COMMONWEALTH OF VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

WATER PLANNING DIVISION

Subject:	**Guidance Memo No. GM17-2004** **Guidance Manual for Total Maximum Daily Load Implementation Plans**
To:	Regional Directors, Melanie Davenport, James Golden, Jeffery Steers
From:	Jutta Schneider, Water Planning Division Director Jutta Schneider
Date:	June 6, 2017
Copies:	Water Permitting Managers, Water Planning Managers, Watershed Programs Staff

Summary:

This manual provides guidance to local governments, soil and water conservation districts, planning district or regional commissions, community watershed groups, and state and federal agencies on developing Implementation Plans (IPs) for waters where TMDLs have been completed. It also addresses the requirements for IPs as outlined in Virginia's 1997 Water Quality Monitoring, Information, and Restoration Act (§62.1-44.19:4 through 19:8 of the Code of Virginia), or WQMIRA. In addition to the requirements of WQMIRA, this guidance manual addresses the requirements of IPs based on EPA's "Guidance for Water-Quality Based Decisions: The TMDL Process," "Supplemental Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories," and "Guidance for Developing Watershed-Based Plans for Impaired Waters."

Electronic Copy:

An electronic copy of this guidance in PDF format is available on the Virginia Regulatory Town Hall website.

Contact information:

For additional information regarding TMDLs, please contact Mark Richards, Watershed TMDL Development Team Leader, at (804) 698-4392 or at mark.richards@deq.virginia.gov.

For additional information regarding TMDL Implementation Plans, please contact Ashley Wendt, TMDL Implementation Analyst, at (804) 698-4042 or at ashley.wendt@deq.virginia.gov.

Disclaimer:

This document is provided as guidance and, as such, sets forth standard operating procedures for the agency. However, it does not mandate or prohibit any particular action not otherwise required or prohibited by law or regulation. If alternative proposals are made, such proposals will be reviewed and accepted or denied based on their technical adequacy and compliance with appropriate laws and regulations.

GUIDANCE MANUAL FOR TOTAL MAXIMUM DAILY LOAD IMPLEMENTATION PLANS

The Commonwealth of Virginia:
Department of Environmental Quality

June 2017

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Table of Contents

APPENDICES

List of Abbreviations Used in the Manual

BASINS - Better Assessment Science Integrating Point and Non-Point Sources
BMP - Best Management Practice
BST - Bacterial Source Tracking
CEDS - Comprehensive Environmental Data System
CPP - Continuing Planning Process
CREP - USDA Conservation Reserve Enhancement Program
CRP - USDA Conservation Reserve Program
CUA - Census Urbanized Area
CWA - Clean Water Act
CWSR - Clean Water State Revolving Fund
DCR - Virginia Department of Conservation and Recreation
DEM - Digital Elevation Model
DEQ - Virginia Department of Environmental Quality
DMME - Virginia Department of Mines, Minerals and Energy
DOF - Virginia Department of Forestry
EPA - United States Environmental Protection Agency
ESC Program - Erosion and Sediment Control Program
EQIP - USDA Environmental Quality Incentives Program
FG - Future Growth
FSA - Farm Service Agency
FTE - Full Time Equivalent
GIS - Geographic Information System
GWLF - Generalized Watershed Loading Functions
HSPF - Hydrologic Simulation Programs in FORTRAN
HUC - Hydrologic Unit Code
IP - Implementation Plan
LA - Load Allocation
LDC - Load Duration Curve
LSPC - Loading Simulation Program in C++
MDAS - Mining Data Analysis System
MS4 - Municipal Separate Storm Sewer System
NASS – National Agricultural Statistics Service
NHD - National Hydrography Dataset
NPDES - National Pollutant Discharge Elimination System
NPS - Nonpoint Source
NRCS - Natural Resources Conservation Service
PCB - Polychlorinated Biphenyl
PDC - Planning District Commission
PS - Point Source
RCPP - USDA Regional Conservation Partnership Program
SERCAP - Southeast Rural Community Assistance Project
SLAF - Virginia Stormwater Local Assistance Fund
SSM - Single Sample Maximum
SWAP - Source Water Assessment Program
SWCD - Soil and Water Conservation District
SWM - Storm Water Management
TMDL - Total Maximum Daily Load

UAA - Use Attainability Analysis
UAL - Unit-Area Pollutant Load or Unit-Area Load
ULR - Unit-Load Reductions
USDA - United States Department of Agriculture
USGS - United States Geological Survey
VCAP - Virginia Conservation Assistance Program
VCE - Virginia Cooperative Extension
VDACS - Virginia Department of Agriculture and Consumer Services
VDH - Virginia Department of Health
VPDES - Virginia Pollutant Discharge Elimination System
VSMP - Virginia Stormwater Management Program
WIP - Watershed Implementation Plan
WLA - Waste Load Allocation
WQIF - Water Quality Improvement Fund
WQMIRA - Virginia Water Quality Monitoring, Information, and Restoration Act
WQMP - Water Quality Management Plan

Introductory Statement

This manual provides guidance to local governments, soil and water conservation districts, planning districts or regional commissions, community watershed groups, Total Maximum Daily Load (TMDL) Implementation Plan (IP) developers, and state and federal agencies on developing IPs for waters where TMDLs have been completed. It also addresses the requirements for IPs as outlined in Virginia's 1997 Water Quality Monitoring, Information, and Restoration Act (§62.1-44.19:4 through 19:8 of the Code of Virginia), or WQMIRA. In addition to the requirements of WQMIRA, this guidance manual addresses the requirements of IPs based on the Environmental Protection Agency's (EPA) *"Guidance for Water-Quality Based Decisions: The TMDL Process,"* "*Supplemental Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories,*" and "*Guidance for Developing Watershed-Based Plans for Impaired Waters."*

This manual also outlines both the recommended and required components of an IP. These elements are listed on page 3. Information pertaining to state and federal guidance for IPs is presented in Chapter 3.

An IP is prepared at some point following EPA approval of a TMDL study. The TMDL represents the maximum amount of pollutant that a waterbody (stream, lake, or estuary) can receive without exceeding water quality standards. TMDLs are pollutant-specific; consequently, waterbodies in which multiple pollutants violate water quality standards will have multiple TMDLs. The TMDL consists of a waste load allocation (WLA) or point source contribution, a load allocation (LA) or nonpoint source (NPS) allocation, and a margin of safety (MOS). IPs are pollutant-specific and should be designed to address multiple pollutants and their associated TMDLs within a waterbody.

Section 303(d) of the Clean Water Act and the EPA's Water Quality Planning and Management Regulation (40 CFR Part 130) require states to develop TMDLs for waterbodies that are exceeding water quality standards. Once a TMDL has been developed, a TMDL report is prepared and distributed for public comment and then submitted to EPA for approval. Following this process, an IP should be developed to describe actions (i.e., best management practices, educational programs, regulations) that should be implemented to meet the nonpoint source load allocations contained in the TMDL. In most cases, WLAs would be addressed through the Virginia Pollutant Discharge Elimination System (VPDES) Program administered by the Virginia Department of Environmental Quality (DEQ).

An IP may consist of two documents referred to as a public document and a technical document. The public document is a condensed version of the technical document and is designed to guide and inform stakeholders, particularly citizens. The technical report provides more detailed analytical information on how the plan was prepared including data used; it provides outputs to assist local technical staff who will be advising stakeholders on how to implement the plan.

Revisions of this manual may be necessary due to statutory or regulatory changes. As changes occur, periodic additions or supplements will be prepared for inclusion into the manual. This manual and any future revisions are available on the DEQ website at http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/ipguide.pdf.

Acknowledgements

The revision of the *Guidance Manual for Total Maximum Daily Load Implementation Plans* (2003) was developed under the direction of Charles Lunsford, Virginia Department of Environmental Quality (DEQ). Revisions of Chapters 4, 7, and 8 were developed by Brian Benham, Gene Yagow, Karen Kline and C.J. Mitchem with the Department of Biological Systems Engineering (BSE), Virginia Tech, Blacksburg, Virginia and Rick Thomas, Gregor Patsch, and Sheila Reeves with Timmons Group, Richmond, Virginia. BSE developed Chapter 5, not in the original 2003 manual. Nesha McRae and Margaret Smigo (DEQ) contributed to the update and revision content. Rick Hill and Heather Longo (DEQ) contributed to the editing and final manual format.

Components of a TMDL Implementation Plan

1.0 Executive Summary

Components of a TMDL Implementation Plan

1. **Executive Summary**
2. Introduction
3. State and Federal Requirements for Implementation Plans
4. Review of TMDL Development
5. Changes and Progress Since the TMDL Study
6. Public Participation
7. Implementation Actions
8. Measurable Goals and Milestones
9. Stakeholders' Roles and Responsibilities
10. Integration with Other Watershed Plans
11. Potential Funding Sources

The Executive Summary chapter of the IP is a summation of the implementation plan process. Because of this, it cannot be written until the IP has been completed.

The chapter should first provide information from the **Introduction** of the IP, such as background on why a TMDL was conducted for the waterbody, including specifics on the dates, the type(s) of impairment(s), and the water quality standard(s) violated. It should include a goal for the IP, such as "This plan was developed with the goal of achieving the reductions stated in the TMDL report and restoring these waters to a fully supporting status."

The Executive Summary chapter should include a summary of the **Review of TMDL Development**. This can include the agencies/organizations involved in the development of the TMDL, the pollutant sources, loads, and transport mechanisms considered in modeling, and the required reductions from the TMDL report.

A summary of any watershed(s) changes and TMDL implementation progress since completion of the TMDL(s), as presented in the chapter **Changes and Progress since the TMDL Study,** should be briefly referenced in the Executive Summary. These may include land use changes, updates to pollutant source assessment information, assessment of water quality monitoring data, and accounting for post-TMDL BMP implementation.

The Executive Summary should also include a section summarizing the **Public Participation** process in IP development. This section should recognize citizens and agencies that provided input for the IP and briefly describe the outputs of any public meetings, working groups, and steering committee meetings.

A brief summary of **Implementation Actions** should be included in this chapter. This summary can include a description of the assessment of actions needed to implement the TMDL and the analysis of implementation costs and benefits.

The Executive Summary should have a section describing the **Measurable Goals and Milestones** of the IP that addresses both implementation and water quality goals. A brief discussion of targeting efforts should also be included in this section.

Finally, the Executive Summary should mention **Stakeholders' Roles and Responsibilities**, **Integration with Other Watershed Plans**, if any, and **Potential Funding Sources**.

2.0 Introduction

*(The language and/or regulatory references included in this section may be inserted into the **Introduction** chapter of the IP.)*

The Clean Water Act (CWA) that became law in 1972 requires that all US streams, rivers, and lakes meet certain water quality standards. It also requires that states conduct monitoring to identify polluted waters or those that do not meet standards. Through this required program, the Commonwealth of Virginia has found that many stream segments do not meet state water quality standards for protection of the six beneficial uses: fish consumption, swimming, shellfishing, aquatic life, public water supply, and wildlife.

Components of a TMDL Implementation Plan

1. Executive Summary
2. **Introduction**
3. State and Federal Requirements for Implementation Plans
4. Review of TMDL Development
5. Changes and Progress Since the TMDL Study
6. Public Participation
7. Implementation Actions
8. Measurable Goals and Milestones
9. Stakeholders' Roles and Responsibilities
10. Integration with Other Watershed Plans
11. Potential Funding Sources

The Introduction should clearly indicate the

- topic of the IP
- purpose of the IP
- IP contents, including information on scope

The Introduction should also address the following questions:

- What is the impairment?
- What is the pollutant or cause of the impairment?
- What is the extent of the impaired segment?
- What is the extent of the watershed (i.e., watershed boundary)?
- What are the designated uses of the waterbody?
- What are the applicable water quality standards?

When streams fail to meet standards, Section 303(d) of the CWA and the EPA's Water Quality Management and Planning Regulation (40 CFR Part 130) require states to develop a TMDL for each pollutant. A TMDL is a "pollution budget" for a stream. That is, it sets limits on the amount of a pollutant a stream can tolerate and still meet a water quality standard. When a TMDL is developed, background pollutant concentrations, point source (PS) loadings, and nonpoint source (NPS) loadings are considered. A TMDL also accounts for a margin of safety as well as seasonal variations. Through the TMDL process, states establish water-quality-based controls to reduce pollution and meet water quality standards.

Once a TMDL is developed and approved by EPA, measures must be taken to reduce pollutant levels in the stream. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in a staged process. The types and number of BMPs, how they will be funded, and the details of implementation are described in a TMDL Implementation Plan (IP).

TMDLs are pollutant-specific, and a separate TMDL must be developed for each pollutant in a waterbody that violates water quality standards. In cases where TMDLs have been developed for multiple pollutants for a given waterbody, the IP should be designed to address the multiple pollutants concurrently. This approach allows multiple pollutant problems to be addressed at the same time by a system of BMPs capable of capturing and treating numerous pollutants. For example, livestock stream exclusion is an implementation action to reduce bacteria loadings to a stream. Fencing off the stream and restoring the riparian area (typically 35 feet) through implementation of buffers (grasses and/or trees) benefits the aquatic habitat and promotes progress toward reaching the general water quality (aquatic life) standard for the stream.

In general, the Commonwealth intends for pollutant reductions to be achieved in a staged fashion. Staged implementation is an iterative process that first addresses those pollutant sources with the largest impact on water quality. For example, livestock exclusion from streams is a promising management practice in agricultural areas of an impaired watershed. It has shown to be very effective in lowering bacteria concentrations in streams, both by limiting cattle manure deposits in the stream and from additional buffering in the riparian zone. Additionally, reducing the human bacteria loading from failing septic systems and straight pipes should be a focus during the first stage because of its health implications. Generally, the first stage of implementation for bacteria TMDLs in Virginia is attaining the de-listing goal, which means that the Single Sample Maximum (SSM) criterion is not violated more than 10.5% of the time. The second stage is full implementation of the TMDL, which in more recent TMDLs equates to not violating the geometric mean.

There are many benefits of staged implementation, including

- As stream monitoring continues, it allows for water quality improvements to be recorded as they are being achieved.
- It provides a measure of quality control given the uncertainties that exist in any model.
- It provides a mechanism for developing public support as communities observe progress in improving water quality.
- It helps to ensure that the most cost-effective practices are implemented initially.
- It allows for the evaluation of the TMDL’s adequacy in achieving the water quality standard.

With successful completion of IPs, Virginia provides a structured road map to water quality improvements based on informed methods for restoring impaired waters and enhancing the value of the Commonwealth’s water resources. Additionally, approved IPs provide stakeholders with enhanced opportunities to obtain grant funding for implementation of water quality improvement practices.

3.0 STATE AND FEDERAL REQUIREMENTS FOR IMPLEMENTATION PLANS

(The language and/or regulatory references included in this section may be inserted into the State and Federal Requirements for Implementation Plans chapter.)

There are a number of state and federal requirements and recommendations for IPs. The goal of this chapter is to clearly define these and explicitly state if the elements are required components of an approvable IP or merely recommended topics for inclusion. This chapter has three sections: 3.1) requirements outlined by the Virginia Water Quality Monitoring, Information, and Restoration Act (WQMIRA) that must be met to produce an IP that addresses the Commonwealth's requirements, 3.2) EPA-recommended elements of IPs, and 3.3) required components of an IP in accordance with EPA Section 319 guidance.

Components of a TMDL Implementation Plan

1. Executive Summary
2. Introduction
3. **State and Federal Requirements for Implementation Plans**
4. Review of TMDL Development
5. Changes and Progress Since the TMDL Study
6. Public Participation
7. Implementation Actions
8. Measurable Goals and Milestones
9. Stakeholders' Roles and Responsibilities
10. Integration with Other Watershed Plans
11. Potential Funding Sources

3.1 State Requirements

The TMDL IP is a <u>requirement</u> of Virginia's 1997 WQMIRA (§62.1-44.19:4 through 19:8 of the Code of Virginia) when the TMDL is not expected to be fully implemented through existing mechanisms (e.g., permits, implementation of local watershed plans). WQMIRA directs DEQ to provide "the expeditious development and implementation of total maximum daily loads." For IPs to be approved by the Commonwealth, they must meet the requirements outlined by WQMIRA.

WQMIRA requires that IPs include

- date of expected achievement of water quality objectives
- measurable goals
- necessary corrective actions
- associated costs, benefits, and environmental impact of addressing the impairment

IPs **must** include these four elements to meet WQMIRA requirements.

3.2 Federal Recommendations

Section 303(d) of the CWA and current EPA regulations do not require the development of implementation strategies. EPA does, however, outline the minimum elements of an approvable IP in its 1999 *Guidance for Water Quality-Based Decisions: The TMDL Process*. The listed elements include:

- a description of the implementation actions and management measures
- a timeline for implementing these measures
- legal or regulatory controls
- the time required to attain water quality standards
- a monitoring plan and milestones for attaining water quality standards

It is strongly suggested that IPs address EPA recommendations in addition to the required components described by WQMIRA.

3.3 Requirements for Section 319 Fund Eligibility

EPA develops guidelines that describe the process and criteria used to award CWA Section 319 nonpoint source grants to states. The guidance is subject to revision, and the most recent version should be considered for IP development. The *Nonpoint Source Program and Grant Guidelines for States and Territories in FY 2013 (www.epa.gov/nps/319)* identify the following nine elements that must be included in an IP to meet 319 requirements:

- Identify the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the watershed-based plan.
- Estimate the load reductions expected to achieve water quality standards.
- Describe the NPS management measures that will need to be implemented to achieve the identified load reductions.
- Estimate the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement the watershed-based plan.
- Provide an information/education component that will be used to enhance public understanding of the project and encourage the public's participation in selecting, designing, and implementing NPS management measures.
- Provide a schedule for implementing the NPS management measures identified in the watershed-based plan.
- Describe interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.
- Identify a set of criteria for determining if loading reductions are being achieved and progress is being made toward attaining water quality standards and if not, the criteria for determining if the watershed-based plan needs to be revised.
- Establish a monitoring component to evaluate the effectiveness of the implementation efforts.

Congress amended the Clean Water Act (CWA) in 1987 to establish the Section 319 Nonpoint Source Management Program. Under Section 319, states, territories, and tribes receive grant money, which supports a wide variety of activities including the restoration of impaired waters.

The EPA publication, *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (2008) (available: https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/handbook-developing-watershed-plans-restore-and-protect) provides details on the nine elements.

4.0 REVIEW OF TMDL DEVELOPMENT

Reviewing and summarizing the TMDL(s) within the IP provides background information for readers regarding the TMDL(s) addressed by the IP and explains why the pollutant control measures outlined in the IP are relevant. This can be especially helpful for stakeholders participating in the IP development process who were not involved in TMDL development. This chapter discusses which information from a typical TMDL report should be included in the IP report and includes examples illustrating the level of detail appropriate for a typical IP technical document. The level of detail in the public document should be minimal.

Components of a TMDL Implementation Plan

1. Executive Summary
2. Introduction
3. State and Federal Requirements for Implementation Plans
4. **Review of TMDL Development**
5. Changes and Progress Since the TMDL Study
6. Public Participation
7. Implementation Actions
8. Measurable Goals and Milestones
9. Stakeholders' Roles and Responsibilities
10. Integration with Other Watershed Plans
11. Potential Funding Sources

THE REVIEW OF TMDL DEVELOPMENT chapter should clearly indicate

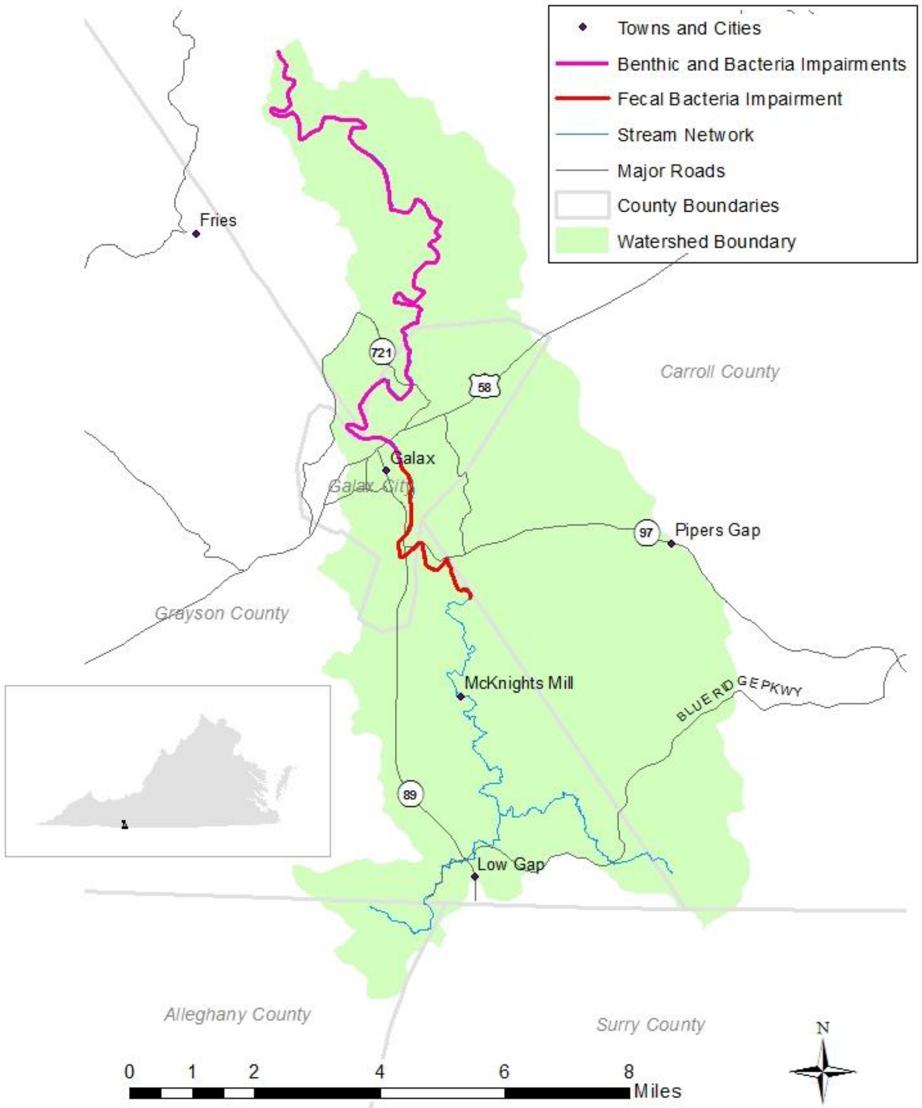
- impairment(s)
- watershed characteristics
- pollutant sources considered
- available monitoring data
- TMDL development approach
- TMDL load allocation scenario

4.1 Description of Impairment(s)

TMDLs are typically developed for specific segments of individual waterbodies that do not meet some applicable water quality standard. Water quality criteria violations exist when monitored water quality data exceed some numeric criteria (e.g., concentration-based limits for bacteria, dissolved oxygen, or metals), when monitoring of macroinvertebrates indicates that the current conditions within the waterbody do not support a healthy, diverse benthic (bottom-dwelling) fauna, or when fish tissue samples indicate excessively high concentrations of bioavailable pollutants (e.g., mercury, polychlorinated biphenyls (PCBs)). While each TMDL addresses a single impairment, implementation is most efficient when impairments and potential implementation actions are considered at the watershed level. Implementation addresses both impairments with completed TMDLs and nested impairments within the watershed. However, toxic substances such as mercury and polychlorinated biphenyls (PCBs) are currently not addressed by IPs in Virginia.

This section of the IP report should clearly identify the impaired segment(s) using data provided in Virginia's 305(b)/303(d) Water Quality Assessment Integrated Report (http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments/2014305(b)303(d)IntegratedReport.aspx) including a description of the location and extent of the impaired segment (length), what standard(s) violation(s) resulted in the impairment, and when each segment was first listed as impaired. A map illustrating the impaired segments (generally taken from the TMDL study report) within the watershed should also be included. In addition to the impaired segment and the watershed boundaries, the map should illustrate the watershed stream network, significant landmarks (e.g., towns, cities, major roads), and should include a scale, directional orientation, and a map legend. Figure 4.1 illustrates a map showing the appropriate level of detail.

Figure 4.1. Map illustrating impaired stream segments



Source: Chestnut Creek TMDL IP Public Document, *Figure 1. Location of the Chestnut Creek watershed and its stream impairments* (http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/ChestnutCrk_public_document_04SEP2015.pdf)

4.2 Description of Watershed Characteristics

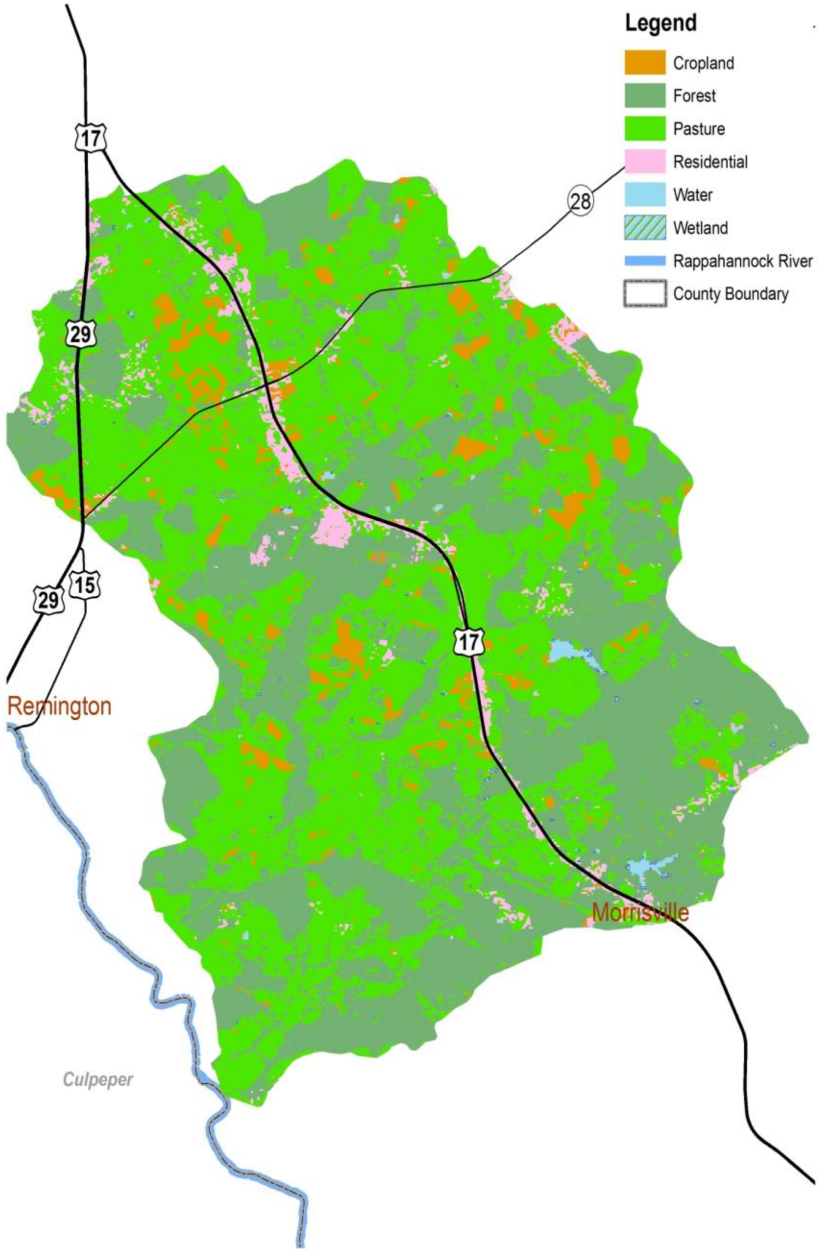
This section should specifically identify the watershed(s) for which the IP is being developed, including 12-digit federal hydrologic unit code (HUC), the Virginia 6th Order NWBD code, and the DEQ Assessment Unit ID and Cause code. The segment Unit ID is available from the DEQ Regional TMDL Coordinator or the Virginia 305(b)/303(d) Water Quality Assessment Integrated Report. A table can effectively summarize the watershed characterization information in the IP. Table 4.1 provides an example of how to present selected watershed characteristic data.

Table 4.1 Example of pertinent watershed characteristic data for inclusion in an IP

Watershed Characteristic	**Example Data**
12-digit Federal Hydrologic Unit Code (HUC)	050500011801 - Crab Creek (Montgomery County, Town of Christiansburg)
6^{th} Order Virginia NWBD Code (HUC)	NE58 - Crab Creek
Virginia Department of Environmental Quality (DEQ) Assessment Unit ID and Cause Code for each of the relevant segments	VAW-N18R_CBC01A00 - Crab Creek, N18R-01-BAC
DEQ Segment Unit ID and Cause Code for nested segments	VAN-A10R_DUT01A06 – Dutchman Creek (Loudoun County), Dutchman Creek, A10R-01-BAC
Source(s) and date(s) of land use data used for TMDL development	2011 National Land Cover Database (NLCD), 2012 National Agricultural Statistics Service (NASS)

In addition to watershed identity, this section of the IP should specify the watershed's size and its land use distribution with the source and date of data used during TMDL development specified. An understanding of the watershed characteristics, particularly the distribution of land use as a percentage of the total land area, is necessary when determining appropriate implementation actions (i.e., BMPs). The general categories of land use that are most commonly used when developing a TMDL include agricultural, residential, urban, and forest. These land uses may be further subdivided depending on the detail provided in the TMDL report. In cases where an IP includes several watersheds or a watershed with a large number of subwatersheds, the IP developer should consider presenting watershed characteristic data in tables. A map showing land use distributions should also be included. Figure 4.2 shows an example TMDL land use map to include in an IP.

Figure 4.2. Example of an appropriate land use map for an IP report



Source: Craig Run, Browns Run and Marsh Run Bacteria Total Maximum Daily Load Implementation Plan, *Fig.2. Land uses in the Craig Run, Browns Run, and Marsh Run watersheds*
(http://www.rrregion.org/pdf/TMDLs/BCM%20IP/Marsh_Run_Technical_Report_FINAL.pdf)

4.3 Description of Pollutant Sources Considered

This section should provide an overview of the various pollutant sources, including both point and nonpoint sources, characterized during TMDL development. Each TMDL includes a waste load allocation (WLA) portion that quantifies the fraction of the receiving water's loading capacity that is allocated to existing or future permitted point sources of pollution in the contributing watershed and a load allocation (LA) portion that quantifies the nonpoint sources. The TMDL also includes a margin of safety (MOS) that accounts for the uncertainty in the response of the waterbody to pollutant loading reductions.

Point source (PS) pollution comes from a discrete, identifiable source. Point sources can include pipes, outfalls, and conveyance channels from municipal wastewater treatment plants, industrial waste treatment facilities, confined animal feeding operations, industrial stormwater discharges, or municipal separate storm sewer systems (MS4s). PS discharges, from which pollutants are or may be discharged to surface waters of the Commonwealth, must apply for a Virginia Pollutant Discharge Elimination System (VPDES) permit. The VPDES permit program classifies dischargers of municipal and industrial wastewater into two categories based on type of discharge and volume:

Major: sewage with a design volume equal to or greater than 1.0 million gallons per day (Require EPA review)

Minor: sewage with a design volume of less than 1.0 million gallons per day; typically small industrial

The minor dischargers will receive one of two types of permits:

General: written for a general class of dischargers; must be adopted by the State Water Control Board.

Individual: requirements determined for each facility on a site-specific basis in order to meet applicable water quality standards

The VPDES permit program also classifies MS4s into three categories: large, medium and small. If included in the IP, the PS permits can be easily verified at the beginning and throughout the IP development process by checking with DEQ's Comprehensive Environmental Data System (CEDS) and verified by associated DEQ or DMME program staff.

In contrast, nonpoint source (NPS) pollution originates from diffuse sources on the landscape (e.g., agriculture and urban land uses) and is mainly influenced by precipitation events – runoff from rain or snowmelt. In some cases, a precipitation event is not required to deliver NPS pollution to a stream (e.g., direct deposition of fecal matter by wildlife or livestock or contamination from leaking sewer lines or straight pipes). Nonpoint sources are typically assessed during TMDL development through an extensive analysis of land use coupled with a consideration for delivery mechanisms (e.g., direct loadings to the stream or land-based loadings that require a precipitation event for delivery of the pollutants to the stream from pervious and impervious surfaces).

Loads from nonpoint pollution sources are typically summarized in the IP as a function of their associated land uses. Tables 4.2 and 4.3 illustrate how bacteria loads and sediment loads were summarized in the 2015 Buffalo, Colliers and Cedar Creeks IP, which addressed multiple impaired segments for two different pollutants, bacteria and sediment.

Table 4.2. Example table summarizing nonpoint source bacteria loading to stream

	Land Uses	Sources	Annual Fecal Coliform Load ($x10^{11}$ cfu/yr)	Percentage of Annual Load (%)
Land-based sources	Cropland	Wildlife: deer, raccoons, muskrats, ducks, geese (primarily near water)	507	0.2
	Pasture	Livestock; Wildlife: deer, raccoons, beaver, muskrats, ducks, geese (primarily near water)	192,110	94.8
	Residential	Pets; Wildlife: deer, raccoons, ducks, geese (primarily near water)	3,816	1.9
	Forest	Wildlife: deer, raccoons, beavers, muskrats, ducks, geese, turkeys	4,248	2.1
Direct deposit sources	Straight pipes	Dwellings with no septic or sewer connection	62	<0.1
	Livestock in stream	Livestock	1,553	0.8
	Wildlife in steam	Deer, raccoons, muskrats, ducks, geese	249	0.1
Total			**202,545**	**100**

Source: Buffalo, Colliers and Cedar Creeks TMDL IP, *Table 3.5. Estimated annual fecal coliform bacteria load in the Buffalo Creek watershed by source*
(http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Buffalo_Cedar_TechnicalDocument_3March2015.pdf)

Table 4.3. Example table summarizing existing sediment loading

Land Use/ Source Group	Area (ac)	Existing Sediment Load (tons/yr)
Row Crops	58.6	78.3
Pasture	3,610.3	8,689.4
Hay	1,236.0	1,355.2
Forest	17,099.8	1,092.8
Harvested Forest	172.7	92.3
Developed	1,181.5	755.0
Chanel Erosion	–	103.7
Permitted WLA	–	103.4
Total	**23,358.9**	**12,270.1**

Source: Buffalo, Colliers and Cedar Creeks TMDL IP, *Table 3.7 Estimated annual sediment load in the Colliers Creek watershed by land use.*
(http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Buffalo_Cedar_TechnicalDocument_3March2015.pdf)

4.4 Description of Available Monitoring Data

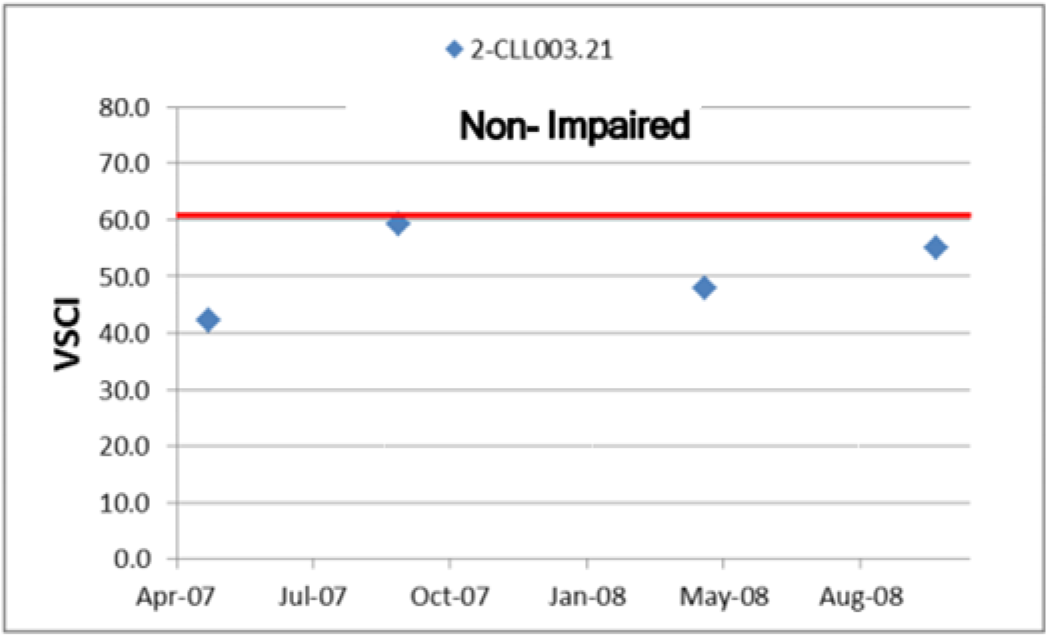
This section should provide a synopsis of the monitoring data used to identify the impairment and develop the TMDL(s) as a way to inform the reader of the water quality conditions at the time of TMDL development. A map should be included to identify the location of all monitoring stations and their positions relative to each other. As is shown in example Table 4.4 below, this section should additionally include a table listing each monitoring station, the parameter(s) used to identify the impairment, the period of record for the relevant parameters, the number of samples collected during that period, and some indication of the water quality standard exceedances that produced the impairment (e.g., for a bacteria impairment, the % violation rate of the relevant water quality criterion). In some cases the data may be more appropriately presented in a graph (e.g., Virginia Stream Condition Index (VSCI) data used to identify a biological impairment; Figure 4.3). Monitoring data used to identify impairments and develop TMDLs are typically collected by DEQ, but other data sources may also be available (e.g., United States Geological Survey (USGS), universities and colleges, local governments, citizen monitoring efforts, VADEQ's flow monitoring group, and partner agencies). All monitoring data used to develop a TMDL should be summarized in this section of the IP.

Table 4.4. Summary of monitoring data presented in the Buffalo, Colliers and Cedar Creeks IP

Station ID	Stream Name	Monitoring Type	Number of Samples	Violation Rate (%)	Period of Record
2-BFN000.07	North Fork Buffalo Creek	*E. coli*	12	17	2007 -2008
2-BFS000.15	South Fork Buffalo Creek	*E. coli*	23	4.8	2007 – 2012
2-BLD000.22	Buffalo Creek	*E. coli*	29	24	2003 – 2012
2-CLL001.99	Colliers Creek	*E. coli*	23	22	2007 – 2012
2-CEC000.04	Cedar Creek	*E. coli*	47	15	2008 – 2012
2-CEC003.60	Cedar Creek	*E. coli*	47	49	2008 - 2012

Source: Buffalo, Colliers and Cedar Creeks TMDL IP, *Table 3.3 DEQ biological and water quality monitoring stations in the Buffalo and Cedar Creek watersheds*
(http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Buffalo_Cedar_TechnicalDocument_3March2015.pdf)

Figure 4.3. Virginia Stream Condition Index (VSCI) scores for Colliers Creek



Source: Colliers Creek TMDL, *Figure 3.2. VSCI trend for Colliers Creek (CLL)* (http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/apptmdls/jamesrvr/MauryCedar_Bacteria_Benthic_FINAL.pdf)

4.5 TMDL Development Approach

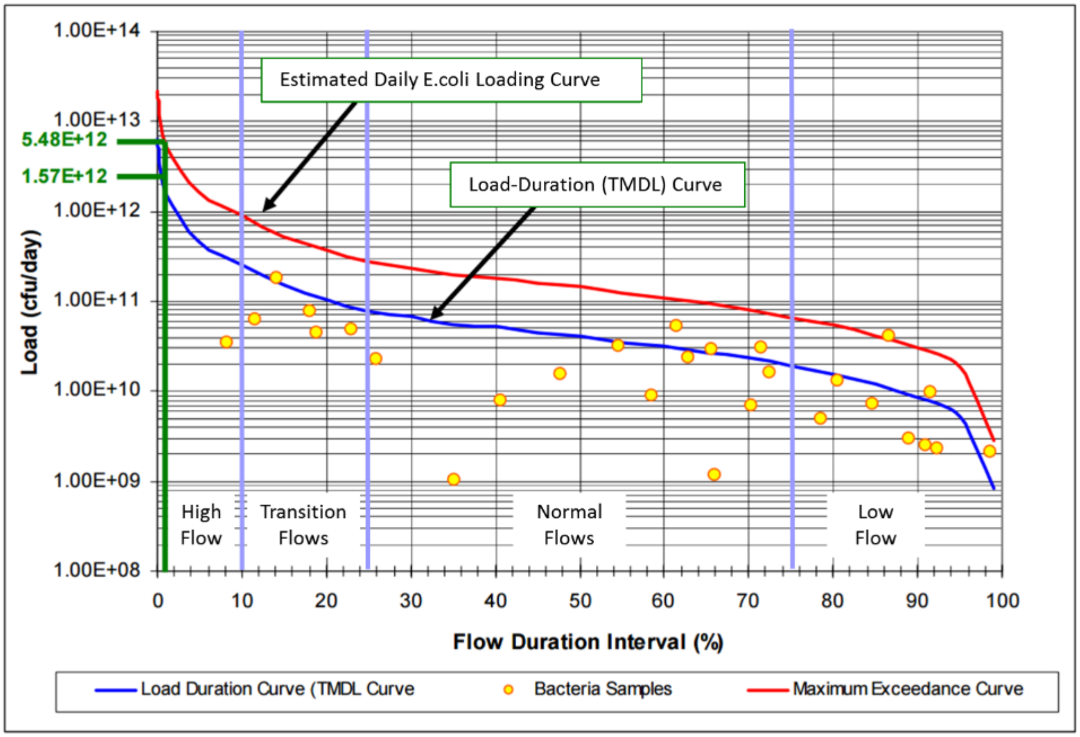
In Virginia, there are two basic approaches used to develop a TMDL: 1) a monitoring-based approach, and 2) a modeling-based approach. The approaches differ in the degree to which the watershed and pollutant sources in a watershed are characterized and quantified during the TMDL development process. In an IP, the approach used to develop the TMDL should be identified and briefly discussed to provide context for IP development.

Monitoring-based TMDL Development

When developing a TMDL for a waterbody in a watershed that has a clearly defined impairment source and/or when the watershed's land use is largely homogenous, the TMDL may be developed using a monitoring-based approach. In the monitoring-based approach, the TMDL and associated pollutant source reductions may be based on a Load Duration Curve analysis. A Load Duration Curve (LDC) is a plot of observed pollutant loads as a function of flow duration. In Figure 4.4, water quality data (pollutant concentrations) and flow data collected simultaneously at the same location are used to calculate observed pollutant loads. In an LDC TMDL, all pollutant sources will likely be reduced by the same amount in the TMDL allocation scenario.

A typical monitoring-based or LDC TMDL will be performed on a smaller scale, and have fairly uniform hydrology and land uses within the watershed. While the LDC method does not allow one to identify specific source loadings (e.g., residential versus agricultural), it does provide useful information about the conditions under which excessive pollutant loading occurs (i.e., high, normal, or low flow regime) and the general types of pollutant sources affecting the waterbody. As shown in Figure 4.4, the bacteria loads tend to follow a pattern similar to the flow, with lower loads occurring during lower flows (higher flow duration interval) and higher loads during higher flows (lower flow duration interval). This pattern indicates that surface runoff, traditionally associated with NPS pollution, is likely the cause of elevated bacteria levels, rather than direct loadings to the stream, which tend to dominate during low flows.

Figure 4.4. Example Load Duration Curve



Source: Neabsco Creek Bacteria TMDL, *Figure 15. Load-duration curve illustrating the TMDL and estimated E. coli load for Neabsco Creek at Station 1ANEA002.89* (http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/potrvr/neabsco.pdf)

Shellfish TMDLs developed in Virginia prior to 2011 were based on a simple volumetric model, because the character of the waterbody is simple from a hydrologic perspective. The waterbody is small in both area and volume with generally a single, unrestricted connection to the receiving waters. Bacteria source tracking (BST) analysis projected the amount of bacteria contributed from human, livestock, pets, and wildlife sources. The TMDL current source loads were based on BST analysis that identified the percent of the total waterbody bacteria load contributed by each of those four nonpoint sources. An allowable load was calculated by reducing each of the nonpoint source loads by a percentage, so the receiving waterbody load does not violate the fecal coliform standard for shellfish consumption. See Table 4.5 for an example table summarizing fecal coliform source reductions from a shellfish TMDL. Since 2011, DEQ has been developing shellfish TMDLs using a modeling-based approach.

Table 4.5. TMDL summary for shellfish impairment

Source	BST Allocation (% of Total Load)	Current Load (MPN/day)	Allowable Load (MPN/day)	Required Reduction
Livestock	31	3.38E+10	8.54E+09	75
Wildlife	14	1.53E+10	1.53E+10	0
Human	38	4.14E+10	0.00E+00	100
Pets	17	1.85E+10	8.54E+09	54
Point Source	–	–	3.27E+08	0
Total	**100**	**1.09E+11**	**3.27E+10**	**70**

Source: Mattawoman Creek TMDL, *Table E.2: TMDL Summary for the Bacteria Impairment of Growing Area 86: Mattawoman Creek Shellfish Condemnation 136C. Current Loads and Estimated Load Reductions Based Upon the Geometric Mean Standard* (http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/baycoast/mattawoman.pdf)

In Virginia, TMDLs developed using the LDC approach typically do include watershed and pollutant source characterization data with enough detail that the IP can include summaries of the watershed's land use distribution and both point and nonpoint pollutant sources. However, because an LDC TMDL does not typically include a spatially explicit (i.e., subwatershed scale) watershed and pollutant source characterization analysis, the IP developer must generally perform an additional, more in-depth watershed and pollutant source assessment before developing the IP. Developers preparing IPs for shellfish TMDLs based on BST analysis also need to conduct a more in-depth source assessment. They must also evaluate the delivery of bacteria for direct and indirect sources, delivery rates of bacteria to the waterbody from different land uses, and instream mixing and distribution of the bacteria using a tidal prism model or other models if available.

When a monitoring-based TMDL development approach is used, the IP should provide details about the data used to develop the LDC (e.g., station location, relevant water quality parameters collected, period of record for data considered when developing the TMDL, range of measured values).

Modeling-based TMDL Development

When the modeling-based TMDL development approach is used, contractors (private consultants and/or university researchers) working with DEQ use coupled hydrology/water quality models to predict water quality based on watershed and pollutant source characterization data. The computer models are used to simulate the transport and fate of various pollutants in the target watershed and impaired waterbody in response to precipitation and other climate conditions. Several different pollutant-management or TMDL load-reduction allocation scenarios can be evaluated using the model.

TMDLs developed using the modeling-based approach typically include more spatial detail than a monitoring-based TMDL. Pollutant sources may be explicitly represented as a time-series model input, (e.g., direct deposition of bacteria into a stream by cattle with unrestricted access to the stream), or as a function of a given land use (e.g., bacteria losses from animal manure applied to cropland as fertilizer or sediment losses from fields subject to a certain type of tillage). The level of detail required to accurately link watershed and pollutant source characteristics to water quality (i.e., modeling) provides an advantage to the IP developer, because the more detailed watershed and pollutant source characterization required for a modeling-based TMDL allows the IP developer to better understand the type of pollution control measures needed and where those measures might be most effective. Several models have been used to develop TMDLs in Virginia for a variety of pollutants under various conditions (e.g., upland freshwater streams, urbanized watersheds, and downstream, tidal freshwaters and estuarine waters). Below, find brief descriptions of common models used to develop TMDLs in Virginia.

Generalized Watershed Loading Function Model (GWLF): GWLF is an empirically-based model that simulates streamflow and nutrient and sediment loading from both pervious and impervious areas. The model considers the watershed as a single unit and aggregates loads from all land use areas into a watershed total, but it can also be used to configure subwatersheds as separate models to increase spatial variability. It allows for different land use types and areas to contribute runoff volumes and nutrient and sediment loads for each of them. It is a continuous simulation model which uses daily time steps to determine the stream flow and nutrient and sediment loadings based on weather data and water balances. The GWLF model uses a lumped parameter approach, so source areas are not calculated as spatially distributed (Borah et al, 2006). BMPs can be simulated through land use changes, changes in loading factors, and application of efficiency factors during post-processing (i.e., spreadsheet-based analysis) of model output (Yagow, 2004). In Virginia, GWLF is most commonly used to develop sediment TMDLs, but it has also been used to develop nutrient TMDLs.

Hydrologic Simulation Program – FORTRAN (HSPF): HSPF simulates both point and nonpoint pollutant sources, performs flow routing through streams and reservoirs, and simulates in-stream water quality processes (Duda et al., 2001). It is an example of a complex watershed-scale, continuous, process-based, lumped-parameter model that combines watershed data, pollutant source physical data, and a substantial set of parameters to simulate hydrology and pollutant transport and fate (Donigian et al, 1995; Migliaccio and Srivastava, 2007). HSPF simulates the movement of water, sediment, and a wide range of water quality constituents (e.g., nutrients, sediment, bacteria) on pervious and impervious surfaces, in soil, in streams, and in well-mixed reservoirs. HSPF is typically run using an hourly time step. In Virginia, HSPF is most commonly used to develop bacteria TMDLs, but it has been used to develop TMDLs addressing other pollutants including PCBs. HSPF is part of a larger modeling software package that is supported by EPA called BASINS (Better Assessment Science Integrating Point and Non-Point Sources; http://water.epa.gov/scitech/datait/models/basins/index.cfm). While the BASINS package can be useful in structuring an HSPF model, the geo-spatial data included in the BASINS package is often coarser in resolution than can be obtained locally for improved discretization of watershed characteristics for the development of local TMDLs in Virginia.

Loading Simulation Program in C++ (LSPC): LSPC is a watershed modeling system that includes streamlined HSPF algorithms for simulating hydrology and general water quality constituents, as well as a simplified stream transport model. LSPC was derived from the Mining Data Analysis System (MDAS), which was developed by EPA and has been widely used for mining applications and TMDLs. The MDAS system also contains a module to assist in TMDL calculation and source allocations. For each model run, it automatically generates comprehensive text file output by subwatershed for all land layers, reaches, and simulated modules, which can be expressed in hourly or daily intervals. The Microsoft Visual C++ programming architecture allows for seamless integration with modern-day, widely-available software such as Microsoft Access and Excel (EPA, 2016). In Virginia, LSPC is occasionally used to develop bacteria TMDLs, but it has also been less frequently used to develop TMDLs addressing other pollutants, such as PCBs.

Tidal Prism: Tidal prism is a mass balance model simulating the physical transport processes and biogeochemical kinetic processes in small coastal basins and associated tributaries using the concept of tidal flushing. The physical and biogeochemical processes are decoupled; non-conservative substances are calculated in time steps within the tidal cycle, and physical processes are modeled with a tidal cycle time step. The tidal prism model requires cross sections at specific intervals throughout a modeled reach, including tributaries, in order to model changes in intertidal and stream inflow volumes within the reach (Kuo et al., 2005). In Virginia, tidal prism is most commonly used to develop estuarine recreational and shellfish bacteria TMDLs.

When a modeling-based TMDL development approach is used, the IP should summarize critical modeling-related information in the TMDL review chapter. The following modeling-related information should be included in the IP:

- modeling software and the version used (e.g., HSPF,v.12.2); include relevant citations/URLs, as needed
- period of record (dates) used for model calibration and validation (note: some models may be applied without calibration)
- IDs of water quality station(s) used to calibrate and validate the TMDL model (include DEQ station ID, name, description, and period of record of available data)

4.6 TMDL Load Allocation Scenario

Each TMDL report will include a section that specifies the level of pollutant reduction needed from specific pollutant sources to meet the TMDL (i.e., the TMDL load allocation scenario). The level of detail provided in this section will be a function of the method used to develop the TMDL. As previously discussed, monitoring-based TMDLs will have less TMDL load allocation detail. TMDLs developed using a modeling-based approach will have more detailed TMDL load allocation scenarios, because the model used to develop the TMDL will have also been used to compare alternative TMDL allocation scenarios. Typically, point sources (the TMDL WLA) are addressed through VPDES permits. As a result, the TMDL load allocation scenario focuses on NPS pollutants.

This section of the IP should summarize the TMDL load allocation scenarios presented in the TMDL. The water quality criteria used to develop the TMDL should also be referenced to provide perspective and context for the pollutant load reductions called for in the TMDL load allocation scenario. Herein, the IP developer should clearly identify the water quality goal that will be used when developing the IP. TMDLs, particularly bacteria TMDLs, often show two allocation targets. The first is a delisting target where the TMDL developer has determined the bacterial load reductions needed to achieve a SSM bacteria violation rate that is not exceeded greater than 10.5 % of the time. The second allocation target is the condition where there are zero violations of the geometric mean and SSM water quality bacteria criterion. This second target requires greater load reductions. As a result, bacteria TMDL IPs include multiple phases or stages, wherein the first stage is developed in most cases to achieve the delisting reduction target.

Table 4.6 provides an example of a TMDL allocation scenario developed for the monitoring-based (LDC) Neabsco Creek bacteria TMDL. This TMDL load allocation scenario corresponds to the LDC shown in Figure 4.4. Note that the “Required Reductions” specified in Table 4.6 are uniform across all applicable bacteria sources.

Table 4.6. Load allocation for a monitoring-based bacteria TMDL

	WLA (Excluding MS4) (cfu/day)	MS4 and LA (cfu/day)				
	VPDES Point Sources	Humans 0%	Pets 20%	Livestock 1%	Wildlife 79%	Totals (cfu/day)
Existing Daily Load	4.39×10^{10}	0	1.09×10^{12}	5.44×10^{10}	4.29×10^{12}	5.48×10^{12}
Required Reductions	N/A	N/A	75%	75%	75%	71%
Allowable Load/TMDL Load	2.20×10^{10}	0	2.70×10^{11}	1.35×10^{10}	1.07×10^{12}	1.57×10^{12}

Source: Neabsco Creek Bacteria TMDL, *Table 21. Daily load distribution, reduction, and allowable load by source category for Neabsco* (http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/potrvr/neabsco.pdf)

Table 4.7 provides a bacteria TMDL source load allocation example for Glade Creek that was included in the Upper Roanoke River IP. This TMDL was developed using the modeling-based approach (HSPF).

Table 4.7. Source load allocations for a modeling-based bacteria TMDL

	Annual Average *E. coli* Loads (cfu/yr)		
2006 Land Use/Source	**Existing**	**Allocation**	**Percent Reduction (%)**
Developed	2.65E+15	9.95E+13	96
Cropland	1.24E+13	4.67E+11	96
Pasture/Hay	1.15E+15	4.30E+13	96
Forest	1.85E+15	1.58E+14	91
Water/Wetland	4.51E+11	4.06E+10	91
Other	2.07E+12	7.77E+10	96
Livestock Direct	3.03E+12	0.00E+00	100
Wildlife Direct	1.30E+14	3.89E+13	70
Failing Septic Systems	1.51E+13	0.00E+00	100
Total	**5.82E+15**	**3.40E+14**	**94**

Source: Upper Roanoke River TMDL IP, *Table 3-6: Glade Creek/Laymantown Creek Load Allocation for E. coli.* (http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Drafts/Upper_Roanoke_Draft_IP.pdf)

The two TMDL allocation examples presented thus far have dealt with bacterial impairments. Table 4.8 shows the sediment TMDL load allocation that was modeled to address a benthic impairment on the Roanoke River. The reductions reflect a uniform load reduction of 75% across all land use and instream sources. The TMDL allocation example shows no reduction in point sources of sediment.

Table 4.8. Load allocation reductions for a modeling-based sediment TMDL

2006 Land Use Category		**Existing Load (tons/year)**	**Allocated Load (tons/year)**	**Percent Reduction (%)**
Land Sources	Developed	7,465	1,862	75
	Cropland	95	24	75
	Pasture/Hay	561	140	75
	Forest	396	99	75
	Water/Wetlands	–	–	–
	Other	393	98	75
Instream Erosion		17,268	4,307	75
Point Sources		295	295	0
	Total	**26,473**	**6,824**	**74**

Source: Upper Roanoke River TMDL IP, *Table 3-24: Roanoke River load allocation for sediment* (http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Drafts/Upper_Roanoke_Draft_IP.pdf)

Using the model developed for the TMDL study, allocation scenarios that result in attainment of the applicable water quality criteria are developed for stakeholder consideration. The TMDL report also includes a chapter discussing reasonable assurance and implementation. The information provided in the TMDL Implementation chapter may be useful in selecting appropriate implementation actions.

5.0 CHANGES AND PROGRESS SINCE THE TMDL STUDY

Watersheds may undergo alterations in the time between TMDL completion and IP development. Some changes impact the previously-developed TMDL modeling, simulation and/or calculation of existing loads, and/or load reductions. Such differences may require official TMDL modification in consult with DEQ and in accordance with DEQ's public participation policy prior to IP development. Other changes include those related to the dynamic nature of the watershed, such as changing land uses, human and animal populations, BMP implementation, and water quality variations detected in ongoing monitoring. Effective IPs document these alterations and their effects on loads and reductions by using data to illustrate relevant TMDL revisions.

Components of a TMDL Implementation Plan

1. Executive Summary
2. Introduction
3. State and Federal Requirements for Implementation Plans
4. Review of TMDL Development
5. **Changes and Progress Since the TMDL Study**
6. Public Participation
7. Implementation Actions
8. Measurable Goals and Milestones
9. Stakeholders' Roles and Responsibilities
10. Integration with Other Watershed Plans
11. Potential Funding Sources

The CHANGES AND PROGRESS SINCE THE TMDL STUDY Chapter should clearly indicate

- changes that may have required formal TMDL modifications prior to IP development
- changes that may require modifications to TMDL modeling during IP development
- changes that may affect the WLA
- accounting for BMP implementation (by watershed since TMDL was completed)
- updates to source assessment as appropriate
- assessment of monitoring data post-TMDL study

5.1 Changes that may require TMDL Modifications

Changes that affect the information on which TMDL load allocations and reductions are based may require a formal modification of the TMDL document before IP development. These include updates in evaluated model input parameter values, such as those that affect land use distribution or channel erosion loads, and changes in watershed boundaries, which may even affect WLA calculations. If the need for TMDL modification is identified during implementation planning, DEQ should be consulted as to whether the IP should be delayed until the TMDL is appropriately updated and re-submitted for approval, as was the case with the Hardware River IP.

5.1.1 Changes that affect the simulated existing and TMDL loads and load reduction scenarios

Two types of typical situations affect one or more of the load calculations in the TMDL: modifications to TMDL land use distribution and/or characterization and modifications to TMDL modeling. Either of these scenarios may be uncovered during implementation planning when determining methods for load reductions.

Modifications to TMDL land use distribution and/or characterization

Modifications to land use distribution and/or characterization may result from a misinterpretation of proper land use classifications, errors uncovered in watershed boundaries, and other errors in evaluation of individual model input parameter values. For instance, during analysis of land use data from the Smith Creek TMDL study, a small amount of land (24.83 acres) had been classified as transitional (areas transitioning from one land use to another, commonly exhibiting large amounts of disturbance) in the Gap Creek area. This land was then re-assessed during IP development as mixed forest areas with rock-outcrops and reassigned to the “forest” land use category.

Also during implementation planning for Smith Creek, an error in the watershed boundary was discovered. It most likely arose from the use of digital elevation model (DEM) elevation data to define the drainage area during the TMDL study. Because this boundary was not consistent with the state 6th Order 12-digit NWBD HUC watershed boundaries, the TMDL watershed boundary was adjusted to the 6th Order 12-digit NWBD HUC watershed boundary in the one affected subwatershed and the Harrisonburg MS4 area. Subwatershed, total watershed, and MS4 acreages were revised accordingly. This boundary change also modified the length of roads available for street sweeping within the City of Harrisonburg, the perennial stream length in the Harrisonburg portion of the Smith Creek watershed, the percentage of the load attributable to the MS4 area and the pet waste load. These changes in area, baseline loads, and target loads in the Smith Creek IP are summarized in a single table (Table 5.1) as one way of illustrating the changes between the original and revised calculations.

Table 5.1. Example summary of sediment loads and IP target loads based on original and revised watershed boundaries

			Sediment Loads			
	Watershed Area (acres)		**Existing Load (tons/yr)**		**IP Target Load (tons/yr)**	
Sediment Load Categories	**Original**	**Revised**	**Original**	**Revised**	**Original**	**Revised**
Forest	33,598.4	33,480.3	149.9	149.3	149.9	149.3
Water	100.8	97.7	0	0	0	0
Pasture	28,985.3	28,731.3	12,205.6	12,098.6	9,520.3	9,436.9
Cropland	2,656.1	2,622.0	2,705.9	2,671.3	2,110.6	2,083.6
Transitional	158.6	76.2	232.6	111.8	181.4	87.2
Urban Non-MS4	1,999.7	1,972.4	51.5	12.9	40.2	10.1
MS4	499.3	153.0	12.9	3.2	10.0	2.5
MS4 as % of Urban	20.0%	7.2%	–	–	–	–
Totals	**67,999.0**	**67,133.0**	**15,358.3**	**15,047.1**	**12,012.5**	**11,769.6**

Adapted from: Smith Creek TMDL IP (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/smithip.pdf)

Modifications to TMDL modeling

When a TMDL is developed using a model (e.g., HSPF, GWLF), it is important for the IP contractor to become familiar with the model files and be able to reproduce the results from the TMDL study. Occasionally, TMDL model errors in software coding, unit conversion, human input, parameter estimation procedures, and others may be revealed. For instance, during implementation planning for Stroubles Creek, a separate research project provided site-specific field-based measures of channel erosion. These measures revealed that channel erosion rates used in the TMDL were greatly underestimated. Because sediment was the identified pollutant, this meant that any BMP employed during implementation to address the channel erosion component would not represent accurate reductions in an IP. Therefore, an adjustment to the existing loads was made in the IP.

5.1.2 Changes that may affect the WLA

Changes that may affect the WLA include expiration of old permits, addition of new permits, and/or changes in permit limits. If a reserved Future Growth (FG) allocation is incorporated in the TMDL, new permits’ allocations may be taken from the FG allocation. Where a FG allocation is not included or is insufficient to accommodate new permits, changes to the TMDL and/or rebalancing allocations between LA and WLA may be required.

Another change that may affect the WLA is the inclusion of new MS4 areas within a given watershed. Every 10 years in conjunction with the decennial US census, areas of dense population are identified as Census Urbanized areas (CUAs). Existing CUAs identified in previous decennial censuses may increase in area or new CUAs may be identified. Owners or operators of MS4s in CUAs are subject to MS4 regulations. Additionally, regulated MS4 permittees may more specifically define the area served by the MS4, which may not match previous regulated MS4 service area assumptions used in modeling. All of these scenarios would require changes to the WLA that may not have been envisioned during the TMDL study. Another source of change or predicted growth are local long-term plans. These may outline when and where growth has occurred or may be occurring.

5.2 Changes and Progress that affect the IP

5.2.1 Interim BMP Implementation

The IP should account for load reductions calculated for all BMPs installed since the TMDL and verified to be within their life span and currently functioning. For example, in the Upper Roanoke River IP Part 1 (2016), which included a large number of reported stormwater BMPs by local governments without installation dates, the contractor used one-half the BMP efficiency for those BMPs with unknown installation dates. These interim load reductions will not affect the TMDL but will result in a reduced load remaining to be addressed through the IP.

An inventory of agricultural BMPs that receive state and/or federal cost-share funding is maintained by the Virginia Department of Conservation and Recreation (DCR) and can be obtained directly from a query of their web-based database (http://dswcapps.dcr.virginia.gov/htdocs/progs/BMP_query.aspx) for a specified range of dates at the 6th Order 12-digit NWBD HUC watershed level. Similar data at either the 6th Order 12-digit NWBD HUC or smaller watershed level can be directly requested from DEQ TMDL staff. Urban and residential stormwater BMPs are generally accounted for via requests from DEQ to local governments. Table 5.2 is an example of how BMPs implemented between the TMDL and implementation planning can be summarized in the IP.

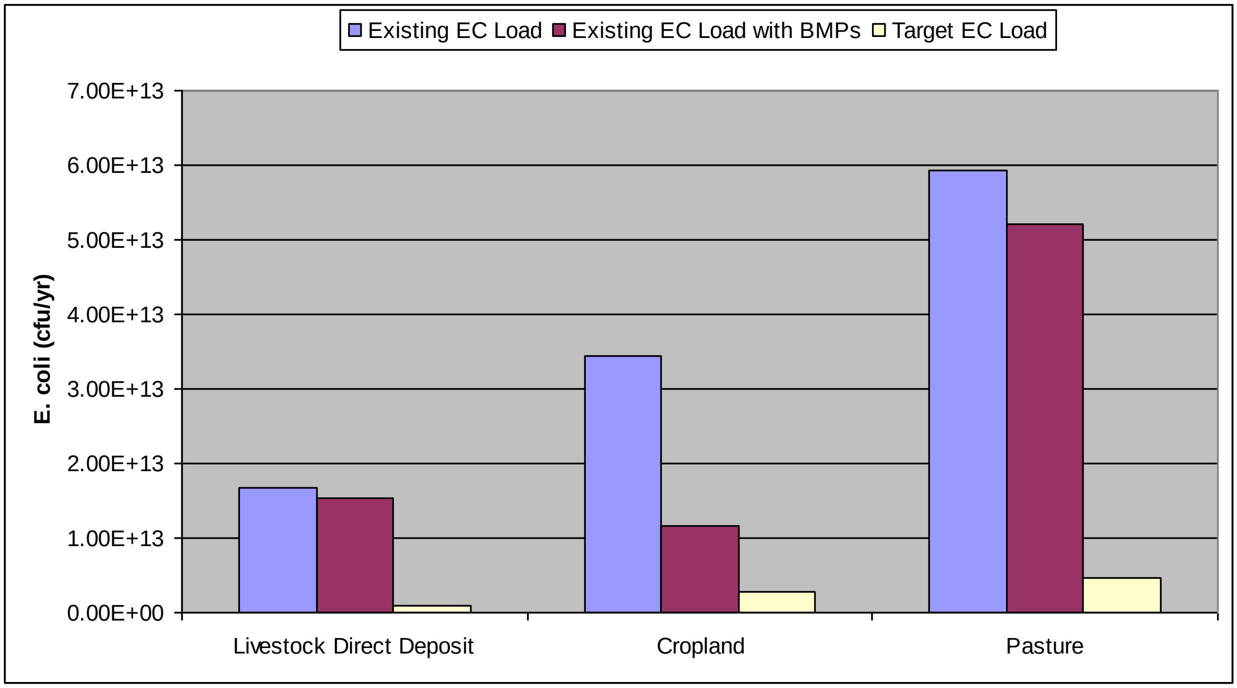
Table 5.1. Summary of agricultural BMPs implemented in the Smith Creek watershed between the completion of the TMDL and IP development

BMP Code	BMP Name	Extent Installed	Units	Area Benefitted (Ac)	Animal Waste Treated (tons/yr)
SL-1	Permanent vegetative cover on cropland	71.9	Acres	71.9	–
SL-11	Permanent vegetative cover on critical areas	30.5	Acres	3.4	–
SL-11B	Heavy traffic animal travel lane stabilization	00.2	Acres	35.1	–
SL-5	Diversion	1,760.0	Linear ft	35.0	–
SL-6	Grazing land protection	4,780.0	Linear ft	283.1	–
SL-8B	Small grain cover crop	2,586.9	Acres	2,638.5	–
WP-2	Stream protection	2,060.0	Linear ft	20.0	–
WP-3	Sod waterway	1,850.0	Acres	1.3	–
WP-4	Animal waste control facility	4.0	System	–	45,863
WQ-1	Grass filter strips	18.6	Acres	18.6	–

Adapted from: Smith Creek TMDL IP (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/smithip.pdf)

As the example in Figure 5.1 illustrates, IPs should also include data on load reductions that may be credited to installation of BMPs (post-TMDL to IP start-up) based on accepted BMP pollutant reduction efficiencies and land use loading rates. Current nitrogen, phosphorus, and sediment load reduction information for many BMPs is available under the Resources section at http://www.vasttool.org/Documentation.aspx. For load reductions for BMPs or pollutants (e.g., bacteria) not included therein, reduction efficiencies or unit-load reductions from documented literature sources or based on reasonable assumptions may be used in consultation with the DEQ Nonpoint Source Coordinator.

Figure 5.1. Bacteria load reductions in Smith Creek credited to BMPs implemented between the completion of the TMDL and IP development



Source: Smith Creek TMDL IP, *Figure ES- 3. Progress in Bacteria Load Reductions in Smith Creek Watershed* (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/smithip.pdf)

5.2.2 Changes in land use and populations

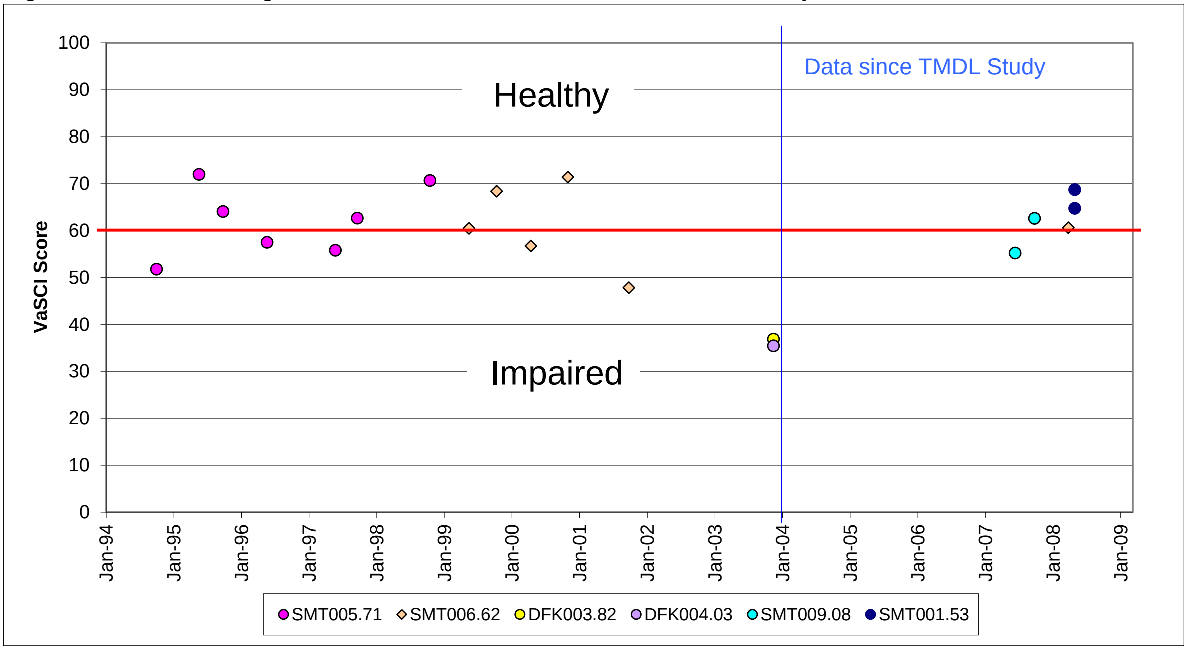
Because many pollutants are simulated as a function of either land use or population, it is important to look at how watershed changes in land use distribution and populations of humans, livestock, wildlife, and pets may have altered existing pollutant loads in the time since TMDL development. For shellfish TMDLs, where source load reductions are based on BST results (human, livestock, wildlife and pets), it will be necessary in the IP development process to inventory current populations of those sources. This is necessary to quantify direct and indirect bacteria loads from these sources and to assess pathways and delivery of bacteria loads from these sources to receiving waters.

5.2.3 Monitoring

To evaluate ongoing changes in water quality, monitoring typically continues at one or more DEQ monitoring sites in the watershed after TMDL completion. Volunteer citizen groups also offer a valuable resource in ongoing monitoring in TMDL watersheds. Coordination with Citizen Monitoring (CitMon) groups can result in better evaluation of the watershed's water quality and enable better implementation planning. Efforts to highlight CitMon data and contributions in reports, presentations, and conversations should be made. More information on citizen monitoring is available at
http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/Citize

nMonitoring.aspx and
http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/CitizenMonitoring/FollowupMonitoring.aspx. See also Section 8.1.2 below.
The IP should include graphs or tables to summarize relevant data that include the interim period, as shown in Figure 5.2 and Table 5.3.

Figure 5.2. Monitoring in Smith Creek before and after TMDL completion



Adapted from: Smith Creek TMDL IP (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/smithip.pdf)

Table 5.3. *E. coli* single sample maximum criterion violation rates in Chestnut Creek before and after TMDL completion

		Before TMDL Study[1]			Since TMDL Study[2]		
VADEQ Station	Stream	Sample dates	No. of samples	Criteria violations (%)	Sample dates	No. of samples	Criteria violations (%)
9CST002.64	Chestnut Creek	03/05-08/05	4	25	12/05-11/10	19	16
9CST016.82	Chestnut Creek	07/02-08/05	16	38	09/05-11/08	19	16

[1] Adapted from: Chestnut Creek TMDL Report (http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/newrvr/chestnut.pdf)
[2] Adapted from: Chestnut Creek Implementation Plan (http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/ChestnutCrk_public_document_04SEP2015.pdf)

An analysis of monitoring data collected during the interim period could compel modifications to source allocations before proceeding with implementation planning. For example, during development of the Bacterial Implementation Plan for the James River and Tributaries – City of Richmond (MapTech, 2011), an inspection of bacteria concentration data collected in Reedy Creek after TMDL development revealed higher values than those used to develop the TMDL. A recalibration of the Reedy Creek *E. coli* model was performed using the more recent bacteria data, which resulted in a different set of source allocations that were then used in implementation planning.

6.0 PUBLIC PARTICIPATION

Components of a TMDL Implementation Plan

1. Executive Summary
2. Introduction
3. State and Federal Requirements for Implementation Plans
4. Review of TMDL Development
5. Changes and Progress Since the TMDL Study
6. **Public Participation**
7. Implementation Actions
8. Measurable Goals and Milestones
9. Stakeholders' Roles and Responsibilities
10. Integration with Other Watershed Plans
11. Potential Funding Sources

Because of their interest in and familiarity with local water quality needs and conditions, individuals, agencies, organizations, and businesses within the watershed(s) offer invaluable input for the development and execution of an IP. Public participation facilitates dialogue between local stakeholders and government agencies to develop goals and milestones that are locally acceptable and provides information on resources such as funding and technical assistance available to support TMDL implementation. Community members are best suited to identify and resolve sources of water quality problems.

In many watersheds across Virginia, there are a number of diverse watershed planning activities led by individuals, nonprofits, community groups, and government. These include basinwide water quality management plans (WQMPs), the Chesapeake Bay Watershed Implementation Plan, roundtables, and comprehensive plans (further details in Chapter 9).

Questions to consider in formulating a PUBLIC PARTICIPATION process:

- What partnerships currently exist in the watershed that could enhance public participation?
- What local media resources can be used to enhance public understanding?
- What are the target audiences in the watershed?
- What are the concerns and priorities of the target audiences?
- Which strategies are best suited for reaching and engaging the public in this watershed?

PUBLIC PARTICIPATION in the development of TMDL IPs may be facilitated through

- public meetings
- working groups
- a steering committee
- websites
- the media
- mailings/surveys

In many cases, stakeholder involvement in the IP process may involve coordination with these ongoing efforts on a much smaller geographical scale.

The approaches to public participation listed in the text box (left) have successfully been used in the development of IPs in Virginia.

The public participation chapter of the IP should describe the approaches, such as those listed at left, that were used to inform the public and solicit input during IP development.

Public meetings provide a forum for the general public to be informed of TMDL requirements, the IP development process, and actions the IP will require. Working groups provide a way for a smaller number of individuals within the community to come together to address specific implementation issues. A steering committee to consider recommendations that are formulated by the working groups and to provide leadership in the implementation process is also recommended. Other watershed-specific approaches may be developed as well. The DEQ Water Division guidance document, *Public Participation Procedures for Water Quality Management Planning* (http://www.deq.virginia.gov/Portals/0/DEQ/Water/Guidance/142016.pdf) provides specific recommendations on meeting Administrative Process Act and Freedom of Information Act requirements when engaging the public and conducting meetings to develop implementation plans.

6.1 Public Meetings

Often, there may be limited attendance at public meetings held during the TMDL development process. Many individuals are only interested in the bottom line – "What needs to be done to meet the TMDL, and how will this impact my personal property?" Therefore, individuals who did not attend TMDL development public meetings are more likely to attend public meetings for the related IP. It is suggested that a minimum of two public meetings be held during IP development. The first meeting should provide a general description of what a TMDL is, a more detailed description of the TMDL and IP development processes, information on additional monitoring completed since the TMDL was finalized, and a solicitation for participation in working groups. The primary purpose of the second public meeting is to present the draft TMDL IP for public comment. There is a 30-day public comment period for each public meeting. During the 30-day comment period for the final public meeting, written comments on the draft IP are received by DEQ.

The IP should document the location(s) and attendance at all public meetings and summarize the verbal and written comments provided.

6.2 Working Groups

Working groups can be formed to deal with a number of implementation issues such as agriculture, residential, urban, business, and government. The membership of such groups should include some key individuals who are local leaders and are knowledgeable about the specific issue the working group is to address. The groups' objectives are to:

- provide input on various BMPs that could be implemented to address a particular pollutant source sector based on local interest and applicability
- share ideas on outreach tools that will maximize landowner participation in implementation efforts
- provide feedback on implementation timelines
- review BMP cost estimates
- identify resources various stakeholder groups (e.g., government agencies) may provide

The IP text should summarize input from each of the working groups and provide recommendations from reports prepared by the working groups. Minutes from the working group meetings are used for the content of working group reports. Minutes and reports are included in an appendix to the IP.

For example, the agricultural working group could consider how to promote community participation in the implementation of BMPs on agricultural lands to address load reductions for the various NPS pollutant sources documented in the TMDL. The residential working group may deal with ways to address bacteria loadings from septic system failures, straight pipes, pets, and even nutrients and sediment loadings in stormwater runoff in urbanized watersheds. The government working group could consider what financial and technical resources as well as existing local, state, and federal regulatory authorities are available to implement the TMDL. The business working group could discuss strategies to alleviate pollution sources from commercial properties.

6.3 Steering Committee

The formation of a steering committee or advisory committee is recommended to provide leadership in the TMDL implementation process. Representation on this committee should comprise stakeholders from the various working groups as well as personnel from the key agencies involved in plan development. This committee typically reviews the working group recommendations and comments from public meetings, assists with planning for the final public meeting, and reviews a draft of the implementation plan prior to the final public meeting. The steering committee may choose to remain active after IP development is complete in order to provide overall guidance during the implementation process. In such cases, DEQ staff will often continue to provide assistance with meeting planning and facilitation. Ongoing committee roles may include grant applications and administration, coordinating volunteer efforts, and citizen monitoring.

6.4 Websites

Information about the TMDL and the development of the IP can be posted on various agencies' and organizations' websites. Also, links can be made to the websites at DEQ, Planning District Commissions (PDCs), and other local, state, and federal agencies to provide more information on the programs that support TMDL implementation efforts.

6.5 Media

Public service announcements can be made through multiple forms of media such as local cable channels, radio, newspapers, newsletters, and various websites. A feature story in a local newspaper provides a forum to explain what is happening and how the public can be part of the process. All press releases and other outreach materials issued to local media should be shared with the DEQ Office of Public Information and Outreach prior to distribution.

6.6 Mailings

During the TMDL development process, a database of watershed landowners may have been compiled to notify residents of public meetings. If such a database is not available, it is suggested that one be compiled with input from the local soil and water conservation district (SWCD), business and industry stakeholders, chambers of commerce, clubs and environmental organizations, schools, etc. The watershed residents could be notified of public meetings and provided fact sheets and other educational materials pertaining to the IP. All mailings should briefly explain the TMDL and IP processes and roles of local citizens in simple and clear language. Based on the size of the watershed, mailings may need to be restricted to a subset of landowners such as riparian landowners with over 25 acres. This information can be collected using county tax parcel data.

6.7 Reasonable Assurance

Public participation is an integral part of IP development and is critical to help provide reasonable assurance that implementation activities will occur and the goals of the TMDL will be met. During the public participation process, IP developers should be able to evaluate, to some degree, the willingness of the public to voluntarily participate in implementation. Stakeholders should be provided the opportunity to express which BMP options they feel will be most effective and practical in resolving water quality problems within the context of local cultural issues. For instance, some groups may be willing to voluntarily participate in implementation actions but reluctant to support programs sponsored or funded by the government. Having this information available during IP development enables developers to provide BMP options that are most appropriate for the stakeholders in the watershed, thereby providing reasonable assurance that they will be implemented. Stakeholder input can also guide the IP's initial implementation milestone (i.e., years two to three) based on what they perceive as being reasonably accomplished in the first several years of implementation. Finally, the IP should detail the availability of funds and incentives for implementation of voluntary actions to provide reasonable assurance that TMDL pollutant allocations will be met.

7.0 Implementation Actions

Assessing implementation actions involves identifying appropriate BMPs to alleviate the impairment and assessing the extent and funding of each implementation action needed. The level of effort required to identify and select the appropriate implementation actions depends on the amount and type of data available from the TMDL, the complexity of the watershed characteristics, and the complexity of the impairment(s). This chapter explains how to select the appropriate implementation actions and how to quantify the overall implementation efforts. By quantifying implementation action needs, the costs and benefits of implementation can be assessed. The following sections discuss the methodology involved in assessing implementation needs and estimating costs and benefits to assist plan developers in identifying the information already available and the information still needed to select appropriate implementation actions.

Components of a TMDL Implementation Plan

1. Executive Summary
2. Introduction
3. State and Federal Requirements for Implementation Plans
4. Review of TMDL Development
5. Changes and Progress Since the TMDL Study
6. Public Participation
7. **Implementation Actions**
8. Measurable Goals and Milestones
9. Stakeholders' Roles and Responsibilities
10. Integration with Other Watershed Plans
11. Potential Funding Sources

The IMPLEMENTATION ACTIONS chapter should include

- an assessment of implementation action needs
- an assessment of technical assistance and educational outreach needs
- implementation costs and benefits

The terms "implementation actions," "corrective actions," and "management measures" are used interchangeably in TMDLs and IPs. They can include structural and non-structural practices and/or activities used to prevent or reduce the amount of pollution entering surface and groundwater systems, i.e., BMPs. Implementation actions can also include things like educational campaigns (e.g., pet waste education programs and storm drain stenciling). EPA requires the description of needed implementation actions and/or management measures as one of the nine elements of an IP. The Virginia WQMIRA requires the quantification of necessary corrective actions as one of four elements included in an IP. Quantifying the implementation actions needed to achieve TMDL pollutant load reductions enables the IP developer to estimate both the costs and potential benefits of TMDL implementation.

As described in Chapter 4, the approach used to develop the TMDL (monitoring-based vs. modeling-based) impacts the level of effort and analysis necessary to quantify the corrective actions required to achieve the pollutant load reductions specified in the TMDL. Regardless of whether the IP developer begins with a monitoring- or modeling-based TMDL, the detailed implementation action estimation analysis required to develop an IP is typically performed using a variety of tools including GIS, spreadsheets, and, if available, watershed water quality models. The data required to perform the TMDL implementation action analysis typically comes from a variety of sources including DCR, DEQ, and the Virginia Department of Health (VDH), PDCs, SWCDs, local governments, the Natural Resources Conservation Service (NRCS), Virginia Cooperative Extension (VCE), and this manual, among others. The sources for the data needed are largely a function of the land uses present in the IP watershed.

Determining where corrective actions could/should be most effectively located in the IP watershed typically requires a more in-depth spatial data analysis than was performed when developing the TMDL. For example, while stream network data (e.g., flow, connectivity) may have been considered when developing the TMDL, the level of spatial data analysis that determines whether livestock have access to those streams is only performed during IP development. In addition to determining where corrective actions could/should be located (typically locations are not specified at scales finer than the subwatershed level), the IP developer must determine the types and quantities of needed corrective actions. This analysis requires that the IP developer understand the types of pollutants that different corrective actions address and how effective each corrective action is at reducing pollutant loads. The IP developer should also consider local conditions that can impact the effectiveness of various BMP practices, such as topography and karst geology. A successful IP developer must also effectively engage stakeholders in the selection of suitable BMPs. Because impaired waters are typically dominated by unregulated NPS pollution, an important element of any water quality improvement effort is the voluntary adoption of implementation actions. In order to encourage voluntary implementation, pertinent information must be provided about the types of practical and cost-effective BMPs that can achieve TMDL pollutant load reductions.

7.1 Assessment of Implementation Action Needs

Implementation actions must be assessed based on water quality impact projections, reasonable assurance of implementation, cost, and availability of existing funds. Chosen implementation actions should be practical, cost-effective, equitable (i.e., dealing fairly with all problem areas), and based on the best available science and research.

7.1.1 Identifying Implementation Actions

Appendix A provides detailed information about selected BMPs that are available to IP developers to reduce pollutant loads. Each table in the appendix addresses a different pollutant (e.g., Table A-1 is specific to bacteria). The information provided in the tables includes each BMP name, the BMP efficiency (i.e., the expected pollutant reduction that can be credited to each BMP, expressed as a percentage), the average per unit cost, and a reference for cost and efficiency data used. Appendix B provides descriptions of the specific BMPs listed in these tables. The public IP document should include photos of BMPs, especially those unfamiliar to stakeholders. Such photos may be requested from DEQ TMDL staff.

A wide array of implementation actions is available for consideration, especially for accomplishing land-based reductions. An implementation strategy outlining practices that stakeholders are most familiar with, the anticipated level of public and private funding (e.g., participation in cost-share program), and historical implementation levels in the particular watershed will enable IP developers to reduce the list of potential implementation actions to a manageable level. Pollutant reductions associated with a combination of practices from this shortened list can then be evaluated. The manner in which a specific BMP is implemented could be different for practices that are funded through the State's cost-share program versus private funds based on program requirements. Any practice installed through the Virginia Agricultural Cost-Share Program, such as exclusion fencing (Figure 7.1) must meet established specifications (see the NRCS Field Office Technical Guide, https://efotg.sc.egov.usda.gov/), usually resulting in a more complete system; whereas, a stakeholder trying to minimize private costs may be inclined to install the minimum practice components that will achieve the implementation goals.

Figure 7.1. Streamside exclusion fencing

7.1.2 Quantifying Implementation Actions

The extent of BMPs needed during implementation is determined from calculations of load reductions needed to meet the target TMDL load. Load reductions are generally calculated either as a land use change, by applying a reduction efficiency to the area treated, by crediting a reduction per unit area or per unit length, or some combination of the previous three methods. For a land use change, the difference between the simulated unit-area pollutant load (UAL) of the before and after land uses is multiplied by the area treated. When a reduction efficiency is applied, the UAL of the land use where the BMP is applied is multiplied by the area installed/treated by the BMP and the assigned reduction efficiency. Unit-load reductions (ULRs) are straight load reductions per linear foot or per unit area. Several BMPs – livestock exclusion, grass buffers, and forest buffers – employ a combination of the above reduction mechanisms. In the case of buffers, in addition to a land use change, a filtering efficiency is applied to the upland areas adjacent to the buffer with an area equal to some multiple of the buffer area. Load reductions may be calculated either in separate model runs or through post-processing.

The unit used to quantify an implementation action is typically selected using historical data describing implementation actions that have been used in the area (utilizing sources such as DCR's BMP Database). The number of implementation actions/BMPs is calculated by dividing the total units of measurement by the number of units per implementation action. Possible methods to quantify measurement units include verbal communication with agency staff and stakeholders and/or spatial analyses. Unit quantification may be achieved through verbal communication with stakeholders during IP development and windshield surveys, assuming impairment complexity is low. For instance, a shoreline survey by the VDH Bureau of Shellfish Sanitation can aid in noting the location of straight pipes, septic systems not properly maintained, failing septic systems, and pet sources for land parcels in shellfish growing areas. Additional spatial analyses may be required if unit quantification cannot be determined using data from development of the TMDL or stakeholder input. Typical GIS data that is necessary to perform spatial analyses include land use/land cover, stream network, soils, topography, karst, utilities, property lines, farm tracts, easements, and building footprints.

BMP quantification examples (1-4) provide step-by-step processes in how to quantify livestock stream exclusion fencing practices, on-site sewage systems and connection to public sewer practices, pet waste management BMPs, and stormwater BMPs, respectively. Details provided address which GIS layers, land use information, and database resources to use and describe how to execute the BMP quantification calculations.

Quantification Examples

Quantification Example # 1: Stream Fencing Estimate

Background

- Bacteria and Sediment TMDL
- TMDL specified 100% load reduction in the direct deposition of waste into the stream by livestock

Methods

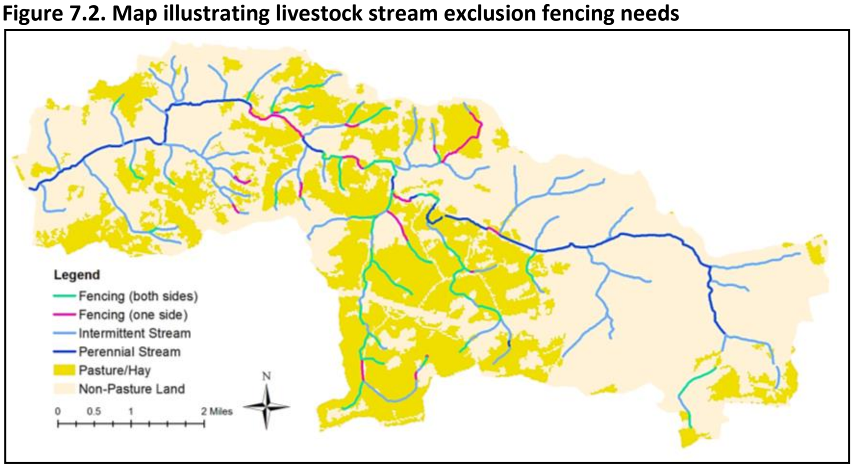
For Streams:

1. Create map using GIS that includes the watershed boundary layer, National Hydrography Dataset (NHD) stream layer, and land use data layer.
2. Identify perennial and intermittent streams segments using the NHD FCodes (FCodes are feature type and attribute codes included in the NHD data).
3. Convert land use data from raster to polygons.
4. Create layer with just pasture/hay land use polygons.
   a. Determine one-sided and two-sided fencing needs.
   b. Select all perennial and intermittent streams that intersect pasture land use polygons.
   c. Visually inspect stream segments. Delete those obviously not in pasture.
   d. Using aerial imagery (via NLCD 2011 data), split selected stream segments into two categories: those needing one side of fencing and those needing two sides. If not obvious from imagery, choose two sides for a conservative estimate.
5. Create 35-ft buffer around streams.
6. Clip perennial stream buffer to pasture/hay land use polygons.
7. Edit stream livestock exclusion polygons to exclude:
   a. Golf course being included in pasture/hay land use – delete sections along golf course
   b. Polygons located in the same fields but not connected due to raster to vector conversion problems
   c. Areas that should not be included based on local knowledge and ground-truthing
   d. Hayland acres present in watershed using National Agricultural Statistics Service (NASS) data layer
8. Consult with SWCD and NRCS staff for their assessment based on local knowledge

For ponds:

1. Create polygon of pond.
2. Create 35-ft buffer around pond.
3. Measure perimeter of pond.

Figure 7.2. Map illustrating livestock stream exclusion fencing needs



Implementation Action Quantification

- Divide total streamside fencing length by average grazing system (e.g., SL-6) or stream exclusion practice (WP-2) fencing length to calculate the total systems needed.
- Query DCR's Agricultural BMP Database for average streamside fencing associated with grazing systems and stream exclusion practices installed in watershed area covered by the IP.

Quantification Example # 2: On-Site Sewage Disposal Systems and Connections to Public Sewer

Background

- Bacteria TMDL
- TMDL specified 100% load reduction from failed septic systems and straight pipes contributing directly to stream

Methods

1. Derive number of straight pipes and failing septic systems from TMDL study. Based on the age of the TMDL and source of data used in the study, number may have to be updated based on VDH and local government input. Numbers have been derived two different ways: based on the entire watershed or a maximum setback from the perennial stream network (e.g., most commonly 300 ft.).
2. Determine system repairs, replacements, and alternative sewage system conversion options based on local Health Department input or from other IPs developed locally.

Figure 7.3. Photo showing home with failing septic system being connected to Western VA Water Authority sewer line (Photo: DEQ)

Implementation Action Quantification

- Calculate number of pump-outs.
- Calculate number of septic system repairs, new septic systems, and alternative sewage systems needed based on proportional percentages as defined by VDH. Percentages of failing systems repaired or replaced with new or alternative sewage systems should be based on knowledge of local permitting.
- Identify houses within certain distance from sewer line eligible to connect according to sewer ordinance.
  - Create distance buffer around sewer line.
  - Overlay buffer with building footprints to determine percentage of houses with failing septic systems that could possibly be connected to sewer.

Quantification Example # 3: Pet Waste

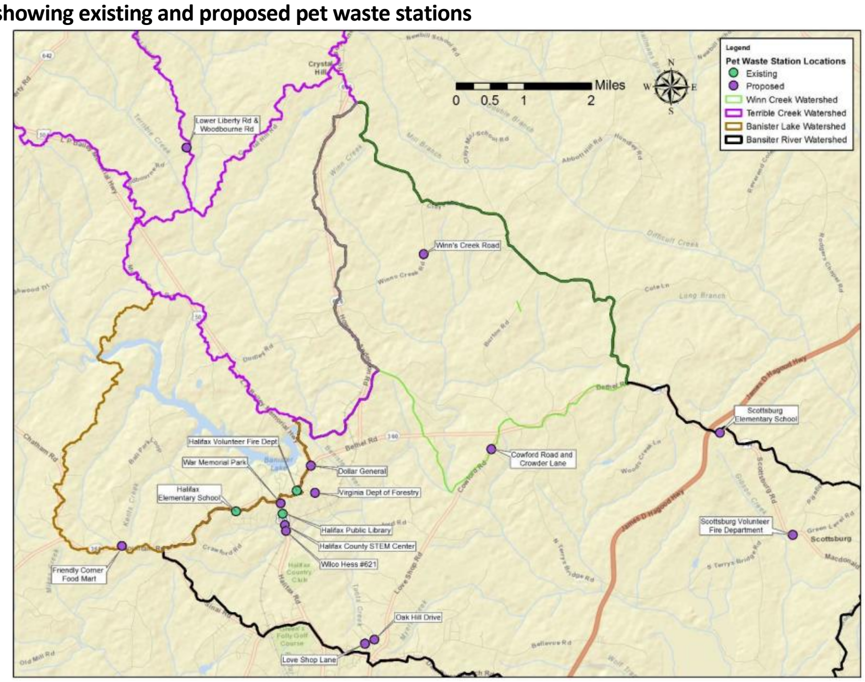
Background

- Bacteria TMDL
- Residential and urban land uses (i.e., high density residential and medium-low density residential)
- NPS load reduction specified by TMDL

Methods

1. Locate and identify existing pet waste disposal stations within the watershed.
2. Working with local stakeholders, identify other potential sites for stations.
3. Develop a GIS map spatially denoting existing and proposed sites (see Figure 7.4).
4. Document stakeholders' roles/responsibilities for maintaining such control measures in the future.
5. Develop components of a pet waste education program(s) by watershed or IP area (number of programs can vary based on number of localities affected).
6. Determine by watershed the number of households where composters or digesters could be used for on-site removal and treatment of waste (better suited for medium to high density residential areas with consideration of local preferences based on stakeholder acceptance of this BMP).

Figure 7.4. Map showing existing and proposed pet waste stations



Source: *Lower Banister River, Winn Creek, and Terrible Creek TMDL Implementation Plan*
(http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Banister_Winn_Terrible_IP.pdf)

Implementation Action Quantification

- Apply documented pet waste program efficiency (includes education component and pet waste disposal stations if included in IP) in reducing bacteria loads from dog waste (see BMP Table A-1 in Appendix A).
- Apply a pet waste reduction efficiency based on the number of composter or digester units to be implemented; total number can be based on a pre-selected number of units or percentage of households where units will be utilized.
- Apply a pet waste reduction efficiency for composters and digesters (see BMP Table A-1in Appendix A).
- Based on the bacteria NPS load for residential/urban land uses, the educational program, composters and digesters alone may not meet the required bacteria load reduction. In such cases, appropriate stormwater BMPs based on local conditions should be identified and quantified to address the additional pet waste reduction required to meet the TMDL pet waste reduction.

Quantification Example # 4: Stormwater BMPs

Background

- Urban watershed
- Phosphorous and sediment TMDL
- Identify BMP retrofit projects

Methods

1. Locate and identify existing stormwater BMPs within the watershed.
2. Identify and isolate existing detention basins.
3. Delineate drainage areas for each identified detention basin.
4. Convert land use data from raster to polygons.
5. Intersect the land use polygon layer with the BMP drainage area and identify BMPs with significant impervious cover composition.
6. Intersect the BMP drainage area layer with a soils layer to determine Hydrologic Soil Group (HSG)* composition within each BMP drainage area.
7. Intersect the BMP drainage area layer with a karst topography layer to identify those BMPs located within karst topography.
8. Exclude those BMPs located within karst topography.
9. Prioritize drainage areas with the largest composition of impervious surface, as they offer the highest potential for water quality treatment.

Figure 7.5. Photo showing an existing dry detention basin

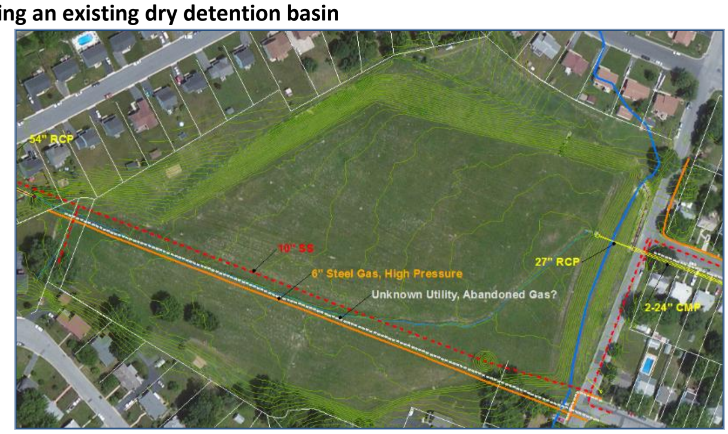
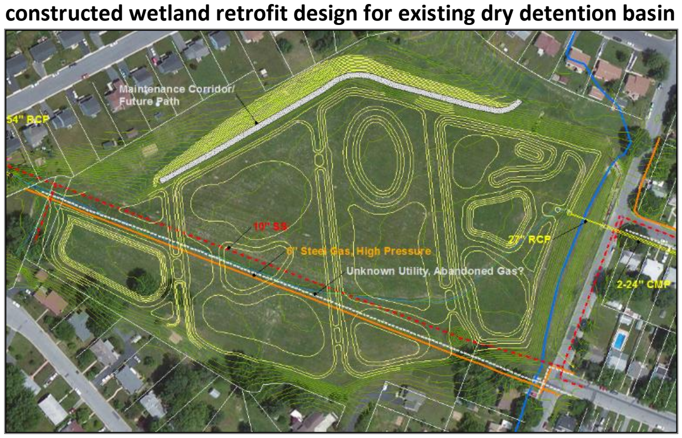


Figure 7.6. Photo showing constructed wetland retrofit design for existing dry detention basin



Abbreviations: SS=Sanitary Sewer; CMP=Corrugated Metal Pipe; RCP=Reinforced Concrete Pipe

Implementation Action Quantification

- Existing BMPs overlying excessively to well-drained soils (HSG* A/B) are appropriate for infiltration and bioretention retrofits, as these practices require that runoff be able to percolate through the soil. Underdrains can be considered when needed.
- Existing BMPs overlying poorly drained soils (HSG* C/D) are more appropriate for retrofit conversion to wetland or wet pond basins.

*Local classification of soils into HSGs is available through county soil surveys or SSURGO GIS mapping (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053627).

When establishing a plan for implementation action, it is important to consider future TMDL needs for the watershed. For example, the first three IPs in Virginia (Muddy Creek, Lower Dry River, Pleasant Run, and Mill Creek watersheds in Rockingham County; Blackwater River watersheds in Franklin County; and Cedar, Hall/Byers, and Hutton Creek watersheds in Washington County) were developed for bacteria TMDLs. However, implementation practices recommended to reduce bacteria loadings in the IPs also helped to treat other pollutants (e.g., sediment and nutrients) to be addressed in future TMDLs. A thorough implementation of a well-thought-out plan will result in comprehensive improvements to water quality.

7.1.3 Estimating Implementation Action Costs

Once the appropriate implementation actions/BMPs have been identified for each watershed, the next step is to gather information on costs for the equipment, structures, installation, and assistance necessary for the successful implementation of those BMPs. The cost of installing and administering implementation actions can be determined through discussions with local contractors, agency staff (e.g., SWCD, NRCS, DCR, DEQ, VDH, VCE), local governments, and local stakeholders. In addition, DCR maintains a database with costs related to the implementation of agricultural practices (the Agricultural BMP Tracking Database). Information from these sources should be gathered, and the average unit cost should be established. It may also be desirable to project the lowest estimated cost and the highest estimated cost for each BMP to provide a range of expected costs.

Once the unit cost is established, the number of total units needed must be multiplied by that cost. For example, if 10,000 square feet of asphalt parking lot must be retrofitted to pervious pavers and the cost of paver installation is $9/sq-ft, $9 is multiplied by 10,000 square feet to determine the total BMP cost of $90,000. It is important to consider and include any additional costs associated with the implementation of the BMP if available (e.g., soil testing, survey, design). Likewise, the cost of routine maintenance could be considered and incorporated into the overall implementation cost when feasible. See Section 6.3 for more information and examples illustrating cost calculations.

Implementation actions that can be promoted through existing programs (e.g., state and federal agricultural cost-share funding, grant programs such as 319 and Virginia Water Quality Improvement Fund (WQIF), and locality stormwater programs) should be identified and coordinated with appropriate representatives of such programs. Implementation actions not currently supported by existing programs (and their potential funding sources) may also be identified. However, without documented pollutant reduction efficiencies, such BMPs cannot be credited toward attaining TMDL load reduction allocations.

Very often, there are ongoing costs associated with technical and administrative assistance, and these require careful consideration in order to produce a reasonable cost estimate for implementation. The number of man-hours needed for technical and administrative assistance, as well as the resulting costs for salary, benefits, travel, and training should be estimated to the extent possible. See Section 7.2 for more information.

7.2 Assessment of Technical Assistance and Educational Outreach Needs

Sufficient technical assistance and education are key components to getting citizens involved in implementation. There must be a proactive approach by agencies to contact landowners in the impaired watershed(s) to articulate the TMDL IP implementation goals and what will most practically get the job done. Several education/outreach techniques can be utilized during implementation. Articles describing the TMDL process, reasons why there is a problem, methods through which the problem can be corrected (i.e., BMPs), assistance currently available for landowners to deal with the problem, and potential ramifications of not dealing with the problem should be made available through as many channels as possible (e.g., newsletters and targeted mailings). Workshops and demonstrations can be organized to show landowners the extent of the problem, effectiveness of BMPs, and the process for obtaining technical and financial assistance. The IP should describe the technical assistance and types of outreach actions identified for the watershed(s) in each of the relevant sectors (e.g., agricultural, residential, urban).

Agricultural

Historically, staff from SWCDs and NRCS have taken the lead on agricultural technical assistance in Virginia. The level of technical assistance that a full time equivalent (FTE) can be expected to provide during a year must be estimated using historical records and/or stakeholder input. The Agricultural BMP Database can be utilized, for example, to quantify the number and type of agricultural control practices historically designed and implemented through the local SWCD cost-share program to estimate the average number of BMPs a FTE can process annually. If historical data are not available, use an estimate derived from working group discussions. Dividing the total implementation actions needed to be installed per year during implementation by the number of implementation actions that a FTE can process in a year will equal the number of FTEs considered necessary for technical assistance during implementation. It is anticipated three-quarters of an FTE will be dedicated to technical assistance on design and installation of implementation actions, and the remaining one-quarter of the FTE will be devoted to educational outreach.

Potential technical assistance and educational outreach tasks associated with agricultural programs:

1. Contact landowners/producers in the watershed and absentee landowners to make them aware of implementation goals and cost-share assistance programs.
2. Complete forms for cost-share sign-up and track cost-share.
3. Assist with BMP surveys, designs, layout, and approvals of installations.
4. Develop educational materials and programs based on local needs.
5. Organize educational programs (e.g., pasture walks, presentations at field days, or grazing club events).
6. Distribute educational materials (e.g., informational articles in Farm Service Agency (FSA) or Farm Bureau newsletters, local media).
7. Assess and track progress toward BMP implementation goals.
8. Follow up with landowners who have installed BMPs.
9. Coordinate use of existing agricultural programs and suggest modifications where necessary.

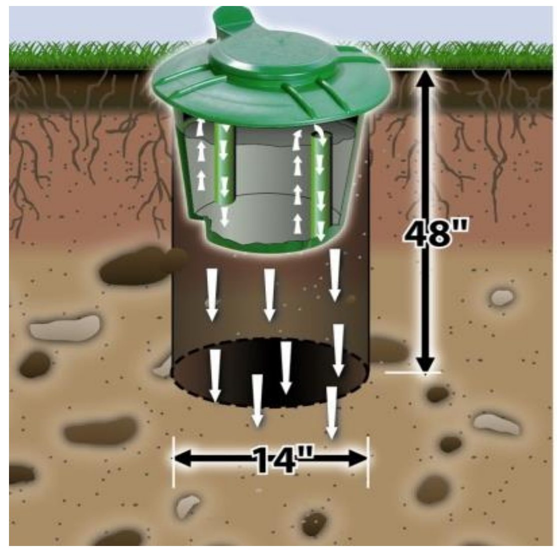
An effective forum for engaging the agricultural community may be field days, pasture walks, and presentations offered through local farm groups. Emphasis should be placed on local farmers discussing their experiences with cost-share programs, demonstrating the advantages of BMPs, and presenting monitoring results to demonstrate the problem. Farmers are more likely to be receptive to individualized discussions with local technical personnel or fellow farmers who have implemented the suggested BMPs than they would be to presentations made at a larger forum. Virginia SWCDs have documented that the most successful outreach method for promoting adoption of agricultural BMPs is a farmer implementing a BMP and sharing with his neighbors how the BMP has improved his property and operation.

Residential

Traditionally, the focus of TMDL implementation actions for the residential community has been on septic system maintenance and other on-site sewage issues. In growing urbanized areas where benthic impairments are present, implementation actions to address sediment and nutrient sources from residential properties must also be considered. As TMDL Action Plans are used to address the TMDL requirements, municipalities are actively developing TMDL compliance strategies that include encouraging community awareness and voluntary implementation of practices for pollution prevention. For example, pet waste management programs are successful pollutant management strategies targeted at the residential community for reducing bacteria associated with pet waste. These programs typically have two main pollutant reduction components: 1) waste reduction through the implementation of pet waste collection stations (Figure 7.7) and in situ treatment with backyard composters/digesters (Figure 7.8) and 2) public education. In addition, stormwater management practices, both voluntary and incentive-based (e.g., credits toward stormwater utility fees) and those implemented as part of stormwater regulatory compliance for new neighborhoods, are becoming increasingly common within residential communities.

Figure 7.7.Pet waste disposal station

Figure 7.8. Diagram of a Doggie Dooley digester system (Photo: doggiedooley.com)



As part of their MS4 Program Plans, a number of municipalities have successfully addressed stormwater pollutant reductions from residential sources. These same approaches can be utilized not only by the MS4 permittees, but also by any stakeholders who are voluntarily implementing NPS strategies. They can include education and/or cost-sharing programs that target stormwater treatment and flow reduction from residential impervious surfaces using rain barrels, rain gardens (Figure 7.9), rooftop disconnection, permeable pavement, conservation landscaping, and riparian buffer restoration. Because Virginia is part of the Chesapeake Bay watershed, many resources and websites are available as technical references for stormwater management practices that target nutrient reduction. Many of the stormwater BMPs that address nutrients can also be used as compliance strategies for other pollutants of concern, including sediment, bacteria, and others.

Technical guidance produced by DEQ for the design of many stormwater management facilities to address water quality and quantity from new development or redevelopment can be found on the Virginia BMP Clearinghouse website (http://www.vwrrc.vt.edu/swc/). The BMP Clearinghouse, however, provides detailed technical design data and facility management practices targeted more toward the engineering community for regulatory compliance with stormwater criteria. The *Virginia Conservation Assistance Program (VCAP) Implementation and Design Manual* (available at VCAP website, http://vaswcd.org/vcap) provides descriptions and specifications for stormwater BMPs to be installed in small-scale settings at the source of stormwater discharges on residential and small businesses properties. Resources directed at homeowners are available from numerous online sources, including:

- Chesapeake Stormwater Network website (http://chesapeakestormwater.net/2014/06/residential-stormwater-bmp-workshop/), including their guide for homeowners, entitled, *Homeowner Guide for a More Bay Friendly Property* (2014)
- Chesapeake Bay Program (http://www.chesapeakebay.net/)
- Virginia Cooperative Extension (VCE) (http://www.ext.vt.edu/), including a 15-part series on urban stormwater management practices
- EPA Septic Smart Program (https://www.epa.gov/septic/septic-systems-outreach-toolkit)

The VDH is the lead state agency working with the public on residential on-site sewage disposal issues. However, depending on the local situation VDH may not have adequate resources to fully commit to an active role in implementation beyond what technical services they already provide to comply with state code. In a number of TMDL implementation projects, the local SWCD has taken the lead (with VDH consultation) in outreach and administering cost-share to address local on-site sewage disposal deficiencies.

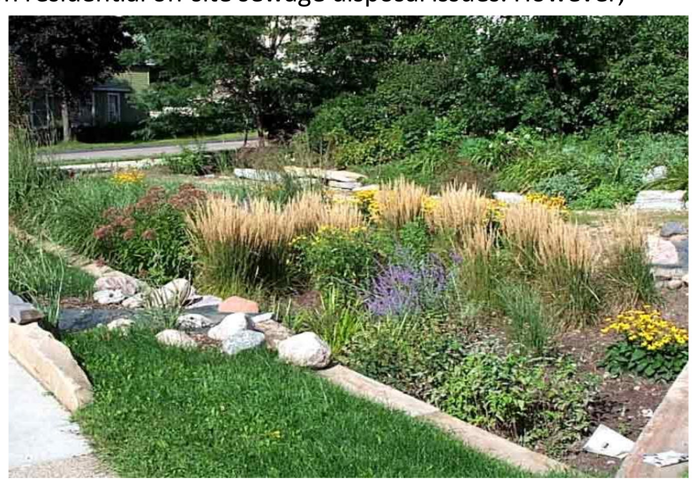


Figure 7.9: Rain garden (Photo: Timmons Group)

Information provided by an agency/group can be utilized to determine the level of technical assistance that an FTE can be expected to provide annually. If not available, use an estimate derived from working group discussions. Dividing the total implementation actions needed to be installed per year during implementation by the number of implementation actions that a FTE can process in a year will equal the number of FTE considered necessary for technical assistance during implementation. It is anticipated three-quarters of the FTE will be dedicated to technical assistance on design and installation of implementation actions, and the remaining one-quarter of the FTE will be devoted to educational outreach.

Potential technical assistance and educational outreach tasks associated with residential programs for on-site sewer systems:

1. Identify failing septic systems and straight pipes using stream walks, analysis of aerial photos, and/or monitoring and report to VDH.
2. Complete forms for cost-share sign-up and track cost-share.
3. Track septic system repairs/replacements/ installations.
4. Develop educational materials and programs.
5. Organize educational programs (e.g., demonstration on septic pump-outs).
6. Distribute educational materials (e.g., informational pamphlets on TMDLs and on-site sewage disposal systems).
7. Assess progress toward implementation goals.
8. Follow up with landowners who have participated in the program(s).

Potential technical assistance and educational outreach tasks associated with pet waste management and residential stormwater programs:

1. Develop educational materials and programs.
2. Organize educational programs (e.g., technical workshops for project implementation).
3. Partner with community interest organizations (e.g., watershed groups, scouting programs, homeowners associations).
4. Distribute educational materials (e.g., informational pamphlets on TMDLs, social networking announcements, community interest groups, veterinarians).
5. Develop cost-share programs and/or other monetary incentives for voluntary participation.
6. Handle and track cost-share.
7. Assess progress toward implementation goals.

Small community meetings (similar to the small workshops proposed for the agricultural community) could be effective forums for educating homeowners about environmental issues and management considerations (e.g., septic system maintenance and collection and disposal of pet waste). Many homeowners are unaware of the need for regular septic system maintenance. Notices regarding septic systems (e.g., a reminder to pump-out septic tanks every three to five years) should be released through all available media outlets. An educational packet about septic system issues can be provided to new homeowners. Additionally, educational tools, such as a model septic system that can be used to demonstrate functioning and failing septic systems and a video of septic maintenance and repair, will be useful in communicating the problem and needs to the public.

Urban Stormwater

Urban stormwater management continues to be an important issue in Virginia, particularly with the implementation of the revised stormwater regulations, including the Virginia Stormwater Management Act and Virginia Stormwater Management Program (VSMP) (2014). MS4 permittees are often the lead entity working on urban stormwater issues and already have in place a local Stormwater Program. Because of the resources required to operate a compliant MS4 Program, several communities across the state have established a stormwater utility. TMDL action plans (i.e., Chesapeake Bay TMDL Action Plan and local TMDL Action Plan) are now incorporated into MS4 permit requirements. As such, municipalities located within TMDL watersheds now have to identify, plan, and implement specific BMPs (e.g., Figure 7.10) that will reduce the pollutant(s) of concern. Compliance strategies associated with the MS4 permit requirements range from those that encompass the entire jurisdiction to strategies that only apply in the MS4-regulated area. As a result, municipalities can be strong partners that can offer local knowledge and planning tools during IP development in urban watersheds. IPs include corrective actions needed to achieve pollutant(s) source load reductions; whereas, TMDL Action Plans include corrective actions to address pollutant(s) source waste load reductions. The former is addressed through voluntary compliance, while the latter is addressed through regulatory compliance.

While developing an IP, it is important to have an understanding of the technical requirements of stormwater BMPs, particularly in urban areas where public safety, aesthetics, and available BMP footprint space may impact their feasibility. There are many resources available for technical assistance in project implementation. Technical guidance produced by DEQ for the design of many stormwater management facilities can be found on the Virginia BMP Clearinghouse website (http://www.vwrrc.vt.edu/swc/). The Chesapeake Bay Program (http://www.chesapeakebay.net/) is another resource for technical assistance. Because a large portion of Virginia is located in the Chesapeake Bay, DEQ has finalized the *Chesapeake Bay TMDL Action Plan Guidance* (GM14-2012) document (http://www.deq.virginia.gov/Portals/0/DEQ/Water/Guidance/152005.pdf). This document can be an important tool for IP developers, because it defines for the MS4 operator how to demonstrate compliance with the Chesapeake Bay TMDL. When IP developers understand and can relate the IP process to the MS4 Action Planning process, it results in better quality IPs that are more effective.

An effective forum to raise awareness of pollution prevention practices among the urban community could be to focus on public education utilizing social media outlets and through the use of informational fliers accompanying a utility bill, such as the water/sewer bill or stormwater utility bill if applicable. Social media's rapid dispersion of information to a large audience in a cost-efficient manner is unparalleled. Communities can leverage this technology to reach a wide range of citizens and spark interest among residents in stormwater pollution prevention practices and/or cost-sharing programs. Local workshops and schools can also be outlets for technical information on these practices or programs. Cost-sharing programs or other monetary incentives (e.g., stormwater utility fee discounts) can be critical to the success of implementation strategies. In addition, municipalities can leverage grants to help fund specific projects and initiatives or partner with other municipalities within the same watershed or area to combine resources and more efficiently address the water quality issue. Stakeholders multiplying their efforts through collaboration can become one of the strengths of a non-regulatory iterative approach to managing water quality.

Figure 7.10. Manufactured urban stormwater BMP (Photo: Timmons Group)

Potential technical assistance and educational outreach tasks associated with urban stormwater programs:

1. Contact landowners in the watershed(s) to make them aware of the implementation goals.
2. Develop educational materials and programs.
3. Organize educational programs (e.g., technical workshops for project implementation).
4. Partner with community interest organizations (e.g., watershed groups, scouting programs).
5. Provide assistance for implementing stormwater BMPs (e.g., survey, design, layout, and approval of installation).
6. Distribute educational materials (e.g., informational pamphlets on TMDLs, social networking announcements, community interest groups).
7. Assist in the identification of grant opportunities and writing grant proposals to fund implementation.
8. Track and assess progress toward implementation goals.
9. Follow up with landowners/organizations who have participated in the program(s).

7.3 Implementation Costs and Benefits

7.3.1 Costs

An associated cost for each implementation action (excluding technical assistance) is determined using historical data, estimates from contractors and builders, and estimates from stakeholders. Multiplying the implementation action cost by the total number of implementation actions, based on results from implementation action quantification, defines the associated cost of materials and labor for each implementation action installation. Separate costs associated with source sectors such as agricultural, residential (i.e., sewage disposal systems), pets, urban stormwater, streambank stabilization, abandoned mine lands, silviculture harvesting, etc. should be provided. This organizes the cost data in a way that is more useful for the public. Tables 7.1-7.3 illustrate examples of implementation action cost estimates for residential (septic and pet waste), agricultural, and stormwater (residential and urban) practices, respectively.

Table 7.1. Residential (septic and pet waste) implementation action cost estimates as reported in a TMDL IP

Control Measure	BMP Code	Units	Unit Cost	Total	Total Cost
Failing Septic Systems					
Septic Tank Pump-out	RB-1	system	$300	565	$169,500
Connection to Public Sewer	RB-2	system	$5,000	7	$35,000
Septic Tank System Repair	RB-3	system	$3,500	237	$829,500
Septic Tank System Installation/Replacement	RB-4	system	$7,500	79	$592,500
Alternative On-site Waste Treatment System	RB-5	system	$15,000	36	$540,000
Straight Pipes					
Septic Tank System Installation/Replacement	RB-4	system	$7,500	2	$15,000
Alternative On-site Waste Treatment System	RB-5	system	$15,000	2	$30,000
Pet Waste Management					
Pet Waste Stations[1]		system	$1,300	15	$19,500
Pet Waste Digesters/Composters		system	$100	50	$5,000
Pet Waste Education Program		program	$4,000	1	$4,000
Total					**$2,240,000**

[1]Unit cost based on purchasing system as well as the estimated cost of trash can liners, waste bags, and maintenance for 10 years

Source: Crab Creek TMDL IP, *Table 7-1. Estimated residential BMPs and costs* (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/CrabCr_technical.pdf)

Table 7.2. Agricultural BMP implementation cost estimates as reported in a TMDL IP

Control Measure	BMP Code	Units	Average Unit Cost	No. of Units	No. of Units	Stage 1	Stage 2	Total
Livestock Exclusion with Riparian Buffers	SL-6T, LE-1T	system	$32,800	16	22	$524,800	$721,600	$1,246,400
Livestock Exclusion with Reduced Setback	LE-2T	system	$20,000	2	2	$40,000	$40,000	$80,000
Stream Protection System	WP-2	system	$10,000	1	2	$10,000	$20,000	$30,000
Pasture Management	EQIP 528, SL-10T	acres	$75	3,265		$244,875	–	$244,875
Reforestation of Erodible Pasture	FR-1	acres	$1,000	–	28	–	$28,000	$28,000
Permanent Vegetative Cover on Critical Areas	SL-11	acres	$2,000	–	29	–	$58,000	$58,000
Heavy Use Area Protection	EQIP 561	system	$20,000	–	20	–	$400,000	$400,000
Continuous No-till	SL-15A	acres	$20	5		$100	–	$100
Small Grain Cover Crop	SL-8B	acres	$45	20		$900	–	$900
Total Cost								**$2,088,275**

BMP Codes from DCR *VA Ag Cost-Share Manual* (http://dswcapps.dcr.virginia.gov/htdocs/agbmpman/csmanual.pdf)
Source: Crab Creek TMDL IP, *Table 7-5. Estimated agricultural BMPs needed to reduce bacteria and sediment in the Crab Creek watershed and their costs* (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/CrabCr_technical.pdf)

Table 7.3. Residential and urban implementation action cost estimates as reported in a TMDL IP

Residential		
BMP Type	**BMP**	**Cost (per system)**
Waste Treatment	Septic System Pump-out (RB-1)	$300
	Sewer Connection (Targeted Areas and RB-2)	$9,500
	Repaired Septic System (RB-3)	$3,600
	Septic System Installation/Replacement (RB-4)	$6,000
	Alternative Water Treatment System Installation (RB-5)	$16,000
Pet Waste	Pet Waste Education Campaign	$5,000
	Pet Waste Station	$4,070
Urban		
BMP Type	**BMP**	**Cost (per system)**
Stormwater	Rain Barrel	$150
	Permeable Pavement	$240,000
	Infiltration Trench	$6,000
	Bioretention	$10,000
	Rain Gardens	$5,000
	Vegetated Swale	$18,150
	Constructed Wetland	$2,900
	Manufactured BMP	$20,000
	Wet Pond	$8,350
	Detention Pond	$3,800
	Riparian Buffer: Forest	$3,500
	Riparian Buffer: Grass/Shrub	$350
Other	Street Sweeping	$520/curb mile
	Urban Land Use Conversion	$3,500/acre
	Stream Restoration	$300/ linear ft

Source: Upper Roanoke River TMDL IP, *Table 5-14. Best Management Practice Cost*
((http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Drafts/Upper_Roanoke_Draft_IP.pdf)

Ongoing costs associated with technical assistance must be considered to develop a reasonable cost estimate for implementation. The SWCD, DEQ staff, and members of working groups can work together in determining reasonable costs for salary, benefits, travel, training, and incidentals for education of technical staff. Multiplying these costs by the number of technical FTEs needed yields the total agricultural, residential, and stormwater technical assistance costs for implementation.

Summary of steps for calculating costs

1. Identify/quantify the corrective actions that are needed.
2. Research the unit costs.
3. Multiply the unit cost by the number of units required.
4. Calculate associated costs for technical assistance.

7.3.2 Benefits

Foremost, pollution reduction as a result of BMP implementation will improve water quality in Virginia and thereby increase the number of waterbodies supporting their designated uses. This is the primary benefit that should be recognized in the IP. However, the IP should identify other potential benefits of implementation efforts to watershed residents as related to potential economic gains and overall quality of life.

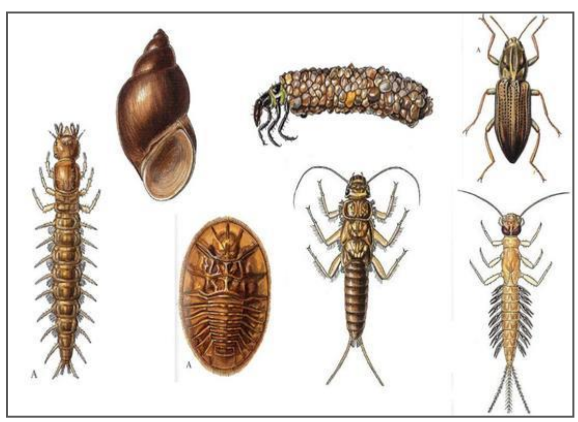
Human Health

One such benefit of IP implementation in bacteria-impaired watersheds is improved public health. The majority of TMDLs and associated IPs being developed in Virginia are for bacteria impairments. Residential implementation programs play an important role in improving water quality by reducing waterway pollution from human waste and the viruses, bacteria, and protozoan pathogens it can potentially carry. It is hard to gauge the impact that reducing bacteria contamination will have on public health, as most cases of waterborne infection are not reported or are falsely attributed to other sources. However, the incidence of infection through contact with polluted surface waters should be reduced considerably, and this should be reported as a benefit. Throughout the United States, the Centers for Disease Control (CDC) estimates that at least 73,000 cases of illness and 61 deaths per year are caused by *E. coli* 0157:H7 bacteria (CDC, 2001). Other fecal pathogens (e.g., *E. coli* 0111) are responsible for similar illnesses. Reducing the presence of bacteria in the watershed should considerably reduce the chances of infection from *E. coli* sources through contact with surface waters in streams.

Healthy Aquatic Communities

Another benefit of implementation of bacteria, sediment and nutrient TMDLs is the improvement of aquatic life. In the agricultural sector, for example, vegetated buffers established from the installation of stream fencing reduce sediment and nutrient transport to the stream from upslope locations. These pollutants have been identified as the major stressors to benthic aquatic communities in the benthic TMDLs completed in Virginia to date. While stream exclusion fencing placed at the top of the stream bank would reduce the bacteria loading from cattle in the stream, the additional benefit of reducing sediment and nutrient loadings from the upland would be lost without the riparian buffer. Streamside buffers of trees and shrubs help reduce erosion and provide shading of the stream. This helps keep water temperatures lower during the summer and allows for a greater amount of dissolved oxygen in the stream, which is beneficial for macroinvertebrates and fish. Healthy fisheries will in turn provide more stock for local anglers. In 2011 alone, approximately $3.5 billion was spent on wildlife recreation in Virginia (US Department of the Interior et al., 2011). Buffers can also improve habitat for wildlife and migratory songbirds that also benefit from having access to a healthy, thriving aquatic community.

Figure 7.11. Examples of intolerant benthic macroinvertebrates



Excessive sediment clogs the spaces in between river bed substrate that usually provides habitat for benthic macroinvertebrates, ultimately smothering and killing the invertebrate flora within that portion of a stream (Harrison et al., 2007). As excessive sedimentation begins to alter the macroinvertebrate community, some taxa will not be able to survive (Figure 7.11). The macroinvertebrate community serves as a major food source for freshwater fish. If their community is altered, there is potential for this to affect the fishery as well. Thus, the health of the whole aquatic ecosystem is dependent in part upon its physical habitat.

Agricultural Production

Exclusion of cattle from streams leads to the development of alternative (clean) water sources which can improve herd health and provide an opportunity for improved pasture and nutrient management. Providing cattle with a clean water source can improve weight gain (Surber et al., 2005; Landefeld and Bettinger, 2002). Increasing weight associated with drinking from off-stream waterers can translate to economic gains for producers as shown in Table7.4 from Zeckoski et al., 2007. Additionally, keeping cattle in clean, dry areas has been shown to reduce the occurrence of mastitis and foot rot. The Virginia Cooperative Extension estimates mastitis costs producers $150 per cow in reduced milk production quantity and quality (Jones and Balley, 2009).

Table 7.4. Production gains associated with provision of clean water for cattle*

Typical Calf Sale Weight	Additional Weight Gain with Access to Clean Water	Price	Increased Revenue
500 lb/calf	5% (25lb)	$0.60/lb	$15/calf

*Surber et al., 2005

Taking the opportunity to implement an improved pasture management system in conjunction with installing clean water supplies also provides economic benefits for the producer. Improved pasture management can allow a producer to feed less hay in winter months, increase stocking rates by 30 to 40%, and, consequently, improve the profitability of the operation. With feed costs typically responsible for 70 to 80% of the cost of growing or maintaining an animal and pastures providing feed at a cost of 0.01 to 0.02 cents/lb of total digestible nutrients (TDN) compared to 0.04 to 0.06 cents/lb TDN for hay, increasing the amount of time that cattle are fed on pasture is clearly a financial benefit to producers (Virginia Cooperative Extension, 1996). Standing forage utilized directly by the grazing animal is always less costly and of higher quality than the same forage harvested with equipment and fed to the animal. In addition to reducing costs to producers, intensive pasture management can boost profits by allowing higher stocking rates and increasing the amount of gain per acre. Another benefit is that cattle are closely confined allowing for quicker examination and handling. In general, many of the agricultural BMPs recommended in IPs provide both environmental and economic benefits to the farmer.

Improvements to Residential Properties

Individual homeowners and residents could also see financial benefits from implementation efforts. Implementation activities will help give homeowners the knowledge and tools needed for properly maintaining and extending the life of their septic systems. The average septic system will last 20-25 years if properly maintained, and the cost of proper maintenance is relatively inexpensive in comparison to repairing or replacing an entire system. The overall cost of ownership could also be reduced by advocating regular pump-outs which cost about $300 compared to the $3,000-$25,000 cost of a repair or replacement system.

Property owners can mitigate flood water damages and any associated costs by installing infiltration BMPs such as rain gardens and vegetated swales. Both of these serve to reduce stormwater volume and flow rates. Johnston et al. (2006) applied two different methods (one cost-based and one value-based) for estimating economic benefits of employing conservation design practices (vegetated swales, green roofs, permeable pavers, and native vegetation). The researchers found quantifiable economic benefits to property values downstream of areas where conservation practices were implemented. Stormwater infrastructure that reduces stormwater runoff on-site can reduce losses from flood damage by $6,700-$9,700 per acre (Medina et al., 2011). The additional services provided by new stormwater BMPs could raise the market value of nearby homes by 0-5% (Braden and Johnston, 2004). Another study in the Chesapeake Bay area found that lower fecal coliform concentrations correlate with increased property values (Leggett and Bockstael, 2000).

Economic Benefits of Stormwater BMPs

Stormwater BMPs can be incorporated into a landscape design as an amenity both on private and public properties. Many BMPs like vegetated swales, buffer strips, and infiltration trenches are inexpensive and easy to implement given limited space and other constraints. Installation of stormwater BMPs provide educational opportunities to increase awareness of water quality strategies (i.e., watershed plans) and green initiatives.

Potential economic benefits of stormwater BMPs (Wise, 2007):

- Incremental implementation and funding can result in less debt service.
- Have lower overall costs and are less capital-intensive
- Can extend existing capacity of current infrastructure
- Capture the asset values of clean water, soil capacity, and open space amenities: value ecosystem services
- Reduce wastewater and drinking water treatment costs
- Increase property values to the benefits of the private sector and public revenue collection

Urban stormwater BMPs can also help increase stormwater retention and lower peak discharges, thereby reducing the pressure on and need for stormwater infrastructure. This will in turn lower engineering, land acquisition, and material costs for municipalities and private enterprises.

Community Economic Vitality

Not only does the implementation of BMPs have direct economic benefits for land owners, it will also benefit the overall regional economy. Cleaner water and improved habitat can encourage increased recreational activities within the watershed. Activities such as fishing, canoeing, kayaking, and hiking support the local economy, tourism, and employment in these areas. Healthy watersheds provide many ecosystem services necessary for a community's well-being. These services include, but are not limited to, water filtration and storage, air filtration, carbon storage, energy, nutrient cycling, removal of pollutants, soil formation, recreation, food, and timber. Many of these services are hard to quantify in terms of dollars and are often under-valued (Bockstael et al., 2000). However, it is understood that many of these services are difficult to replace and often expensive to artificially engineer. Efforts to restore a watershed to a healthier state may reduce the financial burden on residents, businesses, and municipalities who currently bear the cost of damages caused by a degraded aquatic system, such as flooding. Lastly, the combined economic and natural resource benefits provide for a better quality of life for local and regional residents now and in the future.

On a larger scale, TMDL implementation in smaller local watersheds located within the Chesapeake Bay watershed will reduce sediment and nutrient loads as a result of BMPs that are installed to address benthic and bacteria water quality impairments. This action will also help Virginia achieve implementation goals that have been established for the Virginia portion of the Chesapeake Bay TMDL.

Once an IP is complete, organizations in the watershed will be eligible to apply for competitive funding to help cover some of the costs associated with installing the BMPs. These potential funds along with matching funds from other sources will benefit many local contractors involved in the repair and installation of septic systems, building of livestock exclusion systems, and installation and retrofits of stormwater BMPs. In a 2009 study, researchers estimated that every $1 million invested in environmental efforts such as reforestation, land and watershed restoration, and sustainable forest management, would create approximately 39 jobs (Heintz et al., 2009). Economic benefits to the region and individual stakeholders are an indirect result of an IP being implemented. Improvement of water quality provides greater economic opportunities throughout the area.

Further details on these benefits and others can be found in existing TMDL IPs, including Crab Creek in Montgomery County, Buffalo/Colliers/Cedar Creek in Rockbridge County, and Cripple Creek and Elk Creek in Grayson, Smyth and Wythe Counties. These examples and others can be found on the VADEQ website (http://www.deq.state.va.us/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLImplementation/TMDLImplementationPlans.aspx).

Cleaner waters in Virginia will result in improved public health, conservation of natural resources, restored aquatic habitats, and greater economic opportunities for Virginians. These benefits add up to a better quality of life in the Commonwealth of Virginia; the recognition of these effects and their relevance in watersheds will help to ensure successful implementation

8.0 MEASURABLE GOALS AND MILESTONES FOR ATTAINING WATER QUALITY STANDARD

8.1 Establishing Milestones

The end goals of implementation are 1) water quality standard attainment, and 2) delisting of waters from the Commonwealth of Virginia's List of Impaired Waters. Progress can be assessed during the implementation process by tracking implementation action (BMP) installation and water quality monitoring. In establishing measurable goals, it is recommended that a baseline be established against which future progress can be measured. Information on current water quality conditions and the number of BMPs already implemented is needed to set this baseline.

Components of a TMDL Implementation Plan

1. Executive Summary
2. Introduction
3. State and Federal Requirements for Implementation Plans
4. Review of TMDL Development
5. Changes and Progress Since the TMDL Study
6. Public Participation
7. Implementation Actions
8. **Measurable Goals and Milestones**
9. Stakeholders' Roles and Responsibilities
10. Integration with Other Watershed Plans
11. Potential Funding Sources

The MEASURABLE GOALS AND MILESTONES chapter should address the following questions:

- Who will be responsible for tracking control measure installations?
- What are the implementation milestones?
- What type(s) of water quality monitoring will be continued during implementation?
- What implementation goals are to be achieved during implementation for each impaired watershed?
- What water quality goals are to be achieved during implementation?
- What methods will be used during implementation to evaluate progress?
- What actions will be taken if adequate progress is not attained?

Appropriate local stakeholders responsible for tracking implementation actions should be identified during IP development. The Virginia Agricultural Best Management Practices Cost-Share Tracking Program is the most likely tool for tracking implementation actions involving agriculture. (For more information, contact DCR or refer to their website www.dcr.virginia.gov/soil_and_water/costshar.shtml.) This tracking program also captures the implementation of 319-funded residential on-site sewage disposal practices (i.e., septic tank pump-outs, connections to public sewer, septic system repairs, septic system replacements, and alternative waste treatment systems). Other organizations that may have information regarding implementation tracking include local governments for residential, urban, stormwater, or streambank stabilization implementation actions, the Department of Mines, Minerals and Energy's (DMME) Division of Mined Land Reclamation for mining implementation actions, and the VDH Bureau of Shellfish Sanitation for implementation actions associated with bacteria sources identified in shoreline surveys.

Expected progress in implementation is characterized by two types of milestones, *implementation milestones* and *water quality milestones*. Implementation milestones stipulate the number of implementation actions to be installed within certain time frames (e.g., number of livestock exclusion systems installed within three years or number of straight pipes eliminated within five years). Water quality milestones establish the corresponding improvements in water quality (e.g., not violating the bacteria SSM criterion more than 10.5% of the time) that can be expected as the implementation milestone is met. The establishment of implementation milestones and water quality milestones are inextricably linked. The process consists of a trade-off between quickly attaining water quality goals and the availability of implementation resources.

8.1.1 Implementation Milestones

Considerations when establishing implementation milestones

Implementation milestones can be established based on anticipated or modeled effects of differing levels of BMP implementation and discussions with local agency personnel and stakeholders. Some specific items that should be considered when setting implementation milestones include funding and technical resource availability, stakeholder participation and interest, types and quantity of BMPs being implemented, and time needed for BMPs to mature and become fully effective.

Funding sources available for BMP implementation must be identified during IP development. Available grant programs will have project schedules with specific time limits. The time frame of available funding must be considered when setting implementation milestones. A list of potential funding sources is provided in Chapter 11.

Resource availability should be taken into consideration when developing implementation milestones. The installation of some BMPs requires expertise or equipment that only specific contractors can provide (e.g., pump-outs and repairs of failing septic systems, fencing installation, design and construction of stream restoration). In these situations, implementation milestones should consider the number of contractors available to provide assistance and the time it takes to install and implement the BMP. For example, in a watershed where streamside fencing is one of the selected BMPs, consideration should be given to the number of contractors available to install fencing.

When setting implementation milestones, it is also important to consider the number of stakeholders currently familiar with the TMDL process and how much more involvement is necessary to carry out a successful IP. Some implementation milestones may have to allow for further education about BMPs to be implemented and their acceptance by the public, particularly stakeholders such as landowners, absentee landowners, and leaseholders of agricultural land within the watershed. Another example is if pet waste disposal BMPs are included in the IP, measurable milestones may not be achieved until pet owners are educated on the benefits and importance of picking up their pets' waste.

Some implementation actions require an extended time period before water quality improvements can be measured. For example, improvements in water quality from planting trees along a stream will not be measurable until the trees have been in place for some time. This lag time, the time elapsed between BMP installation and detection of resulting measurable water quality improvement, may range from months for relatively short-lived contaminants such as bacteria, to decades for excessive sediment accumulated in a stream or elevated phosphorus levels in the soil.

Staged Implementation

The implementation of BMPs in the impaired watershed will likely be accomplished in stages. In general, the Commonwealth intends for the required reductions to be implemented in an adaptive management process that first addresses the sources with the largest impact on water quality. The staged implementation approach produces a more acceptable and achievable plan in which implementation focuses on the most effective BMPs first.

Staged implementation can be used as an aid for establishing implementation milestones. For most bacteria TMDLs, multiple stages (2-3) may be used to achieve water quality milestones. TMDLs that address sediment, nutrients, or other impairments may not designate multiple implementation stages. For these impairments, total pollutant reduction goals for a specified timeline will be established during the IP development process.

Monitoring should continue to document progress toward goals and to provide a mechanism for evaluating the effectiveness of the implementation actions as well as their suitability for achieving intended water quality goals. The benefits of staged implementation are 1) as stream monitoring continues, it allows for water quality improvements to be recorded as they are being achieved; 2) it provides a measure of quality control, given the uncertainties which exist in any model; 3) it provides a mechanism for developing public support; 4) it helps to ensure that the most cost-effective practices are implemented initially; and 5) it allows for the evaluation of the TMDL's adequacy in achieving the water quality standard.

8.1.2 Water Quality Milestones

Water quality milestones establish the corresponding improvements in water quality that can be expected as implementation milestones are met. Water quality monitoring is the mechanism for tracking water quality improvements and thus determining and evaluating the success of the IP.

At a minimum, water quality milestones should be assessed using DEQ's ambient water quality data. There are, however, other potential sources that may also provide data useful in assessing the water quality milestones. The DEQ ambient monitoring program and other potential sources of monitoring data are discussed below.

DEQ ambient monitoring

DEQ has prioritized water quality monitoring in support of TMDL development and implementation. Virginia's strategy for TMDL implementation monitoring (*TMDL Implementation Monitoring Strategy*, 2014) outlines the current procedure for water quality monitoring of stream segments in watersheds undergoing TMDL implementation for bacteria impairments. The current *Strategy* states that implementation monitoring includes two elements: assessment of impaired status and monitoring to assess implementation effectiveness.

The primary purpose of assessing implementation in impaired watersheds is to determine impairment status once remediation measures or BMP installations are ongoing. This monitoring is focused on minimizing costs and obtaining a minimum number of samples to determine whether restoration efforts have had the desired effect to delist the impaired waterbody. In order to assess the impaired status, the dates and duration of monitoring must minimally fall either within a single year (monthly samples) or within two consecutive years of the same 6-year assessment cycle window (bimonthly samples).

Monitoring should begin no sooner than two years following the initiation of implementation actions identified in an IP. Initiating implementation monitoring after two or more years of implementation will help ensure that enough time has passed for remedial measures to have stabilized and BMPs to have become functional. Monitoring should focus on the listing station(s). When the listing station is a trend station, monitoring should continue as usual. When the listing station is not a trend station, monitoring of field parameters and the appropriate bacterial indicator are the only required parameters.

To meet EPA Nonpoint Source Program requirements, the implementation monitoring strategy will also include a subset of monitoring stations in selected watersheds statewide where continual bacteria monitoring is conducted on a monthly or bimonthly basis after the initiation of implementation. Continual TMDL implementation monitoring is not intended to measure specific BMP effectiveness, but is intended to assess the watershed/subwatershed water quality response to an aggregated number of various BMPs primarily funded through EPA Section 319 funds, the Virginia Natural Resources Conservation Fund, and Water Quality Improvement Fund and also to assess delisting of impaired segments.

The primary purposes of this monitoring are to 1) report water quality monitoring data to EPA documenting water quality improvement for projects receiving federal funding for BMPs, and 2) document that the Commonwealth's TMDL implementation efforts are improving local water quality. As with assessment monitoring, watershed monitoring should begin no sooner than two years following the initiation of implementation actions identified in an IP.

Biological monitoring conducted by DEQ regional biologists, as opposed to monitoring total suspended solids, total dissolved solids, turbidity, phosphorous or nitrogen concentrations/measurements, would be the basis for measuring progress in implementing local sediment and nutrient TMDLs in an impaired stream.

Other sources of monitoring data

In addition to DEQ ambient water quality data, other sources of monitoring data may be available. These sources may include, but are not limited to, citizen monitoring data, special studies, and monitoring by localities. For information on citizen monitoring in Virginia, contact DEQ's citizen monitoring coordinator (http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/CitizenMonitoring/Guidance.aspx). To find out if localities have monitoring programs in your area, contact the county's or city's environmental division. The Buffalo, Colliers and Cedar Creeks Water Quality Improvement Plan provides an example of a volunteer citizen monitoring effort that will be used to refine implementation based on identification of hotspots or problem areas in the watersheds (see Chapter 7 in http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Buffalo_Cedar_TechnicalDocument_3March2015.pdf).

8.1.3 Linking Implementation Actions to Water Quality

Direct Method

A simple approach to linking implementation milestones to water quality milestones is to assume that improvements in water quality are directly related to implementation actions. For example, an IP is being developed for a general standard TMDL (i.e., aquatic life impairment) in an urban watershed in which sediment loads to the stream must be reduced by 30%. The implementation planning team has decided that stormwater runoff is the primary source of the sediment impairment. This team has decided that the installation of six detention ponds within the watershed will reduce the sediment load to the impaired stream to the required allocation. The first implementation milestone is to install three of the six detention ponds (i.e., 50% of the implementation actions) within the first two years. Assuming a direct relationship between implementation and water quality, the first water quality milestone is an expected 15% reduction of the sediment load to the stream (50% of the 30% required) within the first two years.

Modeled Method

If modeling is used to evaluate milestones, water quality can be linked with specific levels of implementation. Table 8.1 illustrates the link between BMPs to reduce bacteria loads and the simulated water quality improvement goals for two implementation stages. Using a watershed-scale model (HSPF), existing exceedances of the single sample maximum and geometric mean water quality criteria were estimated, and reductions in exceedances were estimated for completion of each implementation stage. Occasionally an IP is addressing more than one pollutant in a single waterbody. For example, bacteria and sediment TMDLs were developed for Colliers Creek. During implementation planning, GWLF was used to model the sediment load reductions and HSPF was used to model the bacteria load reductions for each stage of implementation (Table 8.2).

Table 8.1. Implementation and water quality goals by implementation stage for bacteria impairment on North Fork Buffalo Creek

<table>
<tr><th rowspan="2">BMP Type</th><th rowspan="2">Description</th><th rowspan="2">BMP code</th><th rowspan="2">Units</th><th colspan="2">Extent</th></tr>
<tr><th>Stage 1</th><th>Stage 2</th></tr>
<tr><td rowspan="4">Livestock Exclusion</td><td rowspan="3">Livestock Exclusion with Riparian Buffers</td><td>CREP/</td><td rowspan="4">feet</td><td>435</td><td>381</td></tr>
<tr><td>SL-6/LE-1T/SL-6T</td><td>2,610</td><td>2,284</td></tr>
<tr><td>WP-2T</td><td>435</td><td>381</td></tr>
<tr><td>Livestock Exclusion with Reduced Setback</td><td>LE-2T</td><td>5,220</td><td>4,568</td></tr>
<tr><td rowspan="4">Pasture</td><td>Improved Pasture Management</td><td>EQIP (529, 512)</td><td rowspan="4">acres</td><td>1,307</td><td>–</td></tr>
<tr><td>Riparian Buffers</td><td>CREP, SL-6T, WP-2T</td><td>5</td><td>–</td></tr>
<tr><td>Permanent Vegetation On Critical Areas</td><td>SL-11</td><td>3</td><td>0</td></tr>
<tr><td>Reforestation of Erodible Pasture</td><td>FR-1</td><td>17</td><td>0</td></tr>
<tr><td rowspan="2">Cropland</td><td>Continuous No-Till</td><td>SL-15A</td><td rowspan="2">acres</td><td>2</td><td>0</td></tr>
<tr><td>Riparian Buffers</td><td>FR-3/WQ-1</td><td>1</td><td>0</td></tr>
<tr><td rowspan="5">Residential Septic</td><td>Septic Tank Pump-Outs</td><td>RB-1</td><td>pump-outs</td><td>32</td><td>0</td></tr>
<tr><td>Septic System Repair</td><td>RB-3</td><td>repairs</td><td>16</td><td>0</td></tr>
<tr><td>Septic System Replacement</td><td>RB-4</td><td rowspan="3">systems</td><td>10</td><td>0</td></tr>
<tr><td>Septic System Replacement with Pump</td><td>RB-4P</td><td>3</td><td>0</td></tr>
<tr><td>Alternative Waste Treatment</td><td>RB-5</td><td>4</td><td>0</td></tr>
<tr><td colspan="4">Average annual E. coli load (cfu/yr) (Existing=$6.52x10^{13}$ cfu/yr)</td><td>$4.18x10^{13}$</td><td>$3.72x10^{13}$</td></tr>
<tr><td colspan="4">% Violation of the Single Sample E. coli standard (235 cfu/100 ml)
Existing condition = 22.5%</td><td>10.27%</td><td>5.13%</td></tr>
<tr><td colspan="4">% Violation of the Geometric Mean E. coli standard (126 cfu/100 ml)
Existing condition = 46.7%</td><td>27.08%</td><td>0.00%</td></tr>
</table>

Source: Buffalo, Colliers and Cedar Creek Water Quality Improvement Plan, *Table 7.3. Staged implementation goals by stage for North Fork Buffalo Creek*
(http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Buffalo_Cedar_TechnicalDocument_3March2015.pdf)
BMP Code from DCR *VA Ag Cost-Share Manual* (http://dswcapps.dcr.virginia.gov/htdocs/agbmpman/csmanual.pdf)

Table 8.2. Implementation and water quality goals by implementation stage for bacteria and sediment impairments on Colliers Creek

BMP Type	Description	BMP code	Units	Extent	
				Stage 1	Stage 2
Livestock Exclusion	Livestock Exclusion with Riparian Buffers	CREP	feet	2,581	2,093
		SL-6/LE-1T/ SL-6T		15,487	12,558
		WP-2T		2,581	2,093
	Livestock Exclusion with Reduced Setback	LE-2T		30,974	25,115
Streambank	Streambank Stabilization	WP-2A	feet	3,000	0
Pasture	Improved Pasture Management	EQIP (529, 512)	acres	4,380	309
	Riparian Buffers	CREP, SL-6T, WP-2T		29	24
	Permanent Vegetation On Critical Areas	SL-11		5	0
	Reforestation of Erodible Pasture	FR-1		48	49
	Small Acreage Grazing System (Equine)	SL-6A		10	0
	Waste Storage Facility	WP-4	systems	1	0
	Water Control Structures	WP-1	acres treated	0	2,114
Cropland	Continuous No-Till	SL-15A	acres	3	0
	Riparian Buffers	FR-3/WQ-1		1	0
Residential septic	Septic Tank Pump-Outs	RB-1	pump-outs	114	0
	Septic System Repair	RB-3	repairs	56	0
	Septic System Replacement	RB-4	systems	36	0
	Septic System Replacement with Pump	RB-4P		12	0
	Alternative Waste Treatment	RB-5		13	0
Average annual *E. coli* load (cfu/yr) (Existing=7.97 x 10^{13} cfu/yr)				**4.70x10^{13}**	**2.87x10^{13}**
% Violation of the Single Sample *E. coli* standard (235 cfu/100 ml) Existing condition = 27.2%				**10.40%**	**6.98%**
% Violation of the Geometric Mean *E. coli* standard (126 cfu/100 ml) Existing condition = 38.3%				**29.17%**	**14.58%**
Average annual sediment load (T/yr) (TMDL goal = 9,289.27 T/yr)				**9,289.22**	**8,966.06**
% Reduction in sediment load (TMDL goal = 24%)				**24%**	**27%**

Source: Buffalo, Colliers and Cedar Creek Water Quality Improvement Plan, *Table 7.2. Staged implementation goals by stage for Colliers Creek* (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Buffalo_Cedar_TechnicalDocument_3March2015.pdf)
BMP Code from DCR *VA Ag Cost-Share Manual* (http://dswcapps.dcr.virginia.gov/htdocs/agbmpman/csmanual.pdf)

Targeted Method

When using the Direct Method or Modeled Method, installation of implementation actions is assumed to be uniform throughout the watershed. By "targeting" the critical areas in the watershed (the areas with the greatest likelihood of impairment), the greatest impact on water quality can be achieved in the shortest amount of time. Targeting in IPs is important to help scale down implementation to geographical areas that are better suited for short-term grant-funded implementation projects (e.g., two-year projects). Targeting is proposed not only to ensure optimum utilization of resources, but also to support a staged implementation approach. When using the Targeted Method, stream walks, watershed inventory, land use analysis, stream network GIS layers, monitoring results, and BMP survey responses can all be used in determining critical areas for BMP installation.

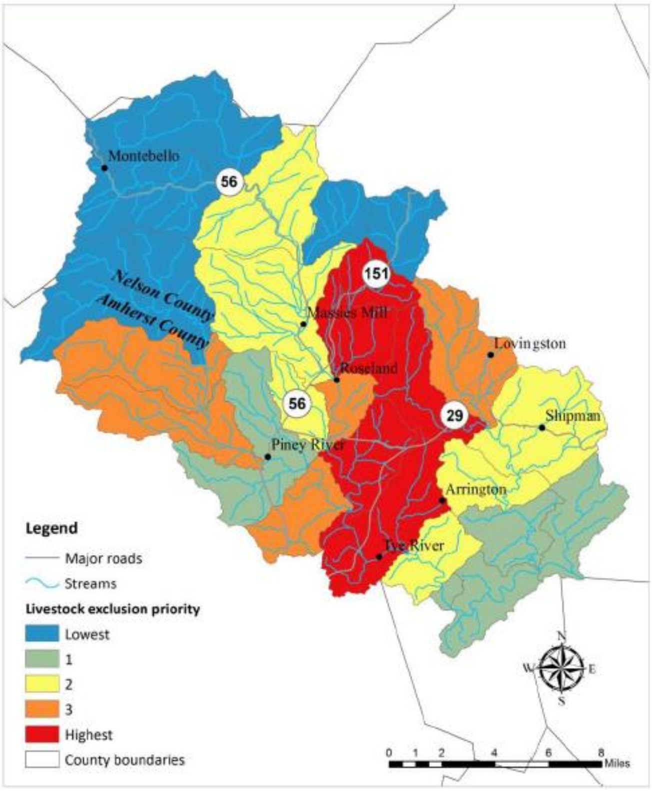
Data collected during the TMDL development process can be used together with spatial analysis results to target subwatersheds where initial implementation resources would result in the greatest return in water quality improvement. Spatial analysis can also be used independently to prioritize areas for implementation. For example, in the Tye River watershed, livestock exclusion was prioritized by subwatershed based on the extent of pasture next to the stream, the number of livestock, and the slope of the pastureland in each subwatershed. The resulting map depicts a ranking system that allows for focus of resources in high-ranked subwatersheds during implementation (Figure 8.1).

Another example of BMP targeting using spatial analysis involves a staged implementation approach in the Stroubles Creek watershed. In this IP, BMPs necessary to achieve required sediment reductions were quantified, and then GIS was used to target the locations of these BMPs in areas where installation was more likely and cost-share funding could be used. The result of this approach for agricultural and stream channel BMPs is included as Figure 8.2, which shows the specific BMP locations targeted by the analysis.

Implementation of practices can also be prioritized and expressed in tabular form. The *Bacterial Implementation Plan Development for the Chickahominy River and Tributaries* (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/chickecip.pdf) ranks the pet waste treatment BMPs needed based on the number of dogs per acre in each subwatershed (Table 8.3).

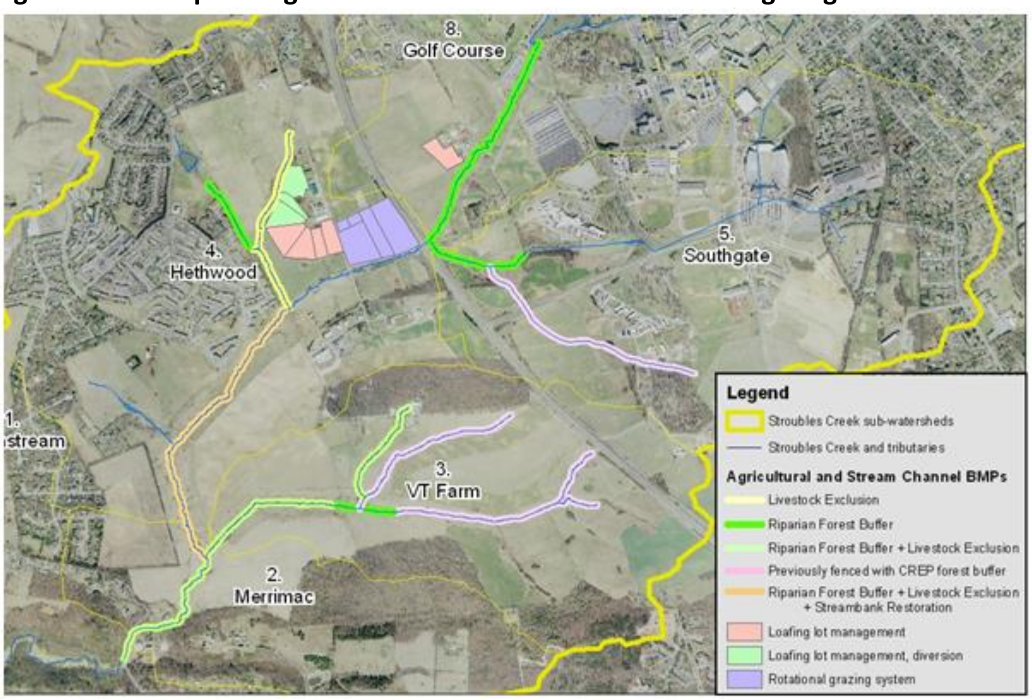
Stakeholder input during IP development can also be used for prioritizing subwatersheds. For example, residential working groups will often identify areas in the watershed that are most likely to have straight pipes and failing septic systems.

Figure 8.1. Example of livestock exclusion fencing targeting by subwatershed



Source: *TYE RIVER, HAT CREEK, RUCKER RUN & PINEY RIVER Water Quality Improvement Plan, Figure 7.2. Fencing prioritization by subwatershed: Tye River, Rucker Run, Hat Creek and Piney River* (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Tye_River_Technical_Document.pdf)

Figure 8.2. Example of agricultural and stream channel BMP targeting



Source: Upper Stroubles Creek Watershed TMDL Implementation Plan, *Figure 6.1. Targeted areas for agricultural and stream channel BMPs* (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/stroubip.pdf)

Table 8.3. Example of pet waste BMP targeting

Subwatershed	Stream	Dog Waste Pick-up Program Target Ranking
26	Upham Brook	1
11	Chickahominy River	2
25	Beaverdam Creek	3
9	Chickahominy River	4
10	Chickahominy River	5
27	Stony Run	6
22	White Oak Swamp	7
24	Boatswain Creek	8
19	Collins Run	9
18	Collins Run	10
12	Chickahominy River	11
14	Chickahominy River	12
16	Chickahominy River	13
13	Chickahominy River	14
15	Chickahominy River	15
7	Chickahominy River	16
23	Boar Swamp	17
6	Chickahominy River	18
8	Chickahominy River	19
3	Chickahominy River	20
4	Chickahominy River	21
5	Chickahominy River	22
2	Chickahominy River	23
1	Chickahominy River	24
20	Dockman Swamp	25
21	Jones Run	26
17	Collins Run	27

Source: Bacterial Implementation Plan Development for the Chickahominy River and Tributaries, *Table 6.4 Spatial targeting results for dog waste pick-up/composter BMPs* (http://www.deq.state.va.us/Portals/0/DEQ/Water/TMDL/ImplementationPlans/chickecip.pdf)

Another implementation targeting approach used in IPs developed in Virginia includes prioritizing subwatersheds based on density of straight pipes and failing septic systems. In addition, GIS analysis to identify potential for establishing riparian buffers along steams has been incorporated.

If modeling can be used for targeting, improvements in water quality can be evaluated by simulating various “targeting scenarios.” Placing implementation actions in more localized areas (instead of assuming a uniform distribution within the watershed) and then running the model for different scenarios can provide a more accurate estimate of water quality improvements.

8.2 Establishing a Timeline for Implementation

Based on meeting the milestones, the IP needs to include for each watershed a timeline that describes the incremental goals for implementation in terms of implementation actions and land use sources (e.g., agricultural, urban, residential, mining), and identifies technical assistance needs and total costs. The timeline must account for the availability of human resources (e.g., stakeholder participation, contractors, technical assistance), funding resources, and regulatory requirements. In addition, the complexity of source sectors addressed by the IP must be considered along with what can be reasonably implemented based on stakeholder buy-in and interest.

Tables 8.4 to 8.6 provide an example of the implementation timeline used in the Chestnut Creek IP. This IP was developed to address both bacteria and sediment impairments. Input from stakeholders and local governments was essential in creating the IP timeline. Water quality milestones were established for two 10-year stages. Potential funding sources available during implementation were identified during plan development and used to allocate the implementation milestones over two-year increments for the timeline. Two-year increment milestones concur with the timeline often used in grant-funded implementation projects.

Table 8.4. Stage 1 implementation practices and water quality goals in an IP addressing bacteria and sediment impairments

BMP Type	BMP	Units	Extent	Cost
Direct Deposition	Livestock Exclusion with Riparian Buffers	systems	154	$3,875,000
	Livestock Exclusion with Reduced Setback	systems	39	$780,000
	Stream Protection System	systems	7	$70,000
Pasture	Improved Pasture Management	acres	11,615	$871,125
	Reforestation of Erodible Pasture	acres	291	$34,920
	Permanent Vegetative Cover on Critical Areas	acres	95	$190,000
	Loafing Lot Management	systems	–	–
	Animal Waste Control Facility	systems	–	–
	Water Control Structures	acres treated	–	–
Cropland	Continuous No-Till	acres	8	$160
	Harvestable Cover Crop	acres	14	$350
	Small Grain Cover Crop	acres	192	$4,800
	Permanent Vegetative Cover on Cropland	acres	2	$350
Streambank Stabilization	Streambank Stabilization	feet	1,985	$595,500
Pet Waste	Pet Waste Education Program	programs	1	$4,000
	Pet Waste Stations	systems	3	$22,500
Septic	Septic Tank Pump-Out	systems	105	$31,500
	Connection to Public Sewer	systems	2	$10,000
	Septic Tank System Repair	systems	192	$672,000
	Septic Tank System Installation/Replacement	systems	259	$1,295,000
	Alternative On-Site Waste Treatment System	systems	28	$420,000
Urban Stormwater	Rain Gardens	acres-treated	18	$90,000
	Riparian Buffer	acres-installed	4.5	$2,250
	Extended Detention	acres-treated	–	–
	Manufactured BMPs	acres-treated	–	–
	Infiltration	acres-treated	–	–
	Vegetated Open Channels	acres-treated	–	–
Average annual *E. coli* load (cfu/yr) (Existing = 8.25×10^{15} cfu/yr)			**1.74×10^{14}**	
% Violation of Single Sample *E. coli* standard (235 cfu/100mL) (Existing = 24%)			**20.40**	
% Violation of Geometric mean *E. coli* standard (126 cfu/100mL) (Existing = 81%)			**29.6**	
Average annual sediment load (T/yr) (Existing = 9,167) (TMDL goal = 6,618)			**6,617**	
% Reduction in sediment load (TMDL goal = 28%)			**28**	
Total Cost for Stage 1 (including Technical Assistance)			**$9,855,955**	

Source: Water Quality Improvement Plan to reduce bacteria and sediment in Chestnut Creek, *Table 20. Practices needed to meet the bacteria and sediment milestones in Stage 1* (http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/ChestnutCrk_public_document_04SEP2015.pdf)

Table 8.5. Stage 2 implementation practices and water quality goals in an IP addressing bacteria and sediment impairments

BMP Type	BMP	Units	Extent	Cost
Direct Deposition	Livestock Exclusion with Riparian Buffers	systems	–	–
	Livestock Exclusion with Reduced Setback	systems	–	–
	Stream Protection System	systems	–	–
Pasture	Improved Pasture Management	acres	–	–
	Reforestation of Erodible Pasture	acres	1,510	$181,200
	Permanent Vegetative Cover on Critical Areas	acres	–	–
	Loafing Lot Management	systems	3	$60,000
	Animal Waste Control Facility	systems	1	$150,000
	Water Control Structures	acres-treated	7,233	$1,012,620
Cropland	Continuous No-Till	acres	–	–
	Harvestable Cover Crop	acres	–	–
	Small Grain Cover Crop	acres	–	–
	Permanent Vegetative Cover on Cropland	acres	–	–
Streambank Stabilization	Streambank stabilization	feet	–	–
Pet Waste	Pet Waste Education Program	programs	–	–
	Pet Waste Stations	systems	–	–
Septic	Septic Tank Pump-Out	systems	–	–
	Connection to Public Sewer	systems	–	–
	Septic Tank System Repair	systems	448	$1,568,000
	Septic Tank System Installation/Replacement	systems	404	$2,020,000
	Alternative On-Site Waste Treatment System	systems	44	$660,000
Urban Stormwater	Rain Gardens	acres-treated	–	–
	Riparian Buffer	acres-installed	–	–
	Extended Detention	acres-treated	–	–
	Manufactured BMPs	acres-treated	–	–
	Infiltration	acres-treated	–	–
	Vegetated Open Channels	acres-treated	–	–
Average annual *E. coli* load (cfu/yr)			**6.47×10^{13}**	
% Violation of Single Sample *E. coli* standard (235 cfu/100mL)			**10.34**	
% Violation of Geometric mean *E. coli* standard (126 cfu/100mL)			**0**	
Average annual sediment load (T/yr) (TMDL goal = 6,618)			**3,732**	
% Reduction in sediment load (TMDL goal = 28%)			**59**	
Total Cost for Stage 2 (including Technical Assistance)			**$6,551,820**	

Source: Water Quality Improvement Plan to reduce bacteria and sediment in Chestnut Creek, *Table 2. Practices needed to meet the bacteria and sediment milestones in Stage 2*(http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/ChestnutCrk_public_document_04SEP2015.pdf)

Table 8.6. Implementation milestones

Control Measure	Units	Stage 1 (10 Years)					Stage 2 (10 Years)				
		Yrs 1-2	Yrs 3-4	Yrs 5-6	Yrs 7-8	Yrs 9-10	Yrs 11-12	Yrs 13-14	Yrs 15-16	Yrs 17-18	Yrs 19-20
Livestock Exclusion with Riparian Buffers	systems	42	31	31	26	24	–	–	–	–	–
Livestock Exclusion with Reduced Setback	systems	6	6	9	9	9	–	–	–	–	–
Stream Protection System	systems	3	1	1	1	1	–	–	–	–	–
Grazing Land Management System	acres	4,000	3,000	1,800	1,800	1,015	–	–	–	–	–
Reforestation of Erodible Pasture	acres	60	60	60	60	51	80	80	80	500	670
Permanent Vegetative Cover on Critical Areas	acres	20	20	20	20	15	20	20	20	20	20
Continuous No-till	acres	5	3	–	–	–	–	–	–	–	–
Cover Crop	acres	50	40	40	40	36	–	–	–	–	–
Permanent Vegetative Cover on Cropland	acres	0.4	0.4	0.4	0.4	0.4	–	–	–	–	–
Loafing Lot Management	systems	–	–	–	–	–	1	1	1	-	-
Waste Storage Facility (beef)	systems	–	–	–	–	–	-	-	-	1	-
Water Retention Structures	acres-treated	–	–	–	–	–	1,100	1,100	1,100	1,900	2,033
Streambank Stabilization	linear feet	397	397	397	397	397	–	–	–	–	–
Septic Tank Pump-out	systems	21	21	21	21	21	–	–	–	–	–
Connection to Public Sewer	systems	1	1	–	–	–	–	–	–	–	–
Septic Tank System Repair	systems	39	39	38	38	38	90	90	90	89	89
Septic Tank System Installation/ Replacement	systems	52	52	52	52	51	81	81	81	81	80
Alternative On-site Waste Treatment System	systems	6	6	6	5	5	9	9	9	9	8
Pet Waste Education Program	number	————— 1 —————					–	–	–	–	–
Pet Waste Stations	number	3	–	–	–	–	–	–	–	–	–
Rain Gardens	acres-treated	4	4	4	3	3	–	–	–	–	–
Urban Riparian Buffers	acres-treated	1	1	1	1	0.5	–	–	–	–	–

Source: Water Quality Improvement Plan to reduce bacteria and sediment in Chestnut Creek, *Table 23. Implementation milestones at two-year increments*
(http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/ChestnutCrk_public_document_04SEP2015.pdf)

8.3 Developing BMP and Implementation Milestone Tracking and Monitoring Plans

8.3.1 Implementation Tracking

During implementation, types, quantities, and locations of BMPs throughout the implementation watershed should be documented in a tracking system. This is critical to continual assessment and adjustment of implementation strategies, as needed. BMP tracking units might include acres of land covered or treated by a BMP, the number and treatment capacities of retention basins in place, or removals of straight pipes discharging to streams within the watershed. IP developers should also track management measures such as number of stakeholders participating in cost-share programs and types of outreach education activities (e.g., workshops, mailings, field days).

While the system should be effective in tracking all BMPs implemented and their attributes as described, its format and technical level should be adapted to the specific watershed, funding programs, and personnel administering the implementation. For example, while incorporating BMP tracking data into a GIS format is highly useful, the resources may not be available to establish such a system for every IP. An example of a basic tracking system that could be adapted to a broad range of implementation projects is presented in Figures 8.3 and 8.4. This example system is a spreadsheet workbook consisting of a general project information (Project Info) tab and a tab for each of the pollutant source types (e.g., Direct Deposit, Pasture, Cropland) in which the applicable BMPs are tracked. In this system, the user would enter basic project information into the "Project Info" tab, including baseline and staged implementation practice tables copied directly from the IP (Figure 8.3). The user would then use the individual sheets named by pollutant source type to track relevant BMPs (Figure 8.4) as they are installed. When implemented completely, data from a tracking system like the one presented here can easily be converted to GIS format.

Existing tracking systems being used by various entities, such as those associated with specific funding or regulatory programs, should be considered when developing a watershed-specific implementation tracking system. An example of such a tracking system is DEQ's NPS Best Management Practices Pollution Reduction Tracking Data Form (see Appendix C) used in tracking certain BMPs funded by various programs including Section 319 of the Clean Water Act and the Virginia Water Quality Improvement Fund. Another example of an existing tracking system is the BMP Warehouse that enables local governments to report a wide variety of water quality BMPs to the DEQ. As described earlier in this chapter, the Virginia Agricultural Best Management Practices Cost-Share Tracking Program is the most likely tool to use for tracking implementation actions involving agriculture. This tracking program also captures the implementation of 319-funded residential on-site sewage disposal practices (i.e., septic tank pump-outs, connections to public sewer, septic system repairs, septic system replacements, and alternative sewage systems). An example of a tool that can be used in a tracking plan to summarize implementation actions using GIS can be found in Appendix C.

Figure 8.3. Sample BMP tracking system project information page

TMDL Implementation BMP Tracking System

Stream Name(s):	Dirty Branch
NWBD Code(s):	ZZ23
ImplementationTracking Entity:	Madeuplocal SWCD
Implementation Period:	
Start	1/1/2014
End	12/31/2024

Instructions:

1. Provide the required information for the stream(s) for which BMPs are being tracked
2. Copy baseline data and staged implementation practices from the Implementation Plan to this page for reference.
3. Enter the required information into appropriate sheets based on pollutant type.

Baseline Data & Staged Implementation Practices (copy below):

Table 5. BMPs installed in the Dirty Branch watershed since the 2008 TMDL study.

BMP Name	BMP Code	Extent Installed	
		Units	Amount
CREP grazing land protection	CRSL-6	linear feet	12,225
CREP riparian forest buffer planting	CRFR-3	acres	34
Extension of CREP watering systems	SL-7	acres	23
Livestock exclusion with reduced setback	LE-2	linear feet	521
Permanent vegetative cover on critical areas	SL-11	acres	2
Permanent vegetative cover on cropland	SL-1	acres	72
Protective cover for specialty crops	SL-8	acres	136
Small grain cover crop for nutrient management	SL-8B	acres	1,721
Stream exclusion with grazing land management	SL-6	linear feet	21,100

Table 15. Practices needed to meet the bacteria and sediment milestones in Stage 1.

BMP Type	BMP	Units	Extent	Cost
Direct Deposition	Livestock Exclusion with Riparian Buffers	system	154	$3,875,000
	Livestock Exclusion with Reduced Setback	system	39	$780,000
	Stream Protection System	system	7	$70,000
Pasture	Improved Pasture Management	acres	11,615	$871,125
	Reforestation of Erodible Pasture	acres	291	$34,920
	Permanent Vegetative Cover on Critical Areas	acres	95	$190,000
	Loafing Lot Management	system	-	-
	Animal Waste Control Facility	system	-	-
	Water Control Structures	acres-treated	-	-
Cropland	Continuous No-till	acres	8	$160
	Harvestable Cover Crop	acres	14	$350
	Small Grain Cover Crop	acres	192	$4,800
	Permanent Vegetative Cover on Cropland	acres	2	$350
Streambank Stabilization	Streambank Stabilization	feet	1,985	$595,500
Pet Waste	Pet Waste Education Program	program	1	$4,000
	Pet Waste Stations	system	3	$22,500
Septic	Septic Tank Pump-out	system	105	$31,500
	Connection to Public Sewer	system	2	$10,000
	Septic Tank System Repair	system	192	$672,000
	Septic Tank System Installation/Replacement	system	259	$1,295,000
	Alternative On-site Waste Treatment System	system	28	$420,000
Urban Stormwater	Rain Gardens	acres-treated	18	$90,000
	Riparian Buffer	acres-installed	4.5	$2,250
	Extended Detention	acres-treated	-	-
	Manufactured BMPs	acres-treated	-	-
	Infiltration	acres-treated	-	-
	Vegetated Open Channels	acres-treated	-	-
Average annual *E. coli* load (cfu/yr) (Existing = 8.25×10^{15} cfu/yr)			1.74×10^{14}	
% Violation of Single Sample *E. coli* standard (235 cfu/100mL) (Existing = 24%)			20.40	

Table 16. Practices needed to meet the bacteria and sediment milestones in Stage 2.

BMP Type	BMP	Units	Exte
Direct Deposition	Livestock Exclusion with Riparian Buffers	system	-
	Livestock Exclusion with Reduced Setback	system	-
	Stream Protection System	system	-
Pasture	Improved Pasture Management	acres	-
	Reforestation of Erodible Pasture	acres	1,51
	Permanent Vegetative Cover on Critical Areas	acres	-
	Loafing Lot Management	system	3
	Animal Waste Control Facility	system	1
	Water Control Structures	acres-treated	7,23
Cropland	Continuous No-till	acres	-
	Harvestable Cover Crop	acres	-
	Small Grain Cover Crop	acres	-
	Permanent Vegetative Cover on Cropland	acres	-
Streambank Stabilization	Streambank stabilization	feet	-
Pet Waste	Pet Waste Education Program	program	-
	Pet Waste Stations	system	-
Septic	Septic Tank Pump-out	system	-
	Connection to Public Sewer	system	-
	Septic Tank System Repair	system	448
	Septic Tank System Installation/Replacement	system	404
	Alternative On-site Waste Treatment System	system	44
Urban Stormwater	Rain Gardens	acres-treated	-
	Riparian Buffer	acres-installed	-
	Extended Detention	acres-treated	-
	Manufactured BMPs	acres-treated	-
	Infiltration	acres-treated	-
	Vegetated Open Channels	acres-treated	-
Average annual *E. coli* load (cfu/yr)			
% Violation of Single Sample *E. coli* standard (235 cfu/100mL)			

Project Info | Direct Dep | Pasture | Cropland | Streambank Stabilization | Pet Waste | Septic | Urban Stormwater

Figure 8.4. Sample BMP tracking system residential septic bacteria BMP tracking page

Septic BMP Tracking Sheet

Stream Name: Dirty Branch

BMP #	Installation Date	BMP Design Life (years)	Land Owner (if available)	BMP Type	Units	Extent	Installed Cost	Funding Source(s)	Site Location (decimal deg.) Latitude	Site Location (decimal deg.) Longitude	Additional Information
1	4/20/2015	6	Bob Renter	RB-1	pumpout	1	$225	private	38.215	-78.5489	
2	4/25/2015	6	Jane Homeowner	RB-1	pumpout	1	$200	private	38.3654	-78.1234	
3	5/4/2015	20	George Renter	RB-3	repair	1	$5,500	mixed	38.9876	-78.1234	50% cost share, 50% private
4	9/5/2015	25	Gail Homeowner	RB-5	system	1	$18,750	mixed	38.215	-78.1234	50% cost share, 50% private
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

Project Info | Direct Dep | Pasture | Cropland | Streambank Stabilization | Pet Waste | Septic | Urban Stormwater

8.3.2 Water Quality Monitoring Plan

An appropriate monitoring plan documents the schedule for and location of water quality monitoring, organization(s) responsible for monitoring, and monitoring procedure(s). If possible, monitoring should be conducted at the same sites used during TMDL development to evaluate changes in water quality once BMPs have been implemented. Also, monitoring should be conducted where needed to assess the effectiveness of targeted aggregated efforts.

Virginia's Water Quality Monitoring Strategy states that for bacteria TMDLs, *E. coli* will be the parameter of concern in freshwater streams, Enterococcus in saltwater, and fecal coliform in shellfish-growing areas. For benthic TMDLs, the assessment should focus on biological monitoring. Implementation monitoring will generally be the same as that done in TMDL development. However, modifications may be made to reflect the needs of the IP. DEQ staff will determine sites, frequency, and duration of implementation monitoring.

Planning an effective monitoring strategy during TMDL Implementation Plan development

There are many things to consider when monitoring the success of implementation and measuring water quality milestones. These may include

- identifying sources of monitoring data - see above text for more information on potential sources
- matching parameters to be monitored with impairment. For a bacterial impairment, water quality analysis should include the appropriate bacteria indicator, e.g., *E. coli* enumerations. For a general standard (benthic) impairment, water quality analysis should include biological monitoring or monitoring of other related indicators that measure reductions in pollutant loadings achieved by BMP implementation (e.g., measuring turbidity or bank stability to assess sediment reduction).
- setting a timeline for achieving water quality milestones

8.4 Evaluation of Implementation Progress

Periodically, as defined in the IP, implementation progress should be evaluated based on water quality standard attainment and the status of meeting implementation milestones. The IP should include a section describing the evaluation process and defining the course of action based on the results of that evaluation. Evaluation of progress includes assessing the goals defined in the IP timeline and the milestones. Data from the implementation tracking system, stakeholder input, and water quality monitoring data should be used in evaluating implementation progress. DEQ will provide the associated water quality data unless otherwise specified in the IP.

Several federal and state implementation tracking systems (e.g., EPA Region III Watershed Tracker Database and DEQ IP CEDS) in place or under development could help facilitate the evaluation of implementation progress. The IP Steering Committee can be a resource to periodically engage local stakeholders to track progress, exchange new ideas, and make adjustments in implementation strategies. In this model, the IP Steering Committee is the group of active/responsible stakeholders who have assumed the charge to ensure implementation of the IP occurs. In tracking implementation progress, the Steering Committee should document attainment and non-attainment of implementation milestones detailed in the IP and, if necessary, develop additional/milestones. The sections below describe potential adjustments based on the results of the implementation evaluation.

8.4.1 Water Quality Attained

If the monitoring process indicates that water quality standards are met, the next step is to delist the waterbody. Delisting will occur as part of the regular statewide water quality assessment process documented in the biennial 305(b) report and following the established 305(b) guidance requirements. In some cases, for example when a large number of BMPs are implemented very rapidly, it may be possible to demonstrate attainment outside of the typical six-year assessment period.

8.4.2 Water Quality Not Attained

A variety of scenarios can result during the implementation phase if water quality standards are not met. Those potential scenarios are listed below with recommended implementation adjustments for each.

Implementation Milestones Met, Water Quality Milestones Met

If the monitoring process reveals that implementation milestones and water quality milestones are being met on schedule, then implementation and monitoring should continue as planned.

Implementation Milestones Met, Water Quality Milestones Not Met

In some cases, monitoring will reveal that implementation milestones are being met, and yet water quality is not showing the expected improvements. This can mean that the TMDL or the IP needs revision, there are greater lag times than anticipated between implementation of BMPs and their full effectiveness, or the TMDL may not be attainable even with the implementation of reasonable BMPs.

If it is determined that the TMDL is not attainable even with the implementation of reasonable BMPs, a Use Attainability Analysis (UAA) may be necessary to re-classify the stream and its designated uses. DEQ anticipates that UAAs would be appropriate only in selected cases. While many streams in the Commonwealth of Virginia are not used for recreational purposes, all waters have been designated as "primary contact recreation" for swimming use regardless of size, depth, location, water quality, or actual use. A UAA can result in a change of the beneficial use to "secondary contact recreation" with less stringent water quality for bacteria.

In some waterbodies, populations of wildlife are so great that the natural condition alone is significant enough to exceed the water quality standards for bacteria. If monitoring during the implementation phase indicates that removal of anthropogenic sources was not adequate to obtain the designated use, a UAA may be performed for that waterbody, which could result in a stream classification being removed and/or added by the State Water Control Board. Additional information on the state's water quality standards can be found at http://www.deq.state.va.us/Programs/Water.aspx.

Implementation Milestones Not Met, Water Quality Milestones Not Met

If neither the implementation nor the water quality milestones are being met as expected, it is critical to determine why. If deterrents to progress are due to external influences that are expected to be resolved (e.g., lack of funding, lag in stakeholder commitment) or to inappropriate selection of BMPs, then it may be appropriate to revise the IP schedule accordingly and establish new goals and milestones. If monitoring reveals that the established milestones are far from being met, a revision of the TMDL may be appropriate.

Implementation Milestones Not Met, Water Quality Milestones Met

It is possible to see improvements in water quality even when implementation milestones are not being met as planned. This could be due to BMPs having a greater effect than expected or to unpredictable causes. In these instances, the IP schedule could be revised to reflect the accelerated progress being made. New goals and milestones should then be established, and evaluation of progress should continue.

8.4.3 Implementation Success

A frequent question that arises during the TMDL process is whether or not there have been any watersheds that have been successfully delisted as a result of the process. There have been, and these success stories can be shared with stakeholders as inspiration or used as models when developing the IP. DEQ has documented Success Stories by point and non-point sources and has made them accessible here: http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualitySuccessStories.aspx. EPA has documented Success Stories by state and made them accessible using an interactive map at the following website: https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/nonpoint-source-success-stories.

8.4.4 TMDL Implementation Progress Web Documents

DEQ has developed an extensive web resource documenting the progress of stakeholders within the TMDL program, from TMDL development through implementation. Documentation of TMDL implementation can be found here: http://deq.state.va.us/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLImplementation.aspx. A menu therein contains links to pages containing this guidance manual, draft and final IPs, descriptions of implementation projects, and documentation of implementation and water quality progress being made by various TMDL implementation projects. EPA also provides detailed information about implementation activity to address nonpoint source pollution through an interactive map found here: https://ofmpub.epa.gov/apex/grts/f?p=110:95:0::NO:::.

9.0 STAKEHOLDERS' ROLES AND RESPONSIBILITIES

(The language included in this section regarding the common stakeholders may be inserted into the Stakeholders' section of the Implementation Plan as appropriate, or it may be modified to meet the needs of the group developing the Plan.)

Stakeholders in the TMDL process include individuals who live or have land management responsibilities in the watershed, including government agencies, businesses, private citizens, and special interest groups. Stakeholder participation and support is essential for achieving the goals of TMDL efforts (i.e., improving water quality and removing waterbodies from the impaired waters list). The purpose of this chapter is to identify and define the roles of stakeholders who will be working together to implement the IP.

The accustomed roles and responsibilities of some of the major stakeholders are described below.

Components of a TMDL Implementation Plan

1. Executive Summary
2. Introduction
3. State and Federal Requirements for Implementation Plans
4. Review of TMDL Development
5. Changes and Progress Since the TMDL Study
6. Public Participation
7. Implementation Actions
8. Measurable Goals and Milestones
9. **Stakeholders' Roles and Responsibilities**
10. Integration with Other Watershed Plans
11. Potential Funding Sources

THE STAKEHOLDERS' ROLES AND RESPONSIBILITIES chapter should address the following questions:

- Who are the stakeholders identified in the TMDL development process?
- Which stakeholders will assist in implementing the IP?
- What will be the specific roles and responsibilities of the stakeholders?
- What resources can the stakeholders provide toward implementation?

9.1 Federal Government

US Environmental Protection Agency (EPA): EPA has the responsibility of overseeing the various programs necessary for the success of the Clean Water Act. However, administration and enforcement of such programs fall largely to the states. The EPA Region III NPS Program reviews IPs developed by the Commonwealth of Virginia to assure that they address the nine elements necessary to meet EPA 319 requirements.

Natural Resources Conservation Service (NRCS): NRCS is the federal agency that works hand-in-hand with the American people to conserve natural resources on private lands. NRCS assists private landowners with conserving their soil, water, and other natural resources. Local, state, and federal agencies and policymakers also rely on NRCS staff expertise. NRCS is also a major funding stakeholder for impaired waterbodies through the Environmental Quality Incentive Program (EQIP). For more information on NRCS, visit http://www.nrcs.usda.gov/.

9.2 State Government

In the Commonwealth of Virginia, water quality problems are dealt with through legislation, incentive programs, education, and legal actions. Currently, there are seven state agencies responsible for regulating and/or overseeing statewide activities that impact water quality in Virginia. These agencies include: Department of Environmental Quality (DEQ), Department of Conservation and Recreation (DCR), Virginia Department of Agriculture and Consumer

Services (VDACS), Virginia Department of Health (VDH), Virginia Department of Forestry (DOF), Virginia Department of Mines, Minerals and Energy (DMME) and Virginia Cooperative Extension (VCE).

Department of Environmental Quality (DEQ): DEQ is the lead agency in the TMDL process. The Code of Virginia directs DEQ to develop a list of impaired waters, develop TMDLs for these waters, and develop IPs for the TMDLs. DEQ administers the TMDL process including the public participation component and formally submits the TMDLs and IPs to EPA and the State Water Control Board for approval. DEQ is also responsible for implementing point source WLAs and monitoring state waters to determine compliance with water quality standards.

DEQ has a lead role in the development of TMDL implementation plans. DEQ also provides grant funding (EPA Section 319 and state Water Quality Improvement Fund) and technical support to project sponsors for TMDL implementation. DEQ works closely with project partners such as SWCDs and local governments to track implementation progress for BMPs. In addition, DEQ works with interested partners seeking grant funding for projects to implement BMPs included in IPs.

Department of Conservation and Recreation (DCR): DCR administers the Virginia Agricultural Cost-Share Program, working closely with 47 soil and water conservation districts to provide cost-share and operating grants needed to deliver this program at the local level and track BMP implementation. In addition, DCR administers the state's Nutrient Management Program, which provides technical assistance to producers in appropriate manure storage and manure and commercial fertilizer applications.

Virginia Department of Agriculture and Consumer Services (VDACS): The VDACS Commissioner of Agriculture has the authority to investigate claims that an agricultural producer is causing a water quality problem on a case-by-case basis (Pugh, 2001). If the claim is deemed a problem, the Commissioner can order the producer to submit an agricultural stewardship plan to the local soil and water conservation district. If a producer fails to implement the plan, corrective action can be taken, which may include civil penalties. The Commissioner of Agriculture can issue an emergency corrective action if runoff is likely to endanger public health, animals, fish and aquatic life, public water supply, etc. An emergency order can shut down all or part of an agricultural activity and require specific stewardship measures.

Virginia Department of Health (VDH): VDH is responsible for adopting, administering, and enforcing regulations for on-site sewage systems. The Sewage Handling and Disposal Regulations, 12 VAC 5-610-10 *et seq*. require homeowners to secure permits for sewage handling and disposal (e.g., repairing a failing septic system or installing a new sewage system). VDH staff provide homeowners technical assistance with septic system maintenance and installation and respond to complaints regarding failing septic systems and straight pipes.

Virginia Department of Forestry (DOF): DOF has prepared a manual to inform and educate forest landowners and the professional forest community on proper BMPs and technical specifications for installation of these practices in forested areas (http://dof.virginia.gov/infopubs/BMP-Technical-Guide_pub.pdf). Forestry BMPs are primarily directed to control erosion. For example, streamside forest buffers provide nutrient uptake and soil stabilization, which can benefit water quality by reducing the amounts of nutrients and sediments that enter local streams. Although the DOF's BMP program is intended to be voluntary, it becomes mandatory for any silvicultural operation occurring within state waters (VA Silvicultural Water Quality Law 10.1-1181.2). For more information on this regulation, visit Chapter 10 in the aforementioned manual.

Virginia Department of Mines, Minerals and Energy (DMME): DMME, through the federally funded Abandoned Mine Land (AML) program, eliminates sources of nonpoint source pollution through the reclamation of abandoned coal mined lands in Virginia. DMME inventories the coalfield counties of Virginia for abandoned mined land features, prioritizes those features based on public health, safety, and environmental impact, selects features for reclamation, and contracts the reclamation of the features to local vendors. Section 319 funds have funded the reclamation of AML in southwest Virginia. The utilization of BMPs, wasteload reduction actions, and offsets as part of DMLR's discharge permitting approach for active mining are helping Virginia reduce pollution and reach the TMDL goals of water quality restoration in coalfield streams.

Virginia Cooperative Extension (VCE): VCE is an educational outreach program of Virginia's land grant universities (Virginia Tech and Virginia State University) and a part of the national Cooperative State Research, Education, and Extension Service, an agency of the US Department of Agriculture. VCE is a product of cooperation among local, state, and federal governments in partnership with citizens. VCE offers educational programs and technical resources for topics such as crops, grains, livestock, poultry, dairy, natural resources, and environmental management. VCE has released several publications that specifically deal with TMDLs. For more information on these publications and to find the location of county extension offices, visit www.ext.vt.edu.

9.3 Local Government

Local government entities (staff and elected officials) work closely with state and federal agencies throughout the TMDL process. These entities' insights on their communities' priorities, how decisions are made locally, and how the watershed residents interact help ensure the success of TMDL implementation. Some local government entities and their roles in the TMDL process are listed below.

Soil and Water Conservation Districts (SWCD): SWCDs are local units of government responsible for soil and water conservation work within their boundaries. The districts' role is to increase voluntary conservation practices among farmers, ranchers, and other land users. District staff work closely with watershed residents and have valuable knowledge of local watershed practices. Districts are a major project sponsor in the implementation of TMDLs through the state funded agricultural cost-share program and as grant recipients working with landowners to incentivize the implementation of agricultural and residential BMPs. For more information or to locate a local district, visit http://vaswcd.org/.

Planning District Commission (PDC): PDCs were organized to promote the efficient development of the environment by assisting and encouraging local governmental agencies to plan for the future. PDCs focus much of their efforts on water quality planning, which is complementary to the TMDL process. TMDL development, IP development, and implementation projects are often contracted through PDCs. For more information on Virginia PDCs, visit http://www.vapdc.org/.

City/County government departments: City and county government staff work closely with PDCs and state agencies to develop and implement TMDLs and IPs. They administer local Erosion and Sediment Control and Stormwater Management Programs that improve water quality in impaired streams. They may also help to promote education and outreach to citizens, businesses, and developers regarding the TMDL process.

9.4 Businesses, Community Groups, and Citizens

While successful implementation depends on all stakeholders taking responsibility for their roles in the process, the primary accountability falls on the local groups that are most affected; that is, businesses, community watershed groups, and citizens.

Community watershed groups: Local watershed groups offer meetings and events for the local community to share ideas and coordinate preservation efforts and to showcase sites for citizen action. Watershed groups also have a valuable knowledge of the local watershed and habitat that is important to the implementation process. Watershed Roundtables can be effective in gaining support from local governments and others to sponsor water quality projects. More information on active watershed roundtables can be found here: http://deq.state.va.us/Programs/Water/WaterQualityInformationTMDLs/watershedRoundtables.aspx.

Citizens and businesses: The primary role of citizens and businesses is simply to get involved in the TMDL process. This may include participating in public meetings (Section 6.1), assisting with public outreach, providing input about the local watershed history, and/or implementing BMPs to help restore water quality.

Community civic groups: Community civic groups take on a wide range of community service including environmental projects. Such groups include Ruritan, farm clubs, homeowner associations and youth organizations such as Boy Scouts, 4-H, and Future Farmers of America. These groups offer resources to assist in the public participation process, educational outreach, and implementation activities in local watersheds.

Animal clubs/associations: Clubs and associations for various animal groups (e.g., beef, equine, poultry, swine, and canine) provide a resource to assist and promote conservation practices among farmers and other landowners, not only in rural areas, but also in urban areas where pet waste has been identified as a source of bacteria to waterbodies.

IPs should also provide specific roles and responsibilities for various stakeholders in implementing the IP-based decisions made during the development process. An example of identifying specific roles and responsibilities and documenting accountability is illustrated in Table 9.1.

Table 9.1 Residential implementation actions with associated funding sources and stakeholder roles

Source Issues	Corrective Actions	Potential Funding Source	Who will assist?
Lack of septic system maintenance	Regular maintenance	WQIF, NFWF grant, homeowners, Section 319 Funds	VDH, SWCD
Septic system failure and/or straight pipes	Septic system repairs, replacement, hook-ups, & maintenance	WQIF, NFWF grant, homeowners, block grants	VDH, RRRC, SWCD
No septic system pump-out tracking	Computerized tracking system	VDH	VDH, local government
Need information on system location at time of home sale	State requirement – initiated by Board of Realtors	Homeowners	VDH
Education needed on septic system function	Septic system education program	WQIF, NFWF grant	Realtors, teachers, VDH, school groups, community interest groups
No pet waste management	Education, bag stations, composters, structural practices in concentrated canine areas (kennels)	VCE, SWCD, WQIF, NFWF grant, Roundtables	Interest Groups, local governments, hunt clubs, veterinarians, SPCA
Waterfowl impact to ponds	Buffer ponds to discourage waterfowl, especially geese	HOAs, NFWF grant, VDGIF	VADOF, landowners
Runoff from streamside properties - non-agricultural	Low impact development techniques, install grass/shrub/tree buffers along streams, education on proper land management including erosion control and fertilizer	Homeowners, developers, NFWF grant, Green Grass program, PEC, VADOF, NFWF grant, private foundations	RRRC, PEC, local government, VCE, interest groups
Best management practices education for horse owners	Pasture management education, alternative watering sources, livestock exclusion	Ag BMPs, WQIF	SWCD, VCE, interest groups

Source: Upper York TMDL IP, *Table 10. Residential implementation action items.*

The benefits of involving the public in the implementation process are potentially very rewarding, but the process of doing so can be incredibly challenging. It is, therefore, the primary responsibility of these stakeholder groups to work with the various state agencies to encourage public participation and assure broad representation and objectivity throughout the IP development process.

Virginia's approach to correcting nonpoint source pollution problems continues to encourage participation through education and financial incentives; that is, outside of the regulatory framework.

10.0 INTEGRATION WITH OTHER WATERSHED PLANS

Each watershed within the Commonwealth is under the jurisdiction of a multitude of individual yet related water quality programs and activities, many of which have specific goals and geographical boundaries. These include but are not limited to coastal zone management plans, Chesapeake Bay Watershed Implementation Plan, local TMDLs, roundtables, WQMPs, Erosion and Sediment Control regulations, stormwater management (SWM), Source Water Assessment Program (SWAP), local comprehensive plans, and much more.

Components of a TMDL Implementation Plan

1. Executive Summary
2. Introduction
3. State and Federal Requirements for Implementation Plans
4. Review of TMDL Development
5. Changes and Progress Since the TMDL Study
6. Public Participation
7. Implementation Actions
8. Measurable Goals and Milestones
9. Stakeholders' Roles and Responsibilities
10. **Integration with Other Watershed Plans**
11. Potential Funding Sources

Questions to consider in coordinating multiple watershed plans:

- What other watershed plans exist or are being developed that should be considered in preparing an IP?
- How are the goals and objectives of these plans different from the TMDL (e.g., TMDLs are pollutant specific)?
- Which of the required components of an IP do these plans address or partially address?
- Can financial and technical resources be maximized for TMDL implementation by coordinating activities of ongoing watershed projects or programs?

10.1 Continuing Planning Process

According to Perciasepe (1997), the continuing planning process (CPP) established by Section 303(e) of the Clean Water Act provides a good framework for implementing TMDLs, especially the NPS load allocations. Under the Section 303(e) process, states develop and update statewide plans that include TMDL development and adequate implementation of new and revised water quality standards among other components. The water quality management regulations at 40 CFR 130.6 require states to maintain WQMPs that are used to direct implementation of key elements of the continuing planning process including TMDLs, effluent limitations, and NPS management controls. These state WQMPs are another way for states to describe how they will achieve TMDL load allocations for nonpoint pollution sources.

The CPP in Virginia is implemented in various state programs, all aimed toward achieving and maintaining the state water quality standards. Virginia Code Sections 62.1-44.15(10) & (13), 62.1-44.17:3, and 62.1-44.19:7 give the Virginia State Water Control Board (SWCB) the duty and authority to conduct the CPP in Virginia. Under the authority of Virginia Code Section 10.1-1183, DEQ serves as the administration arm of the SWCB.

10.2 Watershed and Water Quality Management Planning Programs in Virginia

- <u>Virginia Chesapeake Bay TMDL Implementation Plan</u> – Virginia's Watershed Implementation Plan (WIP) outlines a series of BMPs, programs, and regulations that will be implemented in the Bay drainage to meet nitrogen, phosphorus, and sediment loading reductions in accordance with the Chesapeake Bay TMDL completed in December 2010. The Virginia WIP outlines the Commonwealth's partnership with federal and local governments in achieving the Virginia portion of the Bay TMDL allocations. The TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay are in place by 2025 with at least 60 percent of the actions completed by 2017. Local governments in the Bay watershed will be able to track and receive credit for progress in meeting WIP goals while also working toward implementation goals established in local TMDL implementation plans to improve water quality.

- Coastal Zone Management Plans – One of the purposes of the Virginia Coastal Program is to encourage the preparation of special management plans to provide increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, and improved predictability in governmental decision-making.

- TMDLs – TMDLs are the maximum amount of pollutant that a waterbody can assimilate without surpassing state water quality standards. TMDLs are developed for waterbodies that are listed on a state's 303(d) list, known as the "Impaired Waters List." A TMDL develops a waste load allocation for point sources of pollution and a load allocation for nonpoint sources and incorporates a "margin of safety" in defining the assimilation capacity of the waterbody. A TMDL Implementation Plan outlines strategies to meet the allocations.

- Watershed Roundtables – Roundtables are 501c (3) nonprofit organizations working to achieve clean water by involving citizens in planning, education, coordination, and funding procurement and by serving as advocates for water resources.

- WQMPs – Virginia WQMPs consist of initial plans produced in accordance with Sections 208 and 303(e) of the CWA and approved updates to the plans. Currently, Virginia has a total 17 WQMPs developed under Sections 208 and 303(e). Many of these plans are outdated. The plans will serve as a repository for all TMDLs and IPs that have been approved by EPA and adopted by the SWCB.

- Erosion and Sedimentation Control Program (ESC Program) – The ESC Program requires certain standards and specifications to minimize erosion from various sites with land-disturbing activities equal to or exceeding 10,000 square feet (or 2,500 square feet in Chesapeake Bay localities), excluding agriculture and silviculture sites, which are exempt. Overseen by DEQ, the ESC Program has been primarily delegated to localities. One exception is agencies and companies who cross multiple localities (e.g., public roadways, infrastructure). These agencies and companies must annually file for review of general erosion control specifications, which detail the measures used to meet minimum standards set by DEQ. Additionally, these companies must file detailed information for each land disturbance project. For more information, visit http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/ErosionandSedimentControl.aspx.

- VSMP – Individual and general permits that control stormwater discharges from municipal separate storm sewer systems (MS4s) and construction activities are administered by DEQ through the Virginia Stormwater Management Program (VSMP) regulations (9VAC 25-870), which are authorized by the Virginia Stormwater Management Act. Locally adopted stormwater programs are implemented according to state regulations. These statutes are specifically set forth regarding land development activities to prevent water pollution, stream channel erosion, depletion of groundwater resources, and more frequent localized flooding to protect property values and natural resources. VSMP programs operated according to the law are designed to address these adverse impacts and comprehensively manage the quality and quantity of stormwater runoff on a watershed-wide basis. Localities regulated under the MS4 Program are required to implement a stormwater program, and non-MS4 localities have the option to establish a local program to regulate these same activities on private property in their jurisdiction. If non-MS4 localities do not opt-in to the VSMP program, then DEQ oversees regulated activities in the non-MS4 localities as well as on state and federal property, For more information, visit http://www.deq.virginia.gov/Programs/Water/StormwaterManagement.aspx.

- MS4 Permits – The Storm Water Phase I Rule (55 FR 47990; November 16, 1990) required all operators of medium and large municipal separate storm sewer systems (MS4s) located in incorporated places or counties with populations of 100,000 or more to: 1) obtain a NPDES permit and 2) develop a stormwater management program designed to prevent harmful pollutants from being washed by stormwater into the storm sewer and then discharged from the storm sewer into local waterbodies. As part of the Phase I Rule, EPA identified those medium and large municipal storm sewer systems that qualified. The resulting permits from the Storm Water Phase I Rule are referred to as "Phase I MS4 permits." The Phase II Storm Water Rule that was published December 8, 1999 (64 FR 68722) requires that operators of small MS4s in "urbanized areas" as defined by the most recent decennial Census to obtain permits for stormwater discharges. Small MS4s include storm sewer systems operated by cities, counties, towns, and federal and state facilities. Discharges from small MS4s are regulated under a general permit. These are referred to as Small MS4 permits or Phase II MS4 permits. For more information, visit http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/VSMPPermits/MS4Permits.aspx. TMDL Action Plans (i.e., Chesapeake Bay and local TMDLs) are required in accordance with the Virginia Special Condition of the 2013-2018 General Permit for Discharges of Stormwater from Small (Phase II) MS4s, the reissued Phase I MS4 permits, and any Individual Phase II permits that are issued.

- Source Water Assessment Program (SWAP) – VDH, as the Commonwealth's agency responsible for regulating public drinking water, was required by the 1996 Amendments to the Safe Drinking Water Act (SDWA) to develop a SWAP. The SWAP must delineate the boundaries of the assessment areas from which public water systems receive drinking water using hydrogeological information, water flow, recharge and discharge, and other reliable information. The SWAP includes an inventory of land use activities and determination of the drinking water source's relative susceptibility to these activities. In Virginia, there are approximately 2,700 waterworks withdrawing water from 4,000 ground and surface water locations to provide potable water to more than 80% of the state's population.

- Local Comprehensive Plans – Virginia law requires that all local governments have an adopted comprehensive plan. Typical topics addressed in a comprehensive plan include the analysis of population change, current land use and land use trends, natural and environmental features, transportation systems, and community facilities and services. Local comprehensive plans should be referred to in the TMDL development process as well as in TMDL implementation, especially the latter for urbanized watersheds.

- Additional Natural Resource Management and Conservation Planning – There are a number of organizations working to implement natural resources management and land conservation plans in local watersheds. These include the Virginia Department of Game and Inland Fisheries' quail habitat restoration program and plans from various organizations, such as the Virginia Outdoors Foundation, land trusts, and SWCDs that are working to preserve agricultural land through conservation easements. These easements can also include some form of riparian buffer protection and help to ensure the longevity of efforts made to implement conservation practices on agricultural land.

- The Watershed Protection and Food Prevention Act of 1954, Public Law 83-566 (PL-566) –This law is authorized by the Secretary of Agriculture to assist local sponsors in providing protection from flooding during major storm events within identified watersheds of major river systems. The PL-566 Program administered by NRCS has allowed for acquisition of conservation easements within floodplains where repeated damages have occurred as well as the installation of land treatment measures on individual farms and other private land holdings to protect on-site productivity and improve water quality.

11.0 Potential Funding Sources

The IP should identify potential funding sources available for implementation. A more detailed description of each source can be obtained from the various websites of the local, state, and federal agencies identified in this guidance manual. Each of the sources has specific requirements and benefits that will vary in applicability to specific circumstances. Sources include, but are not limited to:

Components of a TMDL Implementation Plan

1. Executive Summary
2. Introduction
3. State and Federal Requirements for Implementation Plans
4. Review of TMDL Development
5. Changes and Progress Since the TMDL Study
6. Public Participation
7. Implementation Actions
8. Measurable Goals and Milestones
9. Stakeholders' Roles and Responsibilities
10. Integration with Other Watershed Plans
11. **Potential Funding Sources**

State

- Clean Water State Revolving Loan Fund (CWSRF)
- Virginia Agricultural Best Management Practices Cost-Share Program
- Virginia Agricultural Best Management Practices Tax Credit Program
- Virginia Agricultural Best Management Practices Loan Program
- Virginia Forest Stewardship Program
- Virginia Stormwater Local Assistance Fund (SLAF)
- Virginia Water Quality Improvement Fund

Federal

- EPA Section 319 Funds
- USDA Conservation Reserve Program (CRP)
- USDA Conservation Reserve Enhancement Program (CREP)
- USDA Conservation Stewardship Program (CSP)
- USDA Environmental Quality Incentives Program (EQIP)
- USDA Regional Conservation Partnership Program (RCPP)
- USDA Small Watershed Program (PL-566)
- US Fish and Wildlife Service Private Stewardship Program
- US Fish and Wildlife Service Conservation Grants

Local or Regional

- Southeast Rural Community Assistance Project (SERCAP)
- Chesapeake Bay Stewardship Fund
- Chesapeake Bay Small Watershed Grants Program
- Community Foundations

Landowner Contributions and Matching Funds

- The state and federal cost-share assistance programs require a cost-share match, which is generally 25%.

Private Foundations, Nonprofit Organizations, Businesses

- Chesapeake Bay Funders Network
- National Fish and Wildlife Foundation

In the identification of applicable funding sources for TMDL implementation, one must consider the types of BMPs that are necessary for the various land uses (agriculture, residential, urban) in order to reduce the pollutant sources identified in the TMDL. Based on this analysis, potential funding sources can be identified in the IP that would address the watershed conditions. In identifying funding sources, consideration should be given to which sources are only available as grants and who (e.g., government agencies, watershed groups) may apply for the grant(s). Most of the sources described below offer funding for individual landowners, which are made available through traditional soil and water conservation programs.

Descriptions of Potential Funding Sources

State

- Clean Water State Revolving Fund (CWSRF) – EPA awards grants to states to capitalize CWSRFs. Through the CWSRF, states make loans for high-priority water quality activities. As loan recipients make payments back into the fund, money is available for new loans to be issued to other recipients. Eligible NPS projects include agricultural, silvicultural, rural, and some urban runoff control, on-site wastewater disposal systems (septic tanks), land conservation and riparian buffers; and leaking underground storage tank remediation.

- Virginia Agricultural Best Management Practices Cost-Share Program – The program is administered by DCR to improve water quality in the Commonwealth's streams, rivers, and the Chesapeake Bay. The basis of the program is to encourage the voluntary installation of agricultural BMPs to meet Virginia's NPS pollution water quality objectives. This program is funded by the state Virginia Natural Resources Conservation Fund and the federal Chesapeake Bay Program Implementation Grant monies through local SWCDs. Cost-share is typically 75% of the actual cost, not to exceed program requirements. http://www.dcr.virginia.gov/soil-and-water/costshar

- Virginia Agricultural Best Management Practices Tax Credit Program – The program provides a tax credit for approved agricultural BMPs that are installed to improve water quality in accordance with a conservation plan approved by the local SWCD. The goal of this program is to encourage voluntary installation of BMPs that will address Virginia's NPS pollution water quality objectives. The amount of the credit cannot exceed $17,500 or the total amount of the tax imposed by this program (whichever is less) in the year the project was completed. If the amount of the credit exceeds the taxpayer's liability for such taxable year, the excess may be carried over for credit against income taxes in the next five taxable years until the total amount of the tax credit has been taken. http://www.dcr.virginia.gov/soil-and-water/costshar

- Virginia Agricultural Best Management Practices Loan Program – The program offers a source of low interest financing to encourage the use of specific BMPs to reduce or eliminate the impact of agricultural NPS pollution on Virginia's waters. The minimum allowable loan amount is $5,000; there is no maximum amount, and the repayment periods range from one to ten years. Loan requests are accepted through DEQ and loans are administered through participating lending institutions. http://deq.state.va.us/Programs/Water/CleanWaterFinancingAssistance/AgriculturalBMP.aspx

- Virginia Forest Stewardship Program – The program is administered by the DOF to protect soil, water, and wildlife and to provide sustainable forest products and recreation. http://www.dof.virginia.gov/manage/stewardship/fsp-natl-stan-guidelines_2009-02.htm

- Virginia Stormwater Local Assistance Fund (SLAF) – SLAF funds stormwater projects including: 1) new stormwater BMPs, 2) stormwater BMP retrofits, 3) stream restoration, 4) low impact development projects, 5) buffer restorations, 6) pond retrofits, and 7) wetlands restoration. Eligible recipients are local governments, meaning any county, city, town, municipal corporation, authority, district, commission, or political subdivision created by the General Assembly or pursuant to the Constitution or laws of the Commonwealth. The fund is administered by DEQ.

- Water Quality Improvement Fund – This is a permanent, non-reverting fund established by the Commonwealth of Virginia to assist local stakeholders in reducing point and nonpoint source loads to surface waters. Eligible recipients include local governments, SWCDs, and individuals. Grants are administered through DEQ and require matching funds on a 50/50 cost-share basis.

Federal

- EPA 319 Funds – EPA develops guidelines that describe the process and criteria to be used to award Clean Water Act Section 319 NPS grants to states. DEQ is awarded 319 grant funds to implement the NPS program. Stakeholder agencies and organizations can apply on a competitive basis for 319 grants to implement BMPs and educational components included in a TMDL IP. EPA's current guidance on 319 funding is available here: https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/319-grant-current-guidance. For more information on the requirements for Section 319 fund eligibility in Virginia, refer to http://deq.state.va.us/Programs/Water/WaterQualityInformationTMDLs/NonpointSourcePollutionManagement.aspx.

- Conservation Reserve Program (CRP) – The program offers annual rental payments, incentive payments for certain activities, and cost-share assistance to establish cover of trees or herbaceous vegetation on cropland. Contract duration is between 10 and 15 years, and cost-share assistance is provided at up to 50% of costs. Incentive payments for wetlands hydrology restoration equal 25% of the restoration cost. http://www.nrcs.usda.gov/programs/crp/

- Conservation Reserve Enhancement Program (CREP) – In Virginia, this is a partnership program between the USDA Farm Services Agency and the Commonwealth of Virginia with DCR being the lead state agency. The program uses financial incentives including rental payments, incentive payments, and cost-share (75% to 100%) to encourage farmers to enroll in contracts of 10 to 15 years or perpetual easements to establish riparian buffers on pasture and cropland. http://www.dcr.virginia.gov/soil-and-water/crep

- Conservation Stewardship Program (CSP) – This program helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resource concerns. Annual payments are made for installing and adopting additional activities and improving, maintaining, and managing existing activities. Supplemental payments are available for the adoption of resource-conserving crop rotations. Two of the eligible lands addressed by the program include crop and pasture.

- Environmental Quality Incentives Program (EQIP) – The purposes of the program are achieved through the implementation of an EQIP plan of operation, which includes structural and land management practices on eligible lands. Approximately 65% of the EQIP funding for the Commonwealth of Virginia is directed toward "Priority Areas." The remaining 35% of the funds are directed toward statewide priority concerns of environmental needs. Contracts (5-10 years in length) are written with eligible producers to provide 75% cost-share assistance, 25% tax credit, and/or incentive payments to implement conservation practices. Eligibility is limited to persons who are engaged in livestock or agricultural production management. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/eqip/?cid=stelprdb1242633

- Small Watershed Program (PL-566) – More recent program changes have allowed for acquisition of conservation easements within floodplains where repetitive damages have occurred, as well as the installation of land treatment measures similar to PL-534 on individual farms and other private land holdings to protect on-site productivity and improve water quality. http://www.nrcs.usda.gov/wps/portal/nrcs/main/va/programs/planning/wpfp/

- Regional Conservation Partnership Program (RCPP) – This program was authorized through the 2014 Farm Bill. This 5-year program promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. The RCPP competitively awards funds to conservation projects designed by local partners specifically for their region. Eligible partners include agricultural or silvicultural producer associations, farmer cooperatives, state or local governments, municipal water treatment entities, conservation-driven nongovernmental organizations and institutions of higher education. Under the RCPP, eligible landowners of agricultural land and non-industrial private forestland may enter into conservation program contracts or easement agreements under the framework of a partnership agreement. The Chesapeake Bay watershed is one of the eight "Critical Conservation Areas" identified for this program.

- US Fish and Wildlife Service Conservation Grants – The USFWS provides funding to states for implementation of conservation projects that protect federally listed threatened or endangered species and species at risk. http://grants.fws.gov/state.html

Local or Regional

- Southeast Rural Community Assistance Project (SERCAP) –SERCAP can provide (at no cost) on-site technical assistance and consultation, operation and maintenance/management assistance, training, education, facilitation, volunteers, and financial assistance. Financial assistance - small awards and no- to low (up to 4%) interest loans - is available for the repair/replacement/installation of septic systems and alternative sewage systems. Loans are available for families making less than the state median family income. http://www.sercap.org

- Chesapeake Bay Stewardship Fund – This partnership between the EPA Chesapeake Bay Program and the National Fish and Wildlife Foundation provides grants to organizations working on a local level to protect and improve watersheds in the Chesapeake Bay basin while building citizen-based resource stewardship. http://www.nfwf.org/chesapeake/Pages/home.aspx

- Chesapeake Bay Small Watershed Grants – This grant program administered by the National Fish and Wildlife Foundation awards grants of $20,000 to $200,000 to organizations and local governments that work on community-based projects to improve the condition of their local watersheds while building stewardship among residents. Small Watershed Grants support local restoration and protection actions that restore waters and habitats in the Chesapeake Bay region.

- Virginia Conservation Assistance Program (VCAP) – This is an urban cost-share program that provides financial reimbursement to property owners installing eligible BMPs in Virginia's Chesapeake Bay Watershed. It is administered by the Virginia Association of Soil and Water Conservation Districts. http://vaswcd.org/vcap

- Community Foundations – Virginia's Community Foundations make grants from discretionary funds to support new or specific ongoing projects or programs in the areas of cultural, scientific, medical, environmental, social welfare, and educational endeavors. However, grants are typically made only to eligible 501c (3) tax-exempt nonprofit organizations, not to individuals, endowments, or tax-supported institutions. Grant categories and amounts available vary by Foundation location. More information on specific Foundations can be found on their websites, accessible through the map here: http://www.communityfoundationsva.org/.

Private Foundations, Nonprofit Organizations, Businesses

- Chesapeake Bay Funders Network – The Network brings funders together to protect and restore the Chesapeake Bay and the waters, lands, and communities of the broader Bay watershed. The mission is to develop and implement collaborative funding strategies that will make the greatest impact on the watershed-wide Chesapeake Bay restoration.

- National Fish and Wildlife Foundation – The National Fish and Wildlife Foundation is a private, nonprofit 501c (3) tax-exempt organization that fosters cooperative partnerships to conserve wildlife, plants, and the habitats on which they depend. Grants are available to federal, state, and local governments, educational institutions, and nonprofit organizations. The Conservation Partners Program, Environmental Solutions for Communities, and Five Star and Urban Water Restoration Grant Program are all grant programs that are suited to implement strategies and corrective actions in IPs. http://www.nfwf.org/whatwedo/grants/Pages/home.aspx

REFERENCES

Bockstael, N.E., A.M. Freeman III, R.J. Kopp, P.R. Portney, and V.K. Smith. 2000. On measuring economic values for nature. Environmental Science & Technology 34: 1384-1389.

Borah, D. K., G. Yagow, A. Saleh, P. L. Barnes, W. Rosenthal, E. C. Krug, and L. M. Hauck. 2006. Sediment and Nutrient Modeling for TMDL Development and Implementation. *Transactions of the American Society of Agricultural and Biological Engineers.* 49(4): 967−986.

Braden, J.B., and D.M. Johnston. 2004. Downstream Economic Benefits from Storm-Water Management. Journal of Water Resources Planning and Management. Vol. 130, Issue 6.

CDC (Centers for Disease Control). 2001. Outbreaks of *Escherichia coli* 0157:H7 infections among children associated with farm visits --- Pennsylvania and Washington, 2000. CDC MMWR. April 20, 2001. 50(15); 293-297. Available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5015a5.htm.

CH2MHILL. 2000. *Fecal Coliform TMDL Development for Cedar, Hall, Byers and Hutton Creeks, Virginia*. Prepared for Virginia Department of Environmental Quality and Virginia Department of Conservation and Recreation. Available at: http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/tenbigrvr/mfholstn.pdf.

Chesapeake Bay Program. 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.* Annapolis, MD. Available at: http://www.chesapeakebay.net/content/publications/cbp_12439.pdf.

DCR. *Agricultural BMP database.* Division of Soil and Water Conservation, Richmond, Virginia. http://dswcapps.dcr.virginia.gov/htdocs/progs/BMP_query.aspx (last accessed May 2016).

DCR. Website. http://www.dcr.virginia.gov/ (last accessed May 2016).

DCR. 1999. *Virginia Stormwater Management Handbook, Vol. I.* Division of Soil and Water Conservation, Richmond, Virginia.

DCR. 2001. *Virginia Agricultural BMP Manual*. Division of Soil and Water Conservation, Richmond, Virginia.

DCR. 2001. *Virginia Stormwater Management Law*. Richmond, Virginia. 7 p.

DCR. 2001. *Virginia Stormwater Management Regulations*. Richmond, Virginia. 13 p.

DEQ. *Glossary of TMDL Terms.* Water Program, Richmond, VA. http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLGlossary.aspx (last accessed May 2016).

DEQ. 1999. *Virginia's Water Quality Monitoring Strategy*. Office of Water Quality Assessment and Planning, Richmond, Virginia.

DEQ. 2014. TMDL Implementation Monitoring. Office of Watershed Programs. Richmond, VA. 5 p.

DEQ and DCR. 2001. *Draft Interim Nutrient Cap Strategy for the Shenandoah and Potomac River Basins: Draft of Available Actions and Options for Public Review and Comment.* Richmond, VA.

DEQ and DCR. 2001. *Final Report: Fecal Coliform TMDL Development for Muddy Creek, Virginia*. Available at: http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/shenrvr/muddyfe.pdf.

Donigian, A.S., Jr., B. R. Bicknell, and J. C. Imhoff. 1995. Hydrological Simulation Program - FORTRAN (HSPF). In: Computer Models of Watershed Hydrology. V. P. Singh, ed. Water Resources Publications, Colorado. p. 395-442.

Duda, P., J. Kittle, Jr., M. Gray, P. Hummel, and R. Dusenbury. 2001. WinHSPF Version 2.0: An Interactive Windows Interface to HSPF: User manual. Contract No. 68-C-98-010. EPA, Washington, D.C.

EPA. 1999a. *Draft Guidance for Water-Quality Based Decisions: The TMDL Process* (Second Edition). EPA-841-D-99-001. Office of Water, Washington, D.C.

EPA. 1999b. *Urban Storm Water Best Management Practices Study.* EPA-821-R-99-012. Office of Water, Washington, D.C. Available at: https://www.epa.gov/sites/production/files/2015-11/documents/urban-stormwater-bmps_preliminary-study_1999.pdf.

EPA. 2002a. *Guidance for Developing Watershed-based Plans for Impaired Waters*, Draft Outline. Office of Wetlands, Oceans, and Watersheds, Washington, D.C.

EPA. 2002b. *Supplemental Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories in FY 2003*. Office of Wetlands, Oceans, and Watersheds, Washington, D.C.

EPA. 2016. *Loading Simulation Program C*. Office of Research and Development, Washington D.C.

Harrison, E.T., R.H. Norris, and S.N. Wilkinson. 2007. The impact of fine sediment accumulation on benthic macroinvertebrates: implications for river management. Proceedings of the 5th Australian Stream Management Conference. Australian rivers: making a difference. Charles Sturt University, Thurgoona, New South Wales.

Heintz, J., R. Pollin, and H. Garrett-Peltier. 2009. How infrastructure investments support the U.S. economy: employment, productivity and growth. Political Economy Research Institute, Amherst, MA. Available at: http://www.peri.umass.edu/fileadmin/pdf/other_publication_types/green_economics/PERI_Infrastructure_Investments.

Johnston, D.M., J.B. Braden, and T.H. Price. 2006. Downstream economic benefits of conservation development. Journal of Water Resources Planning and Management. Vol 132 (1): p. 35-43.

Jones, G.M., and T.L. Balley, Jr. 2009. Understanding the basics of mastitis. Virginia Cooperative Extension 404-233.

Landefeld, M., and J. Bettinger. 2002. Water effects on livestock performance. Ohio State University Agriculture and Natural Resources Report ANR-13-02, Columbus, Ohio. Available at: http://ohioline.osu.edu/factsheet/ANR-13.

Kuo, A. Y., K. Park, S. C. Kim, and J. Lin. 2005. A Tidal Prism Water Quality Model for Small Coastal Basins. *Coastal Management* 33:101–117.

MapTech, Inc. 2000. *Fecal Coliform TMDL (Total Maximum Daily Load) Development for Middle Blackwater River, Virginia*. Prepared for Virginia Department of Environmental Quality and Virginia Department of

Conservation and Recreation. Available at: http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/roankrvr/mdblwtr.pdf.

MapTech, Inc. 2001. *Draft Total Maximum Daily Load Implementation Plan for Fecal Coliform and Nitrate Reductions in Muddy Creek, Dry River, Pleasant Run, and Mill Creek Watersheds.* Prepared for Virginia Department of Conservation and Recreation. Available at: http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/nriverip.pdf.

MapTech, Inc. 2001. *Draft Total Maximum Daily Load Implementation Plan for Fecal Coliform Reductions in Cedar Creek, Hall Creek, Byers Creek and Hutton Creek Watersheds.* Prepared for Virginia Department of Conservation and Recreation. Available at: http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/mfholip.pdf.

MapTech, Inc. 2001. *Draft Total Maximum Daily Load Implementation Plan for Fecal Coliform Reductions in North Fork Blackwater River, South Fork Blackwater River, Upper Blackwater River, and Middle Blackwater River Watersheds*. Prepared for Virginia Department of Conservation and Recreation. Available at: http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/blkwtrip.pdf.

MapTech, Inc. 2011. *Bacterial Implementation Plan Development for the James River and Tributaries – City of Richmond Technical Report*. Prepared for Virginia Department of Environmental Quality. Available at: http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/jamesricip.pdf.

Medina, D.E., J. Monfils, and Z. Baccata. 2011. Green infrastructure benefits for floodplain management: a case study. Stormwater: The Journal for Surface Water Quality Professionals.

Migliaccio, K.W. and P. Srivastava. 2007. Hydrological Components of Watershed-Scale Models. *Transactions of the American Society of Agricultural and Biological Engineers* 50:1695-1703.

North Carolina State University Water Quality Group. 2003. Water Shedds: A Decision Support System for Nonpoint Source Pollution Control. *http://www.water.ncsu.edu/watershedss/* (last accessed May 2016).

Novotny, V. and H. Olem. 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution. New York: Van Nostrand Reinhold.

Perciasepe, R. 1997. New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs). Memorandum sent August 8, 1997. EPA, Washington, D.C. 6 p.

Pugh, S. 2001. The Agricultural Stewardship Act and TMDLs. Letter regarding, dated February 12, 2001.

Reneau, R. B., Jr. and C. Hagedorn. 1998. Conventional On-site Wastewater Treatment System. Crop and Soil Environmental News, October 1998. Virginia Cooperative Extension, Blacksburg and Petersburg, VA. http://www.sites.ext.vt.edu/newsletter-archive/cses/1998-10/1998-10-01.html (last accessed May 2016).

Shoemaker, L., M. Lahlou, M. Bryer, D. Kumar, and K. Kratt. 1997. *Compendium of Tools for Watershed Assessment and TMDL Development.* EPA841-B-97-006. EPA, Washington, D.C.

Skousen, J., R. Hedin, and B. Faulkner. 1997. Remining in Pennsylvania and West Virginia: Costs and Water Quality Changes. Available at: http://anr.ext.wvu.edu/r/download/45303.

Surber, G., K. Williams, and M. Manoukian. 2005. Drinking water quality for beef cattle: an environmentally friendly and production management enhancement technique. Animal and Range Sciences, Extension Service, Montana State University.
Tetra Tech, Inc. 2002. *Total Maximum Daily Load (TMDL) Development for Blacks Run and Cooks Creek, Aquatic Life Use (Benthic) Impairment.* Prepared for US Environmental Protection Agency, Virginia Department of Environmental Quality, and Virginia Department of Conservation and Recreation. Available at: http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/shenrvr/cooksbd2.pdf.

USDA National Resources Conservation Service. *National Handbook of Conservation Practices.* Available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849.

USDA Natural Resources Conservation Service. 2003. *FY 2003 Average Cost List.*

US Department of the Interior, US Fish and Wildlife Service, US Department of Commerce, and US Census Bureau. 2011. 2011 National survey of fishing, hunting, and wildlife-associated recreation. Virginia, revised 2014. Available at: http://www.census.gov/prod/2013pubs/fhw11-va.pdf.

Virginia Cooperative Extension. 1996. Controlled grazing of Virginia's pastures, by Harlan E. White and Dale D. Wolf, Virginia Cooperative Extension Agronomists; Department of Forages, Crop, and Soil Environmental Sciences, Virginia Tech. Publication Number 418-012. July 1996. Available at: http://pubs.ext.vt.edu/418/418-012/418-012.html.

Virginia Department of Forestry. 1997. *Forestry Best Management Practices for Water Quality in Virginia Technical Guide*. Charlottesville, Virginia. 47 p.

Wise, S. 2007. Bringing benefits together: capturing the value(s) of raindrops where they fall. Center for Neighborhood Technology. Presented at the U.S. EPA Wet Weather and CSO Technology Workshop, Florence, KY, September 2007.

Yagow, G. 2004. Using GWLF for Development of "Reference Watershed Approach" TMDLs. ASAE Paper No. 042262. ASAE, St. Joseph, Michigan.

Zeckoski, R., B. Benham and C. Lunsford. 2007. *Streamside Livestock Exclusion: A tool for increasing farm income and improving water quality*. VCE number 442-766. Virginia Cooperative Extension, Blacksburg and Petersburg, VA and Virginia Department of Conservation and Recreation, Richmond, VA. 17 p.

GLOSSARY

Alternative waste treatment system - Any system for treatment of residential wastewater for return to the environment, other than a standard on-site septic system.

Bacterial source tracking (BST) - A collection of scientific methods used to track sources of fecal contamination.

Benthic - Refers to material, especially sediment, at the bottom of an aquatic ecosystem. It can also be used to describe the organisms that live on or in the bottom of a waterbody.

Best management practices (BMPs) - Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

Cost-share program - A program that allocates project funds to pay a percentage of the cost of constructing or implementing a best management practice. The remaining costs are paid by the landowner or operator.

Discharge - Flow of surface water in a stream or canal or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions released into the air through designated venting systems.

Effluent - Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.

Fecal coliform - Indicator organisms (organisms indicating presence of pathogens) associated with the digestive tract of warm-blooded animals.

Fixed-frequency water quality monitoring - Collecting water samples from a fixed location over time at regular intervals (e.g., bi-monthly, monthly, annually).

Full-time equivalent (FTE) - A means of converting the hours worked by one or several part-time employees to the hours worked by a standard full-time employee (e.g., 40 hours per week). For example, two employees working 20 hours per week would equal one FTE.

GIS (geographic information system) - Computer programs linking features commonly seen on maps (e.g., roads, town boundaries, waterbodies) with related information not usually presented on maps, such as type of road surface, population, type of agriculture, type of vegetation, or water quality information. A GIS is a unique information system in which individual observations can be spatially referenced to each other.

Hardened crossing - A stabilized area (e.g., concrete or wooden bridge) that provides access to and/or across a stream for livestock and/or farm machinery.

Hydrologic Simulation Program - Fortran (HSPF) - A computer simulation tool used to mathematically model nonpoint pollution sources and movement of pollutants in a watershed.

Hydrology - The scientific study of the movement, distribution, and quality of water on earth, including the hydrologic cycle, water resources, and environmental watershed sustainability.

Load allocation (LA) - The portion of a receiving water's loading capacity attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources (i.e., wildlife). Load allocations are best estimates of loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished.

Modeling - A system of mathematical expressions that describe the spatial and temporal distribution of water quality constituents resulting from fluid transport and the one or more individual processes and interactions within some prototype aquatic ecosystem.

Monitoring - Periodic or continuous surveillance to determine the pollutant levels in waterbodies.

MS4 (Municipal Separate Storm Sewer System**)** - A conveyance or system of conveyances otherwise known as a municipal separate storm sewer system, including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains: 1. Owned or operated by a federal, state, city, town, county, district, association, or other public body, created by or pursuant to state law, having jurisdiction or delegated authority for erosion and sediment control and stormwater management, or a designated and approved management agency under § 208 of the CWA that discharges to surface waters; 2. Designed or used for collecting or conveying stormwater; 3. That is not a combined sewer; and 4. That is not part of a publicly owned treatment works.

Nonpoint source (NPS) - Pollution that originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-confinement practices, mining practices, forest practices, and urban and rural runoff.

Nutrient - Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus in wastewater but is also applied to other essential and trace elements.

Pathogens - Microorganisms (e.g., bacteria, viruses, parasites) that can cause disease in humans, animals, and plants.

Point source (PS) - Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial treatment facilities or any conveyance such as a ditch, tunnel, conduit or pipe from which pollutants are discharged. Point sources have a single point of entry with a direct path to a waterbody. Point sources can also include pollutant loads contributed by tributaries to the main receiving water, stream, or river.

Riparian areas - Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.

Runoff - That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.

Silviculture – The growing and cultivation of trees.

Stakeholder - Any person or group with a vested interest in TMDL and/or IP development, e.g., farmer, landowner, resident, business owner, or special interest group.

Storm-event water quality monitoring – Analysis of water samples collected from a location during and/or immediately following a rainstorm.

Straight pipe - Delivers wastewater directly from a building (e.g., house or milking parlor) to a stream, pond, lake, or river.

TMDL (Total Maximum Daily Load) - The sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.

Waste load allocation (WLA) - The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water-quality-based effluent limitation (40CFR 130.2(h)).

Watershed - A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation

APPENDIX A

BMP DETAILS BY POLLUTANT ADDRESSED

Table A-1. BMPs applicable to bacteria (refer to Appendix B for BMP descriptions)

BACTERIA

Best Management Practice	Efficiency	Avg Cost	Unit	BMP Efficiency & Cost References
Agricultural BMPs – Livestock Exclusion/Manure Management				
CREP Livestock Exclusion	100% -direct	$30,000	system	Cost - Chestnut Creek IP (2015)
Livestock Exclusion with Grazing Land Management	100% -direct	$25,000	system	Cost - Chestnut Creek IP (2015)
Small Acreage Grazing System	100% - direct	$9,000	system	Cost - Roanoke River IP (2015)
Livestock Exclusion with Reduced Setback	100% - direct	$17,000	system	Cost - Roanoke River IP (2015)
Stream Protection/Fencing	100% - direct	$21,000	system	Cost - Roanoke River IP (2015)
Poultry Litter Storage	99%	$38,000	system	South River & Christians Creek IP (2010)
Manure Storage – Dairy	80%	$100,000	system	Virginia IP Guidance Manual (2003) Cost - Roanoke River IP (2015)
Manure Storage – Beef	80%	$58,000	system	Virginia IP Guidance Manual (2003) Cost - Roanoke River IP (2015)
Loafing Lot Management System/Without Pack Barn	40%	$35,000	system	Efficiency assumed to be equal to sediment efficiency Cost – Upper Banister River IP (2011)
Agricultural BMPs – Pasture				
Streamside Buffer (10 – 100 ft)	50%		acre	LU conversion + 50% Chesapeake Assessment Scenario Tool, cost – included in cost of livestock exclusion system.
Pasture Management	50%	$75 - $165	acre	Chesapeake Assessment Scenario Tool Cost- various IPs
Vegetative Cover On Critical Areas	75%	$1,200	acre	Based on differential loading rates to different land uses Cost - Roanoke River IP (2015)
Reforestation of Erodible Crop & Pastureland	LU change	$560	acre	Based on differential loading rates to different land uses Cost - Roanoke River IP (2015)
Sediment Retention, Erosion, or Water Control Structure	88%	$150	acre	Center for Watershed Protection (2007) Cost - Roanoke River IP (2015)
Agricultural BMPs – Cropland				
Continuous No-Till	64%	$100	acre	Bacteria efficiency assumed to be equal to sediment efficiency Cost - Roanoke River IP (2015)
Conservation Tillage			acre	
Small Grain Cover Crop	20%	$30	acre	Efficiency and Cost - Roanoke River IP (2015)

BACTERIA

Best Management Practice	Efficiency	Avg Cost	Unit	BMP Efficiency & Cost References
Permanent Vegetative Cover on Cropland	75%	$175	acre	Efficiency and Cost - Roanoke River IP (2015)
Sod Waterway	50%	$1,600	acre	Efficiency and Cost - Roanoke River IP (2015)
Cropland Buffer/Field Borders	50%	$600	acre	Efficiency and Cost - Roanoke River IP (2015)
Agricultural BMPs – Other				
Agricultural Sinkhole Protection			lin. ft	
Barnyard Runoff management			system	
Compost Facility		$5.00/ $16,000 (equine)	cu. ft storage system	Virginia IP Guidance Manual (2003) Spout Run IP (2014)
Constructed Wetland		$2,900	/treated acre	Stormwater Management Handbook (2013) Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Dry Detention Basins	30%	$3,800	/treated acre	Roanoke River IP (2014) Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Diversions/Earthen Embankments	80%	$2.21	lin. ft	Cost - Virginia TMDL Guidance Manual (2003)
Extension of CREP Watering System	25% - 50%	25% - 50%	system	Efficiencies used same as pasture management BMP
Grass Filter Strips			acre	
Wet Ponds	80%	$150	/treated acre	Cost - Roanoke River IP (2015)
Wetland Restoration	varies	$15,000	acre	Spout Run IP (2014)
Residential BMPs – Sewage Systems & Pet Waste				
Alternative Waste Treatment System	100%	$16,000	system	Removal efficiency is defined by the practice. Cost - Roanoke River IP (2015)
Connection to Public Sewer	100%	$9,500	system	Removal efficiency is defined by the practice. Cost - Roanoke River IP (2015) - will vary by locality based on local tap fee charges.
Septic System Pump-Out	5%	$300	system	Chesapeake Assessment Scenario Tool, efficiency assumed to be equal to N efficiency. Cost - Roanoke River IP (2015)
Repair Septic System	100%	$3,600	system	Removal efficiency is defined by the practice. Cost - Roanoke River IP (2015)

BACTERIA

Best Management Practice	Efficiency	Avg Cost	Unit	BMP Efficiency & Cost References
Septic System Installation/Replacement	100%	$6,000 - $9,000	system	Removal efficiency is defined by the practice. Cost - Roanoke River IP (2015)
Pet Waste Disposal Station	75%	$4,070	system	Adapted from Swann, C. 1999. A survey of residential nutrient behaviors in the Chesapeake Bay. Widener Burrows, Inc. Chesapeake Bay Research Consortium. Center for Watershed Protection. Ellicott City, MD. 112 pp. Cost – Roanoke River IP (2015) - includes initial unit and five years of bag and trash can liner refills.
Pet Waste Composter/Digester/Fermentation	50%	$50 - $400	system	South River & Christians Creek IP (2010) Cost from various IPs
Pet Waste Management Program	50% -70%	$5,000	program	Adapted from Swann, C. 1999. A survey of residential nutrient behaviors in the Chesapeake Bay. Widener Burrows, Inc. Chesapeake Bay Research Consortium. Center for Watershed Protection. Ellicott City, MD. 112 pp. Cost - Roanoke River IP (2014)
Pet Waste Confined Canine Unit	100%		system	Removal efficiency is defined by the practice.
Streambank Stabilization /Restoration BMPs				
Streambank Protection and Stabilization (e.g., riprap, gabions)	0.075 %	$75	lin. ft	Chesapeake Assessment Scenario Tool, efficiency assumed to be equal to N efficiency. Cost from Spout Run IP (2014).
Stormwater BMPs				
Infiltration Trench	90%	$6,000	/treated acre	EPA Best Management Practices: Infiltration Trench (2014) Cost - James River IP (2014)
Bioretention	90%	$10,000	/treated acre	EPA Best Management Practices: Bioretention Filter (2014) Cost - Cooks Creek and Blacks Run IP (2006)
Rain Garden	80%	$5,000	/treated acre	EPA-CBP Nonpoint source BMP currently used in Scenario Builder for Phase 5.0 of the CBP Watershed Model (2006, revised 02/09/2011). Cost - Cooks Creek and Blacks Run IP (2006)

BACTERIA

BEST MANAGEMENT PRACTICE	EFFICIENCY	AVG COST	UNIT	BMP EFFICIENCY & COST REFERENCES
Bioswale	80%	$42,000	/treated impervious acre	EPA-CBP Nonpoint source BMP currently used in Scenario Builder for Phase 5.0 of the CBP Watershed Model (2006, Revised 02/09/2011). Cost - Maryland Stormwater BMP Cost Worksheet, see http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx
Filtering Practice (e.g., sand filters)	35%	$58,100	/treated acre	DEQ VA Stormwater Management Handbook (2013) Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Constructed Wetland	80%	$2,900	/treated acre	DEQ VA Stormwater Management Handbook (2013) Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Manufactured BMPs	80%	$20,000	/treated acre	EPA-CBP Nonpoint source BMP currently used in Scenario Builder for Phase 5.0 of the CBP Watershed Model (2006,revised 02/09/2011). Cost – Spout Run IP (2014)
Wet Pond	70%	$8,350	/treated acre	DEQ VA Stormwater Management Handbook (2013) Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Dry Detention Pond	30%	$3,800	/treated acre	DEQ VA Stormwater Management Handbook (2013) Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Riparian Buffer - Forest	57%	$1,000	/treated acre	Moores Creek IP (2012) Cost – Spout Run IP (2015)
Riparian Buffer – Grass/Shrub	50%	$360	/treated acre	Cooks Creek and Blacks Run IP (2006) Cost - Roanoke River IP (2015)
Urban Land Use Conversion – Turf to Trees	LU conversion	$3,500	/treated acre	Quantified through land use change in Generalized Watershed Loading Function model simulations. Cost - Spout Run IP (2014).
Rainwater Harvesting	LU conversion	$100,000	/treated acre	Quantified through land use change in Generalized Watershed Loading Function model simulations. Cost - Spout Run IP (2014)

BACTERIA

Best Management Practice	Efficiency	Avg Cost	Unit	BMP Efficiency & Cost References
Wetland Restoration	varies	$15,000	acre	EPA-CBP Nonpoint source BMP currently used in Scenario Builder for Phase 5.0 of the CBP Watershed Model (2006,revised 02/09/2011). Cost - Spout Run IP (2014)

Table A-2. BMPs applicable to nutrients (refer to Appendix B for BMP descriptions)

NUTRIENTS*

Best Management Practice	Efficiency		Avg Cost	Unit	BMP Efficiency & Cost References
	TN	TP			
Agricultural BMPs					
CREP Livestock Exclusion with Riparian Buffer		50%	$30,000	system	South River & Christians Creek IP (2010) Cost - Chestnut Creek IP (2015)
Livestock Exclusion with Grazing Land Management		LU conversion	$21,000	system	Cost - Roanoke River IP (2015)
Wet Pond (Sediment Retention, Erosion, or Water Control Structure)		60%	$150	acre	South River & Christians Creek IP (2010) Cost - Roanoke River IP (2015)
Constructed Wetlands (Pasture)		50%			South River & Christians Creek IP (2010)
Continuous No-Till		70%	$100	acre	South River & Christians Creek IP (2010) Cost - Roanoke River IP (2015)
Conservation Tillage		LU conversion			South River & Christians Creek IP (2010)
Sod Waterway		LU conversion+ 50%	$1,600	acre	South River & Christians Creek IP (2010) Cost - Roanoke River IP (2015)
Small Grain Cover Crops		20%	$30	acre	South River & Christians Creek IP (2010) Cost - Roanoke River IP (2015)
Nutrient Management Plan		22%		acre	South River & Christians Creek IP (2010)
Contour Farming		41%		acre	South River & Christians Creek IP (2010)
Streambank Stabilization		0.0035 lb/ft/yr		lin. ft	South River & Christians Creek IP(2010)
Alternative Watering System					
Animal Waste Storage System	75%	75%	$58,000 – beef, $100,000 - dairy	system	Virginia IP Guidance Manual (2003) Cost - Roanoke River IP (2015)
Compost Facility			$5.00	cu. ft storage	Virginia IP Guidance Manual (2003)
Constructed Wetland			$2,900	/treated acre	DEQ VA Stormwater Management Handbook (2013) Cost- Center for Watershed Protection Urban Stormwater Retrofit Practices
Detention Ponds/Basins	5-10%	5-10%			Virginia IP Guidance Manual (2003)

NUTRIENTS*

Best Management Practice	Efficiency TN	Efficiency TP	Avg Cost	Unit	BMP Efficiency & Cost References
Diversions/Earthen Embankments			$2.21	lin. ft	Virginia IP Guidance Manual (2003)
Extension of CREP Watering System	25-50%	25-50%			Efficiencies used same as pasture management BMP
Field Borders			$600	acre	Cost - Roanoke River IP (2015)
Grass Filter Strips			$99	acre	Virginia IP Guidance Manual (2003)
Grassed Swales	40-60%	70%	$1,875	acre	South River & Christians Creek IP (2010)
Infiltration Basin	50-70%	50-70%			Virginia IP Guidance Manual (2003)
Infiltration Trench	50-70%	50-70%	$6.000		EPA Best Management Practices: Infiltration Trench (2014) Cost- James River IP (2014)
Irrigation Water Management					
Late Winter Split Application of N on Small Grain					
Manure Application to Corn Using Pre-Side Dress Nitrate Test					
Pasture Management	25 – 50%	25 – 50%	$75 - $165	acre	Virginia IP Guidance Manual (2003) Cost from various IPs
Permanent Vegetative Cover on Cropland	LU conversion	LU conversion	$175	acre	Efficiency based on differential loading rates to different land use. Cost – Roanoke River IP (2015)
Permanent Vegetative Cover on Critical Areas	LU conversion	LU conversion	$1,200	acre	Efficiency based on differential loading rates to different land use. Cost – Roanoke River IP (2015)
Reforestation of Erodible Crop & Pastureland	LU conversion	LU conversion	$560	acre	Efficiency based on differential loading rates to different land use. Cost – Roanoke River IP (2015)
Side Dress Application of N on Corn					
Residential BMPs					
Septic System Pump-Out	5%	5%	$300	system	VA IP Guidance Manual (2003) Cost - Roanoke River IP (2015)
Repair Septic System			$3,600	System	Cost - Roanoke River IP (2015)
Alternative Waste Treatment System			$16,000	system	Cost - Roanoke River IP (2015)
Connection to Public Sewer			$9,500	system	Cost - Roanoke River IP (2015)
Septic System Installation/Replacement			$6,000	system	Cost - Roanoke River IP (2015)

NUTRIENTS*

Best Management Practice	Efficiency		Avg Cost	Unit	BMP Efficiency & Cost References
	TN	TP			
Stormwater BMPs – VA BMP Clearinghouse All efficiencies from: http://www.vwrrc.vt.edu/swc/PostConstructionBMPs.html					
Rooftop Disconnection (HSG Soils Group A&B/C&D)	50% / 25%	50% / 25%			
Sheetflow to Conservation Area (HSG Soils Group A&B/C&D)	75% / 50%	75% / 50%			
Sheetflow to Vegetated Filter (HSG Soils Group A&B/C&D)	50% / 50%	50% / 50%			
Grass Channel without Compost Amendment (HSG Soils Group A&B/C&D)	36% / 28%	32% / 24%	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Grass Channel with Compost Amendment (HSG Soils Group A&B/C&D)	36% / 36%	32% / 32%	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Vegetated Roof (Level 1/Level 2)	45% / 60%	45% / 60%			
Rainwater Harvesting	variable, up to 90%	variable, up to 90%	$100,000		Cost – Spout Run IP (2014)
Permeable Pavement (Level 1/Level 2)	59% / 81%	59% / 81%	$240,000	/treated acre	Cost - Roanoke River IP (2015)
Infiltration (Level 1/Level 2)	57% / 92%	63% / 93%	$60,000	/treated acre	Cost – Maryland Stormwater BMP Cost Worksheet, see http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx
Bioretention (Level 1/Level 2)	64% / 90%	55% / 90%	$10,000	/treated acre	Cost - Cooks Creek and Blacks Run IP (2006)
Urban Bioretention (Rain Garden)	40%	55%	$5,000	/treated acre	Cost - Cooks Creek and Blacks Run IP (2006)
Dry Swale (Level 1/Level 2)	55% / 74%	52% / 76%	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Wet Swale (Level 1/Level 2)	25% / 35%	20% / 40%	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)

NUTRIENTS*

Best Management Practice	Efficiency		Avg Cost	Unit	BMP Efficiency & Cost References
	TN	TP			
Filtering Practice (Level 1/Level 2)	30% / 45%	60% / 65%	$58,100	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Constructed Wetland (Level 1/Level 2)	25% / 55%	50% / 75%	$2,900	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Wet Pond (Level 1/Level 2)	30% (20%)[1] 40% (30%)[2]	50% (45%)[1] 75% (65%)[2]	$8,350	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Extended Detention Pond (Level 1/Level 2)	10% / 24%	15% / 31%	$3,800	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Manufactured BMPs http://www.vwrrc.vt.edu/swc/ProprietaryBMPs.html	varies, see BMP Clearinghouse	varies, see BMP Clearinghouse	$20,000	/treated acre	Cost - Spout Run IP (2014)
Chesapeake Bay Program BMPs All efficiencies from: http://www.chesapeakebay.net/content/publications/cbp_13369.pdf					
Wet Ponds and Wetlands (new)	20%	45%	$24, 115	/treated impervious acre	Cost: Maryland Stormwater BMP Cost Worksheet, see http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx
Wet Ponds and Wetlands (retrofit)	20%	45%	$64,000	/treated impervious acre	Cost: Maryland Stormwater BMP Cost Worksheet, see http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx

NUTRIENTS*

Best Management Practice	Efficiency		Avg Cost	Unit	BMP Efficiency & Cost References
	TN	TP			
Dry Detention Ponds & Hydrodynamic Structures	5%	10%	Dry Detention Pond = $39,000 Hydro-dynamic Structure = $42,000	/treated impervious acre	Cost: Maryland Stormwater BMP Cost Worksheet, see http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx
Dry Extended Detention Ponds	20%	20%	$3,800	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Infiltration Practices without Sand, Veg.	80%	85%	$6,000	/treated acre	Cost - James River IP (2014)
Infiltration Practices with Sand, Veg.	85%	85%	$6,000	/treated acre	Cost - James River IP (2014)
Filtering Practices	40%	60%	$58,100	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Bioretention C/D Soils, Underdrain	25%	45%	$10,000	/treated acre	Cost - Cooks Creek and Blacks Run IP (2006)
Bioretention A/B Soils, Underdrain	70%	75%	$10,000	/treated acre	Cost - Cooks Creek and Blacks Run IP (2006)
Bioretention A/B Soils, No Underdrain	80%	85%	$10,000	/treated acre	Cost -Cooks Creek and Blacks Run IP (2006)
Vegetated Open Channels C/D Soils, No Underdrain	10%	10%	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)
Vegetated Open Channels A/B Soils, No Underdrain	45%	45%	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices cited in Roanoke River IP (2015)

NUTRIENTS*

BEST MANAGEMENT PRACTICE	EFFICIENCY		AVG COST	UNIT	BMP EFFICIENCY & COST REFERENCES
	TN	TP			
Bioswale Vegetated Open Channels A/B Soils, No Underdrain	70%	75%	$42,000	/treated impervious acre	Cost: Maryland Stormwater BMP Cost Worksheet, see http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx
Permeable Pavement without Sand, Veg. C/D soils, Underdrain	10%	20%	$240,000	/treated acre	Cost - Roanoke River IP (2015)
Permeable Pavement without Sand, Veg. A/B Soils, Underdrain	45%	50%	$240,000	/treated acre	Cost - Roanoke River IP (2015)
Permeable Pavement without Sand, Veg. A/B soils, No Underdrain	75%	80%	$240,000	/treated acre	Cost - Roanoke River IP (2015)
Permeable Pavement with Sand, Veg. C/D Soils, Underdrain	20%	20%	$240,000	/treated acre	Cost - Roanoke River IP (2015)
Permeable Pavement with Sand, Veg. A/B Soils, Underdrain	50%	50%	$240,000	/treated acre	Cost - Roanoke River IP (2015)
Permeable Pavement with Sand, Veg. A/B soils, No Underdrain	80%	80%	$240,000	/treated acre	Cost - Roanoke River IP (2015)
Wetland Restoration (Appalachian Plateau Siliciclastic Non-Tidal)	7%	12%	$15,000	/acre	Cost - Spout Run IP (2014)
Wetland Restoration (Coastal Plain Dissected Uplands Non-Tidal; Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Coastal Plain Lowlands Non-Tidal; Coastal Plain Uplands Non-Tidal)	25%	50%	$15,000	/acre	Cost - Spout Run IP (2014)
Wetland Restoration (Blue Ridge Non-Tidal; Mesozoic Lowlands Non-Tidal; Valley and Ridge Carbonate Non-Tidal; Piedmont Crystalline Non-Tidal; Piedmont Carbonate Non-Tidal; Valley and Ridge Siliciclastic Non-Tidal)	14%	26%	$15,000	/acre	Cost - Spout Run IP (2014)

NUTRIENTS*

Best Management Practice	Efficiency		Avg Cost	Unit	BMP Efficiency & Cost References
	TN	TP			
Other Stormwater BMPs					
Urban Riparian Forest Buffer - 435 Bare Root Seedlings/Acre - 300 Potted Trees/Acre	25%	50%	$1529 $2060	/treated acre	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost – www.chesapeakebay.net/content/publications/cbp_13369.pdf
Street Sweeping	0.025 lbs/yr of dry weight collected	0.01 lbs/yr of dry weight collected	$520	/curb mile	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost – Roanoke River IP (2015)
Land Use Change Pervious Non-Tree Vegetation or Impervious Area without Buildings and Roads to Trees	varies based on basin and LU changes	varies based on basin and LU changes	$3,500	/acre	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost – Roanoke River IP (2015)
Urban Stream Restoration	0.075/lin. ft stream restored	0.068/ lin. ft stream restored	$300	/lin. ft	Interim approved removal rates as indicated in the Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost – Roanoke River IP (2015)
Urban Nutrient Management on Unregulated Land (by Site Risk) - High - Low - Unknown (Blended)	20% 6% 9%	10% 3% 4.5%	$5,500	/turf acre treated	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost - Maryland Stormwater BMP Cost Worksheet, see http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx

*Nutrients - No state water quality standards, potential stressors for benthic impairments.

[1]Number in parentheses is slightly lower EMC removal rate in the coastal plain (or any location) if the wet pond is influenced by groundwater, see design specification and CSN Technical Bulletin No. 2 (2009).

[2]Credit is variable and determined using the Cistern Design Spreadsheet. Credit up to 90% is possible if all water from storms with rainfall of one-inch or less is used through demand, and the tank is sized such that no overflow from this size event occurs. The total credit may not exceed 90%.

Table A-3. BMPs applicable to sediment (refer to Appendix B for BMP descriptions)

SEDIMENT*

Best Management Practice	Efficiency	Avg Cost	Unit	BMP Efficiency & Cost References
Agricultural BMPs – Livestock Exclusion/Manure Management				
CREP Livestock Exclusion	40%	$30,000	system	LU change +40% – Spout Run IP (2014) Cost – Chestnut Creek IP (2015)
Livestock Exclusion with Grazing Land Management	40%	$25,000	system	LU change +40% – Spout Run IP (2014) Cost – Chestnut Creek IP (2015)
Small Acreage Grazing System	40%	$9,000	system	LU change +40% – Spout Run IP (2014) Cost – Chestnut Creek IP (2015)
Livestock Exclusion with Reduced Setback	40%	$17,000	system	LU change +40% – Spout Run IP (2014) Cost- Roanoke River IP (2015)
Stream Protection/Fencing	40%	$21,000	system	LU change +40% – Spout Run IP (2014) Cost - Roanoke River IP (2015)
Manure Storage – Dairy	80%	$100,000	system	Virginia IP Guidance Manual (2003) Cost - Roanoke River IP (2015)
Manure Storage – Beef	80%	$58,000	system	Virginia IP Guidance Manual (2003) Cost - Roanoke River IP (2015)
Agricultural BMPs – Pasture				
Pasture Management	30%	$75 - $165	acre	Chesapeake Assessment Scenario Tool Cost – various IPs
Vegetative Cover on Critical Areas	75%	$1,200	acre	Based on differential loading rates to different land uses Cost - Roanoke River IP (2015)
Reforestation of Erodible Crop & Pastureland	LU conversion	$560	acre	Based on differential loading rates to different land uses Cost - Roanoke River IP (2015)
Sediment Retention, Erosion or Water Control Structure	80%	$150	acre	Efficiency and cost - Roanoke River IP (2015)
Agricultural BMPs – Cropland				
Nutrient Management Plan	22%		acre	South River & Christians Creek IP (2010)
Contour Farming	41%			South River & Christians Creek IP (2010)
Conservation tillage	LU conversion		acre	South River & Christians Creek IP (2010)
Continuous No-Till	70%	$100	acre	Efficiency and cost - Roanoke River IP (2015)
Small Grain Cover Crop	20%	$30	acre	Efficiency and cost - Roanoke River IP (2015)
Permanent Vegetative Cover on Cropland	75%	$175	acre	Efficiency and cost - Roanoke River IP (2015)

SEDIMENT*

BEST MANAGEMENT PRACTICE	EFFICIENCY	AVG COST	UNIT	BMP EFFICIENCY & COST REFERENCES
Sod Waterway	LU conversion + 50%	$1,600	acre	South River & Christians Creek IP (2010) Cost - Roanoke River IP (2015)
Cropland Buffer/Field Borders	50%	$600	acre	Efficiency and cost - Roanoke River IP (2015)
Agricultural BMPs – Other				
Streambank Stabilization	2.55 lbs/ft/yr			South River & Christians Creek IP (2010)
Agricultural Sinkhole Protection			lin. ft	
Barnyard Runoff Management			system	
Compost Facility		$5.00 $16,000	cu. ft storage system (equine)	Virginia IP Guidance Manual (2003) Spout Run IP (2014)
Constructed Wetland	80%	$24,115	/treated acre	South River Christians Creek IP (2010) Cost - Planning Level Unit Cost Development for Stormwater BMPs, Maryland. Prepared for the Maryland Department of the Environment, see http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx
Dry Detention Basins	10%	$3,800	/treated acre	Virginia IP Guidance Manual (2003) Cost - Roanoke River IP (2015)
Diversions/Earthen Embankments		$2.21	lin. ft	Virginia IP Guidance Manual (2003)
Extension of CREP Watering System	30%		acre	Efficiency same as pasture management BMP
Grass Filter Strips			acre	
Loafing Lot Management System	40%	$35,000	system	Chesapeake Assessment Scenario Tool Cost – Upper Banister River IP (2011)
Sediment Retention, Erosion, or Water Control Structure	49%	$150	/treated acre	Center for Watershed Protection (2007) Cost - Roanoke River IP (2015)
Riparian Buffer - Forest	70%		acre	Virginia TMDL Guidance Manual (2003)
Riparian Buffer – Grass & Shrub	50%		acre	
Wetland Restoration		$15,000	acre	Spout Run IP (2014)
Alternative Watering System				
Barnyard Runoff Management				

SEDIMENT*

Best Management Practice	Efficiency	Avg Cost	Unit	BMP Efficiency & Cost References
Stormwater BMPs – VA BMP Clearinghouse (Actual efficiencies would be based on site-specific calculations.) http://www.vwrrc.vt.edu/swc/PostConstructionBMPs.html				
Rooftop Disconnection (HSG Soils Group A&B/C&D)	See Chesapeake Bay Retrofit Equation for TSS	$100 per down-spout		Cost - Roanoke River IP (2015)
Sheetflow to Conservation Area (HSG Soils Group A&B/C&D)	See Chesapeake Bay Retrofit Equation for TSS			
Sheetflow to Vegetated Filter (HSG Soils Group A&B/C&D)	See Chesapeake Bay Retrofit Equation for TSS			
Grass Channel without Compost Amendment (HSG Soils Group A&B/C&D)	See Chesapeake Bay Retrofit Equation for TSS	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Grass Channel with Compost Amendment (HSG Soils Group A&B/C&D)	See Chesapeake Bay Retrofit Equation for TSS	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Vegetated Roof (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$10 - $20	square foot	Cost - EPA cited in Roanoke River IP (2015)
Rainwater Harvesting	See Chesapeake Bay Retrofit Equation for TSS	$100,000	/treated acre	Cost - Spout Run TMDL (2014)
Permeable Pavement (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$240,000	/treated acre	Cost - Roanoke River IP (2015)
Infiltration (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$6,000	/treated acre	Cost - James River IP (2014)
Bioretention (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$10,000	/treated acre	Cost -Cooks Creek and Blacks Run IP (2006)

SEDIMENT*

BEST MANAGEMENT PRACTICE	EFFICIENCY	AVG COST	UNIT	BMP EFFICIENCY & COST REFERENCES
Urban Bioretention	See Chesapeake Bay Retrofit Equation for TSS	$5,000	/treated acre	Cost - Cooks Creek and Blacks Run IP (2006)
Dry Swale (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Wet Swale (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Filtering Practice (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$58,100	/treated acre	Cost -Center for Watershed Protection Urban Stormwater Retrofit Practices
Constructed Wetland (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$2,900	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Wet Pond (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$8,350	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Extended Detention Pond (Level 1/Level 2)	See Chesapeake Bay Retrofit Equation for TSS	$3,800	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Manufactured BMPs http://www.vwrrc.vt.edu/swc/ProprietaryBMPs.html	See Chesapeake Bay Retrofit Equation for TSS	$20,000	/treated acre	Cost - Spout Run IP (2014)
Chesapeake Bay Program BMPs All efficiencies from: www.chesapeakebay.net/content/publications/cbp_13369.pdf				
Wet Ponds	60%	$8,350	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Dry Detention Ponds & Hydrodynamic Structures	10%		/treated acre	www.chesapeakebay.net/content/publications/cbp_13369.pdf
Dry Extended Detention Ponds	60%	$3,800	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices

SEDIMENT*

Best Management Practice	Efficiency	Avg Cost	Unit	BMP Efficiency & Cost References
Infiltration Practices without Sand, Veg.	95%	$6,000	/treated acre	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost – James River IP (2014)
Infiltration Practices with Sand, Veg.	95%	$6,000	/treated acre	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost – James River IP (2014)
Filtering Practices	80%	$58,100	/treated acre	Interim Approved Removal Rates as indicated in the Chesapeake Bay TMDL Special Condition guidance (5/18/2015) Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices, from Roanoke River TMDL I P (2015)
Bioretention C/D Soils, Underdrain	55%	$10,000	/treated acre	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost - Cooks Creek and Blacks Run IP (2006)
Bioretention A/B Soils, Underdrain	80%	$10,000	/treated acre	Cost - Cooks Creek and Blacks Run IP (2006)
Bioretention A/B Soils, No Underdrain	90%	$10,000	/treated acre	Cost - Cooks Creek and Blacks Run IP (2006)
Vegetated Open Channels C/D Soils, No Underdrain	50%	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Vegetated Open Channels A/B Soils, No Underdrain	70%	$18,150	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Bioswale	80%	$24,000	/treated acre	Cost - Maryland Stormwater BMP Cost Worksheet, see http://www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/PhaseIIBayWIPDev.aspx
Permeable Pavement without Sand, Veg. C/D Soils, Underdrain	55%	$240,000	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Permeable Pavement without Sand, Veg. A/B Soils, Underdrain	70%	$240,000	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Permeable Pavement without Sand, Veg. A/B Soils, No Underdrain	85%	$240,000	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices

SEDIMENT*

Best Management Practice	Efficiency	Avg Cost	Unit	BMP Efficiency & Cost References
Permeable Pavement with Sand, Veg. C/D Soils, Underdrain	55%	$240,000	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Permeable Pavement with Sand, Veg. A/B Soils, Underdrain	70%	$240,000	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Permeable Pavement with Sand, Veg. A/B soils, No Underdrain	85%	$240,000	/treated acre	Cost - Center for Watershed Protection Urban Stormwater Retrofit Practices
Wetland Restoration (Appalachian Plateau Siliciclastic Non-Tidal)	4%	$15,000	acre	Cost - Spout Run IP (2014)
Wetland Restoration (Coastal Plain Dissected uplands Non-Tidal; Coastal Plain Dissected Uplands Tidal; Coastal Plain Lowlands Tidal; Coastal Plain Uplands Tidal; Coastal Plain Lowlands Non-Tidal; Coastal Plain Uplands Non-Tidal)	15%	$15,000	acre	Cost - Spout Run IP (2014)
Wetland Restoration (Blue Ridge Non-Tidal; Mesozoic Lowlands Non-Tidal; Valley and Ridge Carbonate Non-Tidal; Piedmont Crystalline Non-Tidal; Piedmont Carbonate Non-Tidal; Valley and Ridge Siliciclastic Non-Tidal)	8%	$15,000	acre	Cost - Spout Run IP (2014)
Other Stormwater BMPs				
Urban Riparian Forest Buffer	50%	$1529 - $2060	/treated acre	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost – Chesapeake Bay Program – Best Management Practices for Sediment Control and Water Clarity Enhancement www.chesapeakebay.net/content/publications/cbp_13369.pdf
Street Sweeping	0.3 lbs/yr of dry weight collected	$40	/curb mile	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost - Schilling, J.G. 2005. Street Sweeping – Report No. 1, State of the Practice. Prepared for Ramsey-Washington Metro Watershed District (http://www.rwmwd.org). North St. Paul, Minnesota. June 2005

SEDIMENT*

BEST MANAGEMENT PRACTICE	EFFICIENCY	AVG COST	UNIT	BMP EFFICIENCY & COST REFERENCES
Land Use Change	varies		$3,500	Chesapeake Bay TMDL Special Condition guidance (5/18/2015) Cost – Roanoke River IP (2015)
Urban Stream Restoration – Outside Coastal Plain – Coastal Plain	44.88 lbs /lin. ft 15.13lbs /lin. ft	$300	/treated acre	Chesapeake Bay TMDL Special Condition Guidance (5/18/2015) Cost – Roanoke River IP (2015)

*Sediment - No state water quality standard, potential stressor for benthic impairment.

APPENDIX B

BMP DESCRIPTIONS

Animal waste management - A planned system designed to manage liquid and solid waste from livestock and poultry. It improves water quality by storing and spreading waste at the proper time, rate, and location.

Bioretention areas - Shallow, landscaped depressions that allow stormwater runoff to pond in a designated area and then filter through soil and vegetation. Small-scale bioretention areas are also known as rain gardens.

Compost facility - Promotes treatment of organic agricultural wastes to reduce their pollution potential to surface water and groundwater. The composting facility must be constructed, operated, and maintained without polluting air and/or water resources.

Conservation landscaping - The placement of vegetation in and around stormwater management BMPs. This practice helps to stabilize disturbed areas and enhance the pollutant removal capabilities of a stormwater BMP while improving its overall aesthetics.

Conservation tillage - Any tillage and planting system that maintains at least 30% of the soil surface covered by residue after planting for the purpose of reducing soil erosion by water.

Contour farming - Tillage, planting, and other farming operations performed on or near the contour of the field slope. This results in reduced sheet and rill erosion and reduced transport of sediment and other waterborne contaminants. This practice applies on sloping land where crops are grown and is most effective on slopes between two and 10 percent.

Cover crops and rotations -Establishing grass and/or legume vegetation to reduce soil erosion and enhance water quality.

Critical area planting - Establishing permanent vegetation on sites that have or are expected to have high erosion rates and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal practices. This practice is used in areas with existing or expected high rates of erosion or degraded sites that usually cannot be stabilized by ordinary conservation treatment.

Detention pond/basin - These ponds temporarily fill with stormwater and release most of it over a period of a few days, slowly returning to a maintained depth of permanently-held water. The permanent pool of water enhances the removal of many pollutants.

Diversions - Established channels constructed along the general land slope with a supporting ridge on the lower side. They improve water quality by directing nutrient- and sediment-laden water to sites where it can be used or disposed of safely.

Earthen embankment - A raised impounding structure made from compacted soil. It is appropriate for use with infiltration, detention, extended-detention, or retention facilities.

Fencing - A constructed barrier to livestock, wildlife, or people. Standard or conventional (barbed or smooth wire), suspension, woven wire, or electric fences shall consist of acceptable fencing designs to control the animal(s) or people of concern and meet the intended life of the practice.

Field borders - Established adjacent to wildlife habitats to soften field transitions to other land uses. These borders can be on any side of a field and are not restricted to lower field borders, as are filter strips.

Filtration (e.g., sand filters) - Intermittent sand filters capture the most polluted stormwater from a site, pretreat it to remove sediment, store it while awaiting treatment, and treat it to remove pollutants by percolation through sand media. These filters may be constructed in underground vaults, in paved trenches within or at the perimeter of impervious surfaces, or in either earthen or concrete open basins.

Grade stabilization - A temporary measure employed to stabilize grade and reduce erosion on bare soils until permanent vegetation is established or other long-term erosion control measures are implemented.

Grassed swale - A broad and shallow earthen channel vegetated with erosion-resistant and flood-tolerant grasses. Check dams are strategically placed in the swale to encourage ponding behind them. The purpose of a grassed swale is to convey stormwater runoff at a non-erosive velocity in order to enhance its water quality through infiltration, sedimentation, and filtration.

Grassed waterway - A natural or constructed channel that is shaped or graded to required dimensions and established with suitable vegetation which conveys runoff from terraces, diversions, or other water concentrations without causing erosion or flooding.

Grazing Land Protection System - A structural and/or management practice that enhances vegetative cover to reduce runoff of bacteria, sediment, and nutrients from existing pastureland and reduce NPS pollution associated with grazing livestock.

Green rooftop - A thin layer of vegetation that is installed on top of a conventional flat or slightly sloping roof. It can consist of a lightweight vegetated system or an elaborate rooftop landscape or garden. Internal drainage layers serve to moderate the rate of runoff while allowing for water and nutrient uptake by vegetated materials. Green rooftops can often be engineered to conform to existing load requirements of most roofs, thereby enabling the retrofit of existing buildings.

Infiltration basin - A vegetated open impoundment where incoming stormwater runoff is stored until it gradually infiltrates into the soil strata. While flooding and channel erosion control may be achieved within infiltration basins, they are primarily used for water quality enhancement.

Infiltration trench - A shallow, excavated trench backfilled with a coarse stone aggregate to create an underground reservoir. Stormwater runoff diverted into the trench gradually infiltrates into surrounding soils from the bottom and sides of the trench. The trench can be either an open surface trench or an underground facility.

Land use conversion - BMPs that involve a change in land use in order to retire land that is detrimentally impacting the environment. Some examples of BMPs with associated land use changes are: Conservation Reserve Program (CRP) - cropland to pasture; forest conservation - pervious urban to forest; forest/grass buffers - cropland to forest/pasture; tree planting - cropland/pasture to forest; and conservation tillage - conventional tillage to conservation tillage.

Limit livestock access - Excluding livestock from areas where grazing or trampling will cause erosion of streambanks and degradation of water quality by livestock activity in or adjacent to the water. Such restriction is generally accomplished by permanent or temporary fencing. In addition, installation of an alternative water source away from the stream has been shown to reduce livestock access.

Manufactured BMP systems - Structural measures specifically designed and sized by the manufacturer to intercept stormwater runoff and prevent the transfer of pollutants downstream. They are used solely for water quality enhancement in urban and ultra-urban areas where surface BMPs are not feasible.

Manure incorporation - The practice of directly injecting or incorporating manure into the soil rather than leaving the manure directly on the soil surface. There are several approaches to manure incorporation including disk injection, chisel injection, high-pressure injection, aeration, and surface banding.

Mulching/protective covers - Applying plant residues, by-products, or other suitable materials produced off-site to the land surface. This practice conserves soil moisture, moderates soil temperature, provides erosion control, suppresses weed growth, establishes vegetative cover, improves soil condition, and increases soil fertility.

Nutrient management - Determining nutrient needs for cropland (with the exception of hay or pasture that receives mechanical applications of collected animal manure) and adjusting the application of nutrients accordingly.

On-site treatment system installation - Conventional on-site wastewater treatment and disposal system (on-site system) consists of three major components: a septic tank, a distribution box, and a subsurface soil absorption field (consisting of individual trenches). This system relies on gravity to carry household waste to the septic tank, move effluent from the septic tank to the distribution box, and distribute effluent from the distribution box throughout the subsurface soil absorption field. All of these components are essential for a conventional on-site system to function in an acceptable manner.

Pet waste disposal station - Generally, a receptacle (can or enclosure) and associated materials (waste storage bags) as well as signage for promoting the collection and proper disposal of dog waste to prevent the runoff of bacteria into stormwater conveyance systems or directly into surface waters.

Pet waste composter/digester - An on-site unit for collection and treatment of pet waste that incorporates composting and/or anaerobic digestion/treatment of pet waste within the composter/digester.

Porous pavement - An alternative to conventional pavement, it is made from asphalt in which fine filler fractions are missing or from modular or poured-in concrete pavements. Its use allows rainfall to percolate through it to the sub-base, enhancing soil infiltration and providing water storage that reduces runoff. The water stored in the sub-base gradually infiltrates into the subsoil.

Proper site selection for animal feeding facility - Establishing or relocating confined feeding facilities away from environmentally vulnerable areas such as sinkholes, streams, and rivers to reduce or eliminate the amount of pollutant runoff reaching these areas.

Rain garden - Landscaped gardens of trees, shrubs, and plants placed in commercial or residential areas to treat stormwater runoff through temporary collection of the water before infiltration. They are slightly depressed areas into which stormwater runoff is channeled by pipes, curb openings, or gravity.

Pasture management - Systems of practices to protect the vegetative cover on improved pasture. It includes practices such as seeding or reseeding, brush management (mechanical, chemical, physical, or biological), proper stocking rates and proper grazing heights, soil testing-based nutrient management, and deferred rotational systems.

Re-mining - Surface mining of previously mined and abandoned surface and underground mines to obtain remaining coal reserves. Re-mining operations create jobs in the coal industry, produce coal from previously disturbed areas, and improve aesthetics by backfilling and re-vegetating areas according to current reclamation standards. Re-mining operations also reduce safety and environmental hazards (by sealing existing portals and removing abandoned facilities), enhance land use quality, and decrease pre-existing pollution discharges.

Retention basin - A stormwater facility that includes a permanent pool of water and is, therefore, normally wet even during non-rainfall periods. Inflows from stormwater runoff may be temporarily stored above this permanent pool.

Riparian buffer zone - A vegetated protection method used along streams to reduce erosion, sedimentation, and the pollution of water from agricultural nonpoint sources.

Roof downspout system - A structure that collects, controls, and transports precipitation from roofs. This practice may be applied as a part of a resource management system in order to improve water quality, reduce soil erosion, increase infiltration, protect structures, and increase water quantity.

Septic system pump-out - In the septic tank of an on-site treatment system (see above description), solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically (recommended every three to five years) to maintain proper system functioning.

Sewer line maintenance/sewer flushing - Sewer flushing during dry weather is designed to periodically remove solids that have deposited on the bottom of the sewer and the biological slime that grows on the walls of combined sewers during periods of low-flow. Flushing is especially necessary in sewer systems that have low grades, which result in low-flow velocities inadequate for self-cleaning.

Silt fencing - A temporary sediment barrier consisting of filter fabric buried at the bottom, stretched, and supported by posts, or straw bales staked into the ground, designed to retain sediment from small disturbed areas by reducing the velocity of sheet flows. Because silt fences and straw bales can cause temporary ponding, sufficient storage area and overflow outlets should be provided.

Sod waterway - A constructed watercourse lined with sod or grass and designed to accommodate concentrated flows without erosion. Sod waterways are capable of sustaining higher in-channel velocities than unlined waterways because the vegetation protects the soil by covering it and retarding water velocity.

Streambank protection and stabilization - Stabilizing eroded shoreline areas by landshaping, constructing bulkheads, riprap revetments, gabion systems, or establishing vegetation.

Stream crossing - Providing a controlled crossing for livestock and/or farm machinery in order to prevent streambed erosion and reduce sediment pollution.

Street sweeping - The practice of passing over an impervious surface, usually a street or a parking lot, with a vacuum or a rotating brush for the purpose of collecting and disposing of accumulated debris, litter, sand, and sediments. In areas with defined wet and dry seasons, sweeping prior to the wet season is likely to be beneficial; following snowmelt and heavy leaf fall are also opportune times.

Strip cropping - Growing row crops, forages, small grains, or fallow in a systematic arrangement of equal width strips across a field, strip cropping reduces soil erosion and protects growing crops from damage by wind-borne soil particles.

Terraces - An earthen embankment or a combination ridge and channel constructed across the field slope. Terraces can be used when there is a need to conserve water, excessive runoff is a problem, and the soils and topography are such that terraces can be constructed and farmed with reasonable effort.

Vegetated filter strip - A densely vegetated strip of land engineered to accept runoff from upstream development as overland sheet flow. It may adopt any naturally vegetated form, from grassy meadow to small forest. The purpose of a vegetated filter strip is to enhance the quality of stormwater runoff through filtration, sediment deposition, infiltration, and absorption.

Waste system/storage (e.g., lagoons, litter shed) - Waste treatment lagoons biologically treat liquid waste to reduce its nutrient and BOD content. Lagoons must be emptied and their contents disposed of properly.

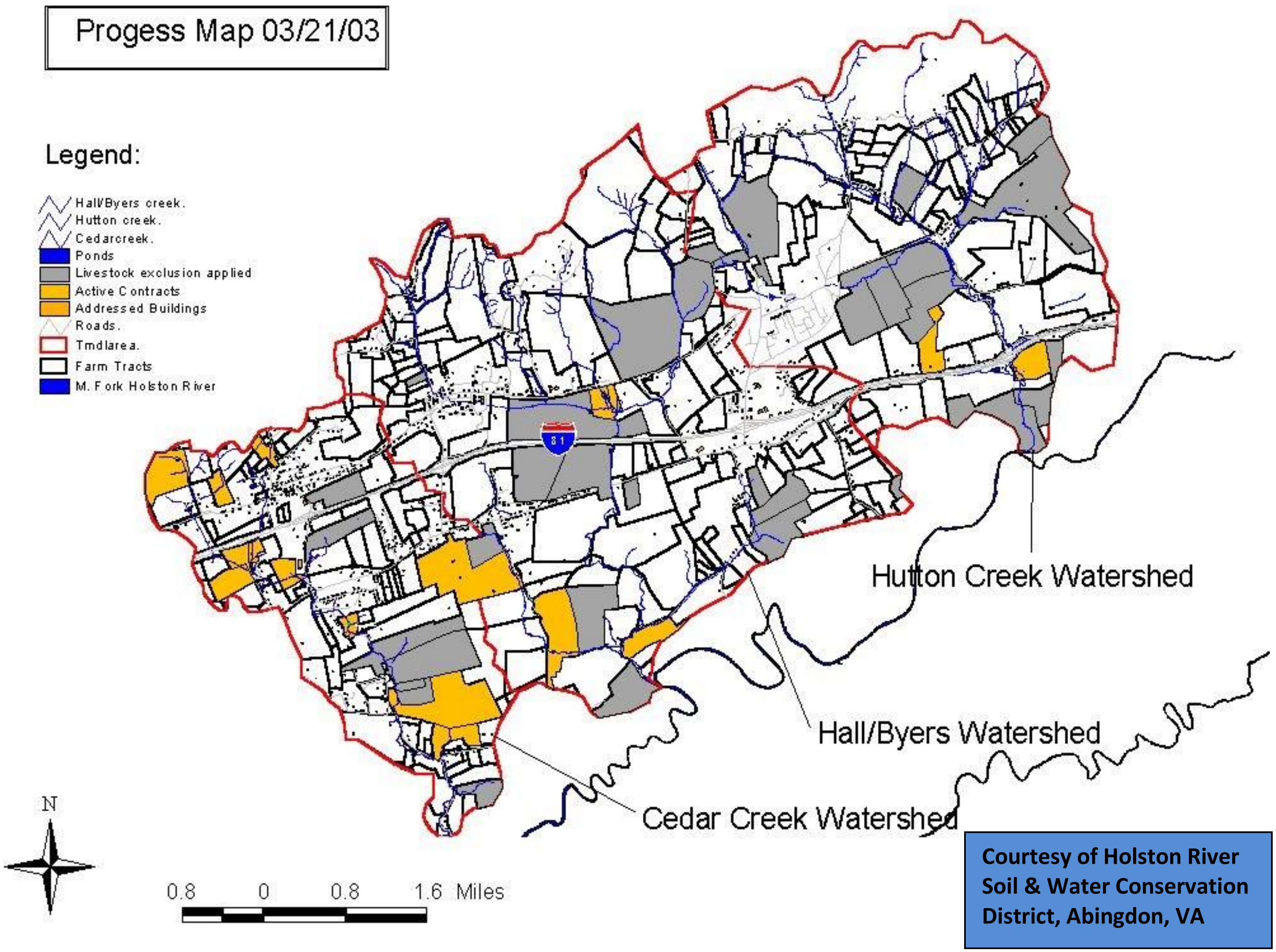
Water treatment - Physical, chemical, and/or biological processes used to treat concentrated discharges. Physicochemical processes that have been demonstrated to effectively treat discharge include sedimentation, vortex separation, screening (e.g., fine-mesh screening), and sand-peat filters. Chemical additives used to enhance separation of particles from liquid include chemical coagulants such as lime, alum, ferric chloride, and various polyelectrolytes. Biological processes that have been demonstrated to effectively treat discharges include contact stabilization, biodiscs, oxidation ponds, aerated lagoons, and facultative lagoons.

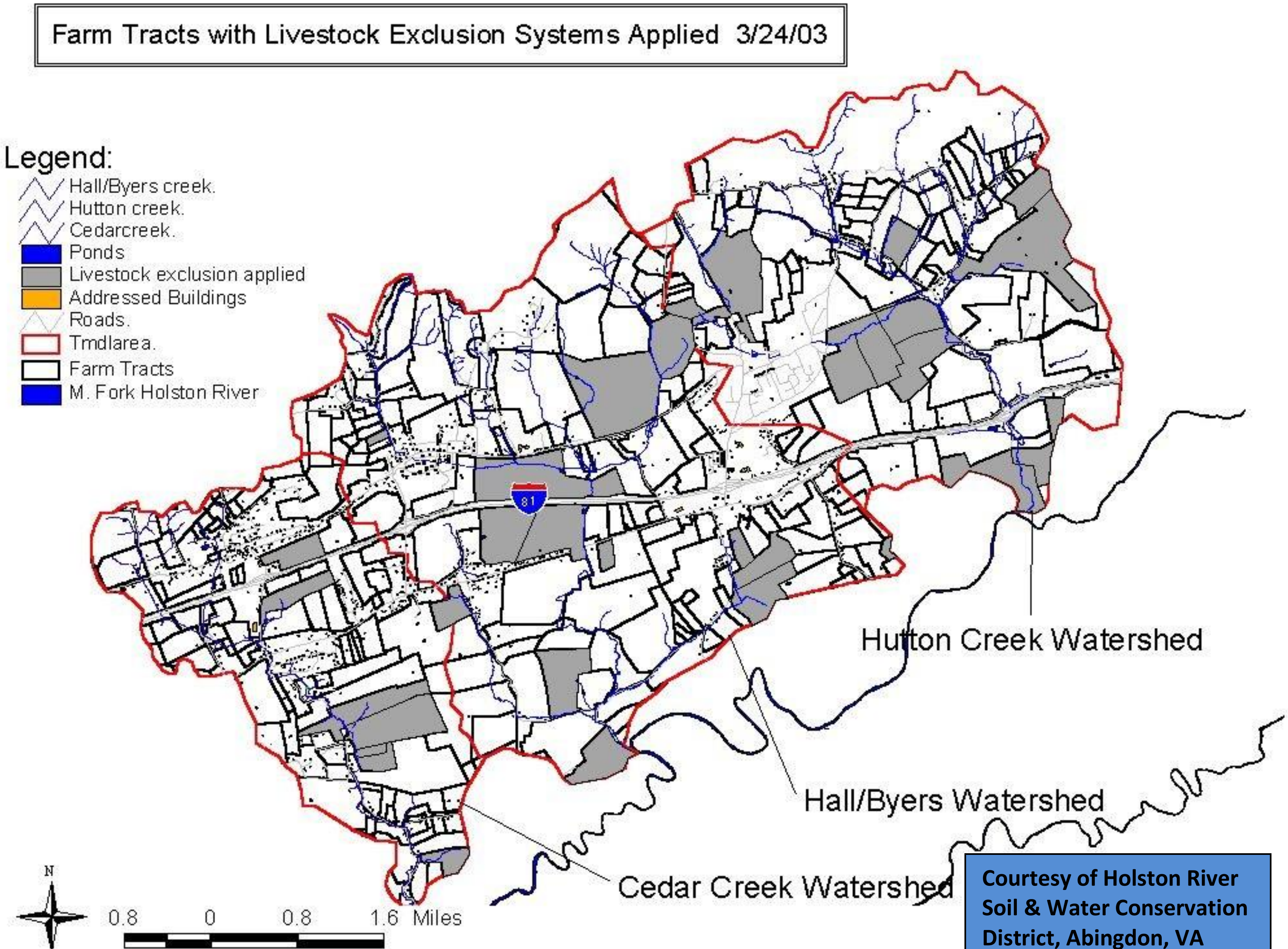
Wetland development/enhancement - The construction of a wetland for the treatment of animal waste runoff or stormwater runoff. Wetlands improve water quality by removing nutrients from animal waste or sediments and nutrients from stormwater runoff.

APPENDIX C

BMP TRACKING TOOLS

Figure C-1 GIS layering used for summarizing implementation actions





Courtesy of Holston River Soil & Water Conservation District, Abingdon, VA