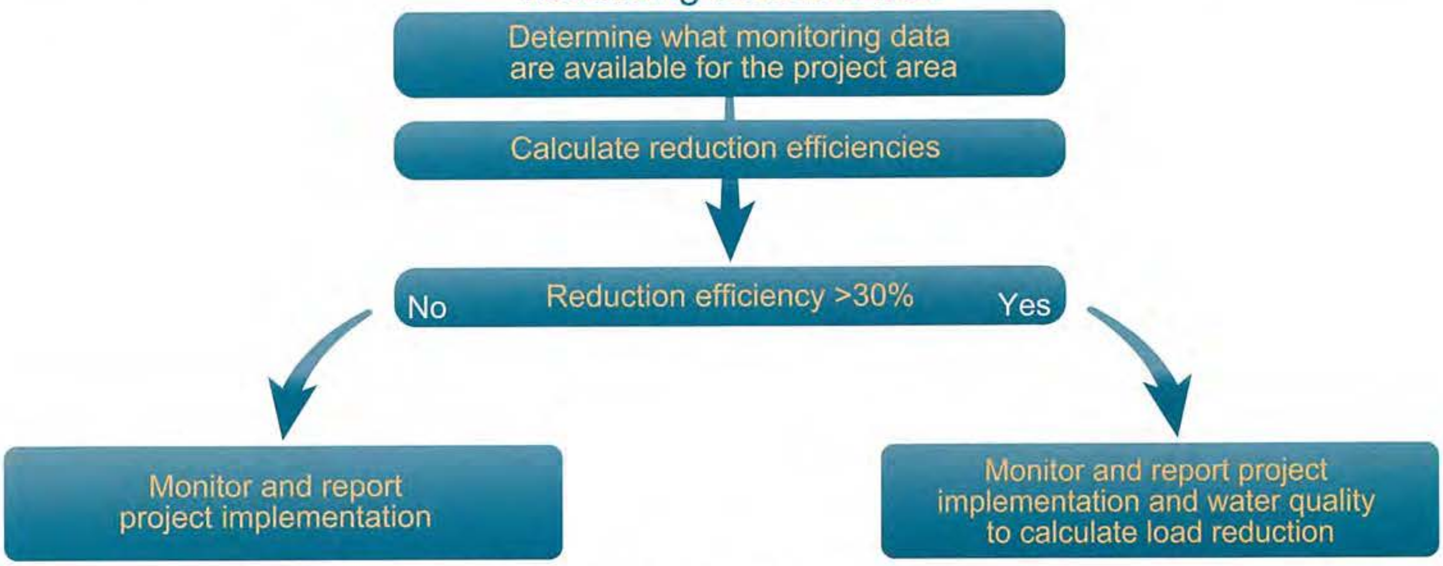
Conceptual diagram of the water cycle and major sources of nitrogen, phosphorus, and sediment pollution to Chesapeake Bay. Once in groundwater, nitrogen can take from months to years to be transported to rivers and the estuary which, combined with variable water quality and precipitation, can make detecting improvements difficult.

[1]*Spooner, J., R.P. Maas, M.D. Smolen, and C.A. Jamieson. 1987. Increasing the sensitivity of nonpoint source control monitoring programs. Symposium on Monitoring, Modeling, and Mediating Water Quality. American Water Resources Association.*

Determine the expected change your BMP will have downstream

Monitoring should be conducted only in areas where BMPs (single or multiple) will significantly reduce pollutant levels (~30% or more) at monitoring points in receiving waters. When emerging techniques for nutrient and sediment reduction are proposed, Trust Fund recipients may be asked to monitor the effectiveness of the new BMP. A list and description of those innovative BMPs will be provided within each request for proposals. Otherwise it is expected that Trust Fund recipients track and report the project implementation.

Monitoring Decision Tree



To estimate gross nutrient reductions expected from Trust Fund projects, applicants should refer to the request for proposals tab on the Trust Fund webpage: http://www.dnr.state.md.us/ccp/funding/trust_fund.asp

This links to the most up-to-date BMP reduction estimates and land use loading rates. In general, the BMP reduction efficiencies are applied against the land use acreage and type in the watershed to determine the load after BMP implementation. The following four steps can be used to assist in determining reduction efficiencies.

1. **Pre BMP watershed load =**
SUM[(Area 1 x Pre loading rate 1) + (Area 2 x Pre loading rate 2) +....]

Where:
Pre BMP watershed load = $lbs.yr^{-1}$
Area = acres
Pre loading rate = $lbs.ac^{-1}.yr^{-1}$

2. **BMP load reduction =**
SUM[(BMP1 reduction x Area 1) + (BMP2 reduction x Area 2) + ...]

Where:
BMP load reduction = $lbs.yr^{-1}$
Area = acres
BMP reduction = $lbs.ac^{-1}.yr^{-1}$

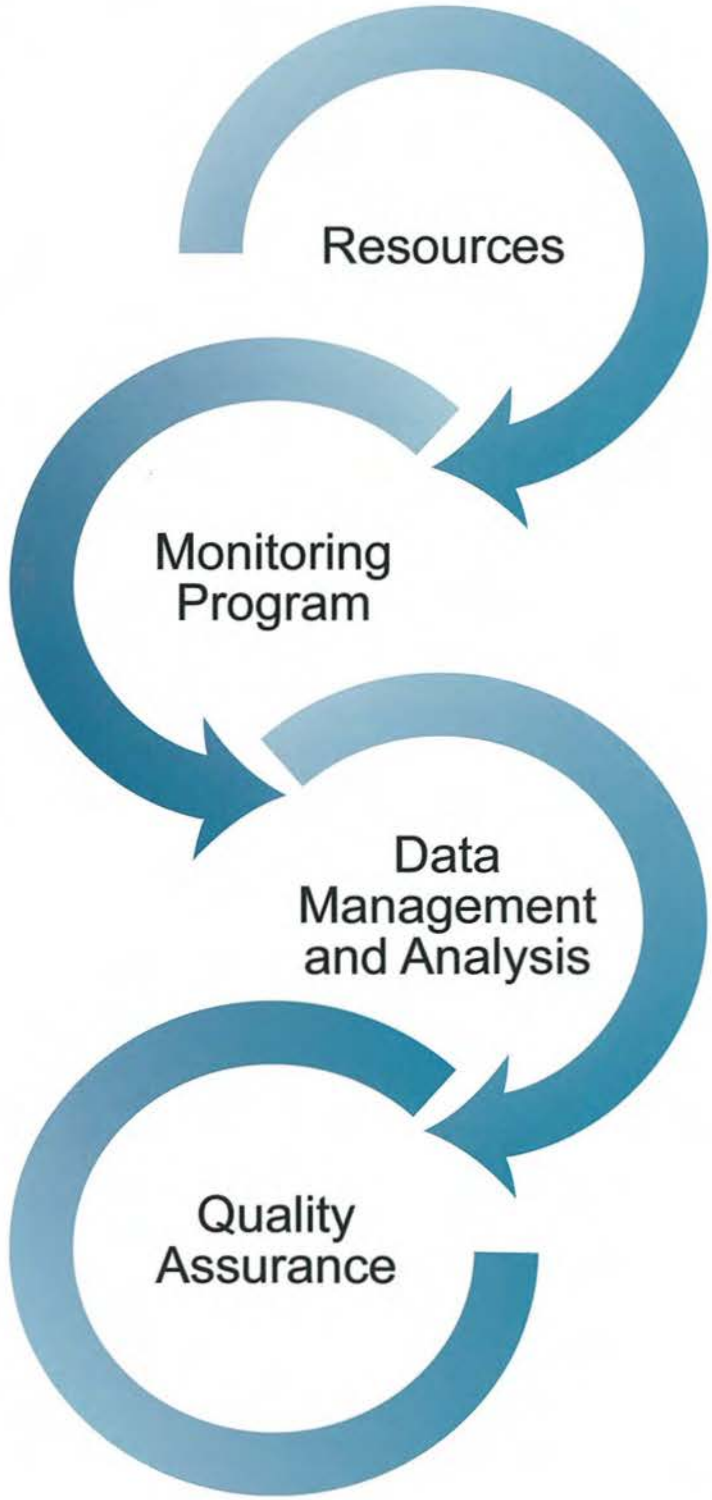
3. **Post BMP watershed load =**
Pre BMP watershed load - BMP load reduction

Where:
Post BMP watershed load = $lbs.yr^{-1}$

4. **% Load reduction =**
[1 - (Post BMP watershed load ÷ Pre BMP watershed load)] x 100

If >30% nutrient reduction predicted, monitoring water quality is advised

Ensuring appropriate spatial distribution and temporal frequency is only one step in the process of acquiring high quality data. Equally important is ensuring that quality-assured data management protocols are in place and that data is readily available to users in the required timeframe. Decisions such as what parameters to measure, what precision is required, what size area should be covered and what instruments to use, all need to be made.



Steps to consider when monitoring the effectiveness of your BMP

1. Resources

Planning a monitoring program without adequate resources is likely to result in poor quality data, leading to incorrect conclusions and ultimately additional time and cost to re-perform sampling.

Implementing a monitoring program requires standardized procedures and access to financial and physical resources, including:

- an equipped laboratory,
- office space,
- equipment for field work,
- transport, and
- trained personnel.

Safety of personnel in the field is also a significant consideration and requires consideration and planning prior to undertaking a monitoring program.

2. Monitoring Program

There are several common and effective monitoring designs that can be used to detect possible changes in water quality from BMP implementation. The most appropriate design will depend on site-specific characteristics of the implementation area. For instance, determining the land use characteristics on the implementation site and surrounding area may indicate that there is an adjacent watershed that could be used as a control (paired watershed). Otherwise, the most effective approach is a "nested" monitoring design to monitor water quality where an effect is likely to be measurable between times (i.e. before and after implementation) and/or locations (i.e. upstream vs. downstream).

Recommended designs for monitoring BMP effectiveness

Design	Advantages	Disadvantages
Nested (above/below or before/after)	• Can attribute water quality to changes in BMPs • Similar or same sampling sites	• Takes several years to see effect if before/after design used • Upstream impacts can overwhelm effect of BMP • Climatic variability could create artifacts if not before /after monitoring
Paired watersheds	• Controls for hydrological variation • Can attribute water quality changes to BMPs	• Difficult to find paired watershed • Difficult to control land/use/treatment in control • Takes several years to see effect

Water quality monitoring done at an implementation site should generally consist of conventional water quality analyses such as total and dissolved nitrogen and phosphorus, and total suspended solids. If all of these constituents cannot be measured, preference should be given to total nitrogen, total suspended solids, and total phosphorus.

Other factors that need to be considered include the frequency of monitoring. Monthly storm-flow monitoring and quarterly baseflow monitoring is recommended. Baseflow can be defined as any period following two days after storm activity. Note also that highly impervious urban watersheds will require stormflow-oriented sampling as water may not be present during baseflow conditions.

Detailed guidance on monitoring program design and standard operating procedures can be sought from staff at the Maryland Department of Natural Resources or from various online sources such as the "Non-point Source Monitoring Guidance" website of the United State Environmental Protection Agency (http://water.epa.gov/polwaste/nps/monitoringguidance.cfm).

3. Data management and analysis

Data management and analysis needs to begin in the monitoring program design phase. Data and analysis results should be documented in electronic files or reports that address the acceptability and suitability of the data for their intended purpose. Data should be entered with applicable identifiers into electronic databases for storage and dissemination to interested parties and be publicly available.
Guidance on data management and analysis can be sought from staff at the Maryland Department of Natural Resources or from various online sources such as the "Non-point Source Monitoring Guidance" website of the United State Environmental Protection Agency
(http://water.epa.gov/polwaste/nps/monitoringguidance.cfm).

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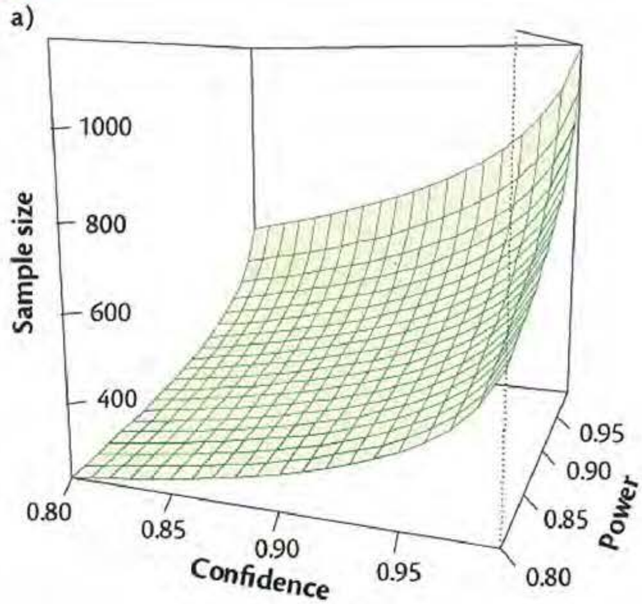


4. Quality assurance

The use of different methodologies, lack of data comparability, unknown data quality, and poor coordination of sampling and analysis efforts can delay the progress of a project or render the data and information collected from it insufficient for decision making. Quality assurance and control practices should be used as an integral part of the development, design, and implementation of a BMP monitoring program to minimize or eliminate these problems.
Guidance on quality assurance and quality control can be sought from staff at the Maryland Department of Natural Resources or from various online sources such as the "Non-point Source Monitoring Guidance" website of the United State Environmental Protection (http://water.epa.gov/polwaste/nps/monitoringguidance.cfm).

Next steps...

As Trust Fund recipients approach the end of their project, there are a number of items that should be considered to ensure project requirements are fulfilled, the BMP has a successful future, and that project outputs make a difference.

A successful BMP can be an excellent public engagement and education tool for all ages and provides momentum for additional natural resource rehabilitation activities. Demonstrating this success though comparison with other BMPs in the region is possible through tools found on the Trust Fund website (http://www.dnr.maryland.gov/ccp/funding/trust_fund.asp).

Fulfilling reporting requirements

Water quality monitoring results that address specific monitoring objectives outlined in the original Trust Fund proposal should be presented.

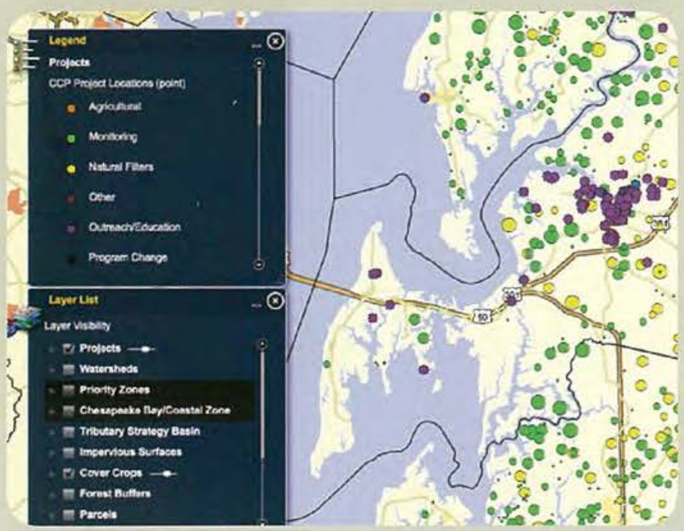
This should define initial, interim, and final nutrient and/or sediment loads and costs associated with the restoration activity. Changes in nutrient and/or sediment loading per dollar expenditure should be summarized and comparisons made with other similar studies to help build the knowledge base of BMP effectiveness.

Continuing life of BMPs following project completion

Funds to sustain Trust Fund BMP projects may end following successful implementation and monitoring, but this does not mean that continued efforts to maintain and expand the benefits of the original project should end. This requires additional funding and/or volunteer assistance. Ongoing BMP maintenance can be assisted through a written plan, inspection checklists, record keeping, periodic reviews, inspection personnel and education. Cost, safety and effectiveness are key factors in determining who and how maintenance needs will be carried out.

Fitting your BMPs into the big picture

It is important for Trust Fund recipients to step back and assess what role their BMP has in improving the general health of Chesapeake and Atlantic Coastal Bays. One tool to assist recipients in monitoring progress of their own BMP and others is via the Trust Fund mapper found on the Maryland Department of Natural Resource website (http://www.dnr.maryland.gov/ccp/funding/trust_fund.asp). This tool allows you to track project and spending progress on projects of interest in your area.



Influencing planning decisions with your BMP project

Data and knowledge gained from Trust Fund BMP design, construction and monitoring can influence planning decisions relevant to the immediate and surrounding watersheds where the BMP is located. The planning office of your local authority can advise you on how best to provide this information.

Continuing public support through engagement and education

It is important that those who live near Trust Fund BMPs, understand its purpose and the practices that keep it operating. Consider using a newsletter, signage or a neighborhood gathering to talk about and show the merits of the new BMP. For example, involving the community in on-going BMP maintenance activities is a cost-effective way to prolong the life of the BMP and to prevent pollution. Most of the time people are unaware that their activities contribute to pollution. Through education, people become aware of how their activities impact water quality and flooding, and they become stakeholders in protecting their environment.

The Chesapeake and Atlantic Coastal Bays Trust Fund was created in 2007 in an effort to reduce nutrient and sediment pollution to these bays. The Trust Fund has focused its financial resources on the implementation of effective non-point (i.e., diffuse) source pollution control projects using best management practices (BMPs) in high priority watersheds. Examples of projects supported by the Trust Fund include stream channel restorations, stormwater retrofits, and cover crops. Evaluating BMP effectiveness is necessary for demonstrating whether projects actually reduce pollutant yields. The current monitoring strategy indicates that BMPs implemented in Trust Fund projects must demonstrate a water quality response (e.g., improvement in water quality) within three years of completion.

This document provides an overview of the challenges facing Chesapeake and Atlantic Coastal Bays and provides guidance to potential and current Trust Fund recipients in determining suitable approaches for measuring BMP effectiveness.

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Cover Photo

Regenerative Stormwater Conveyance on the mainstem of Cypress Creek, Severna Park, MD
Photo courtesy of Michael Williams