BIG OTTER WATERSHED TMDL IMPLEMENTATION PLAN SUMMARY

Submitted to:

The Stakeholders of the Big Otter Watershed

Prepared by:

Big Otter IP Steering Committee

In Cooperation With:

Virginia Tech Department of Biological Systems Engineering and Center for TMDL and Watershed Studies,

Virginia Department of Environmental Quality,

and

Virginia Department of Conservation and Recreation

July 6, 2006

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1. Introduction

A Total Maximum Daily Load or TMDL describes the amount of pollution a stream can receive and still meet water quality standards. TMDLs are tools that assist in correcting water quality impairments by identifying the sources of pollution, the amounts of pollution from each source, and the reductions in pollutants needed to meet water quality standards. The Clean Water Act requires states to develop TMDLs for pollutants for streams that are not meeting water quality standards and are therefore considered "impaired."

Legislation in Virginia called the Water Quality Monitoring, Information and Restoration Act (WQMIRA) requires that a plan to achieve fully supporting status for impaired waters be developed and implemented. This means that after a TMDL is developed for an impaired water body, an Implementation Plan (IP) must be developed and implemented with the goal of meeting the water quality standards for the water body. The purpose of a TMDL IP is to identify and quantify best management practices (BMPs) that may be implemented in a watershed in order to meet the water quality standards.

This document serves as an abridged version of the full *Big Otter River Basin TMDL Implementation Plan*. The key components of the implementation plan are discussed in the following sections:

- Review of the TMDL Studies
- Public Participation
- Implementation Actions
- Implementation
- Cost / Benefit Analysis
- Stakeholder Responsibilities

As a result of monitoring performed by the Virginia Department of Environmental Quality (VADEQ), nine stream segments in the Big Otter River (BOR) Basin are currently listed as impaired. Five of these stream segments (Sheep Creek, Elk Creek, Machine Creek, Little Otter River, and Big Otter River) were added to Virginia's impaired waters list in 1998 for violations of the fecal coliform bacteria water quality standard. A TMDL was developed for each of these stream segments in 2000. Four additional segments, North Otter Creek, Big Otter River within the Elk Creek watershed, and two segments inside the Buffalo Creek watershed, were listed as impaired in 2004. TMDLs have not been developed for these four segments; however, since they are within the BOR Basin, this IP includes practices that address those impairments. Recent water quality monitoring data in Buffalo Creek show that the stream is not meeting water quality standards for bacteria. It is expected that these recent data will result in Buffalo Creek being listed as impaired in the near future. Figure 1 shows the impaired stream segments and watershed boundaries within the BOR Basin. The impairments are summarized in Table 1.

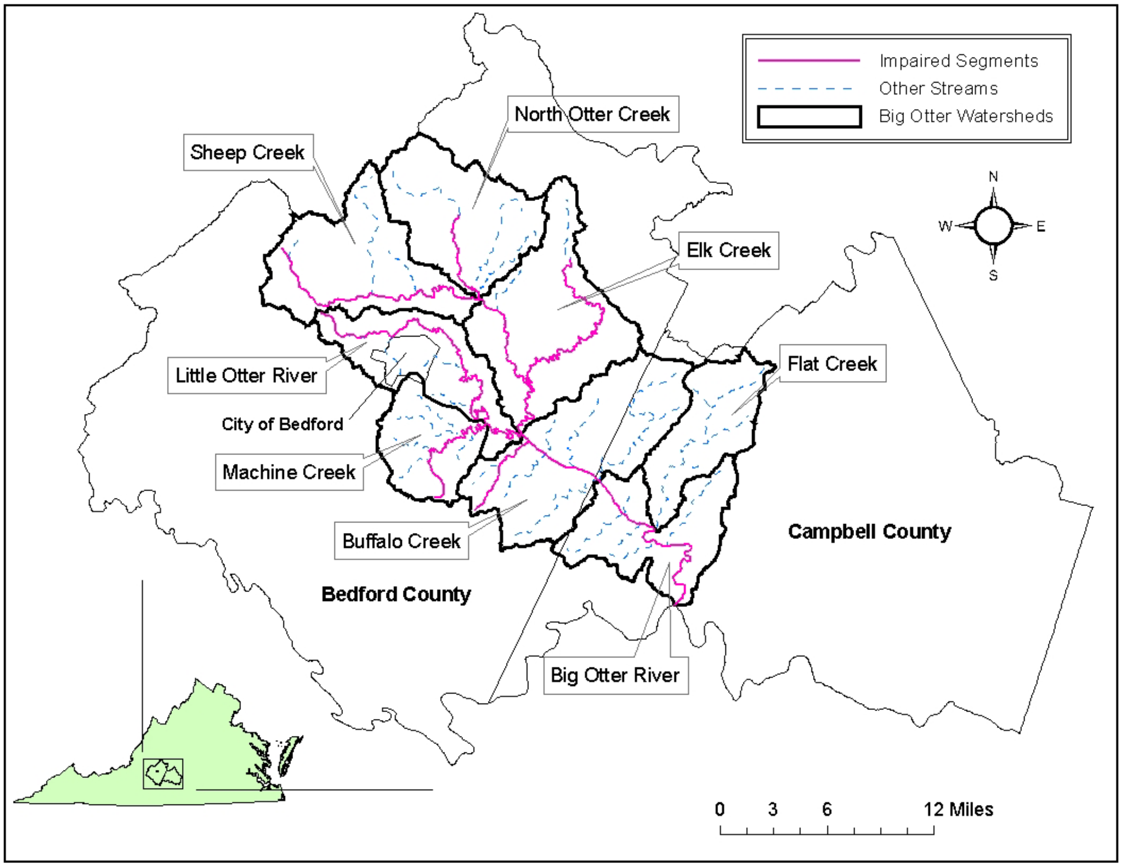

Figure 1 – Big Otter River Basin location and watersheds

Table 1 – Big Otter River Basin impaired segments

Stream	Original Listing Date	Instantaneous Fecal Coliform Criterion at Time of Listing
Targeted in 2000 TMDL		
Sheep Creek (VAW-L23R-01)	1996	1,000 cfu/100 mL
Elk Creek (VAW-L25R-01)	1998	
Machine Creek (VAW-L26R-03)	1996	
Little Otter River (VAW-L26R-01)	1996	
Big Otter River (VAC-L28R-01)	1998	
Listed as impaired since the 2000 TMDL		
Big Otter River (Elk Creek)‡ (VAW-L25R-01)	2004	400 cfu/100 mL
Big Otter River, Falling Creek† (VAW-L27R-01)	2002, 2004	
North Otter Creek (VAW-L25R-01)	2004	

‡The portion of the Big Otter River inside the Elk Creek watershed (Figure 1) was listed in 2004
†The portion of Big Otter River inside the Buffalo Creek watershed (Figure 1) was listed in 2002; Falling Creek, also inside the Buffalo Creek watershed, was listed in 2004; Buffalo Creek itself is not listed.

At the time of the development of the Big Otter TMDLs, fecal coliform was the indicator species for Virginia's bacteria water quality standard. In 2003, Virginia began a transition to using *E. coli* as the indicator species of bacterial contamination. *E. coli* is a subset of the fecal coliform bacteria group that has been shown to have a stronger correlation to gastrointestinal illness in humans than fecal coliform. Currently USEPA guidance allows VADEQ to remove a stream segment from the impaired waters list (delisting) when the violation rate of the standard is 10.5% or less over a defined assessment period.

Fecal coliform and E. coli bacteria are used as indicators of the presence of microorganisms that cause illness in humans including Cryptosporidium, Giardia, Shigella and E. coli O157:H7. These bacteria are found in the digestive systems of warm-blooded animals. The detrimental effects of bacteria in food and water supplies have been documented in areas throughout the United States and Canada. In May 2000 there were seven confirmed deaths with four other deaths under investigation, and over 2000 poisonings all attributed to drinking water polluted by E. coli Type 0157:H7 in the town of Walkerton, Ontario (Raine, 2000; Miller, 2000). The contamination resulted in a $250 million class action lawsuit filed against the Ontario government. The source of the pollution according to the Cattleman's Association was probably runoff from a feedlot located more than 5 miles from the wells used for the town's water supply.

Fecal contamination of surface and drinking waters has also impacted communities in Virginia. The Virginia Department of Health (VDH) was notified of campers and counselors at a Shenandoah Valley summer camp developing serious gastrointestinal illness in August 1994. E. coli 0157:H7 was confirmed as the causative agent. In Franklin County Virginia, a 1997 outbreak of illnesses involving 3 children was attributed to E. coli (0157:H7) in Smith Mountain Lake. The children were exposed to the bacteria while swimming in the lake and a two year old almost died as a result of the exposure (Roanoke Times, 1997). In August of 1998, 7 children and 2 adults at a daycare center in rural Floyd County were infected with E. coli (0157:H7). Upon investigation, two of the properties' wells tested positive for total coliform (Roanoke Times, 1998). On June 6, 2000 Virginia's second largest water source, Crystal Spring in Roanoke, was shut down by VDH for E. coli contamination (Roanoke Times, 2000).

These are not isolated cases. Throughout the U.S., the Center for Disease Control estimates at least 73,000 cases of illnesses and 61 deaths per year caused by E. coli 0157:H7 alone (CDC, 1995 and 2001). Other fecal coliform pathogens (e.g. E. coli 0111) are responsible for similar illnesses. During 2001 and 2002, the Centers for Disease Control and Prevention received reports of 30 outbreaks (defined as >2 people experiencing illness) of gastroenteritis related to recreational waters, many tied directly to fecal contamination (CDC, 2004). These 30 outbreaks account for more than 1,900 confirmed cases of illness. Whether the source of contamination is human or livestock, the threat of these pathogens appears more prevalent as both populations increase.

With successful development and implementation of IPs, Virginia will be well on the way to restoring impaired waters and enhancing the value of this important resource.

Additionally, development of an approved IP will improve a locality's chances for obtaining monetary assistance during implementation.

2. Review of TMDL Studies

The BOR Basin (388 mi²) lies in portions of Virginia's Bedford and Campbell counties and encompasses the City of Bedford and suburbs of Lynchburg. The Big Otter River discharges into the Roanoke River, which flows south into North Carolina and eventually discharges to the Albemarle Sound. Sheep Creek, Elk Creek, Machine Creek, and Little Otter River are all tributaries to the Lower Big Otter River. The basin is dominated by forest (59%) and pasture (28%) land uses (Table 2 and Figure 2). The City of Bedford is located within the Little Otter River watershed.

Table 2 – Land Uses in the Big Otter River Basin TMDL Segments

		Percentage of total area			
Watershed Name	**Total Area (acres)**	**Forest**	**Pasture**	**Cropland**	**Urban/ Residential**
Sheep Creek	34,736	67	25	2	6
Elk Creek	42,880	50	33	1	16
Machine Creek	18,294	41	45	6	8
Little Otter River	26,065	42	36	2	20
Lower Big Otter River	27,645	72	19	2	7

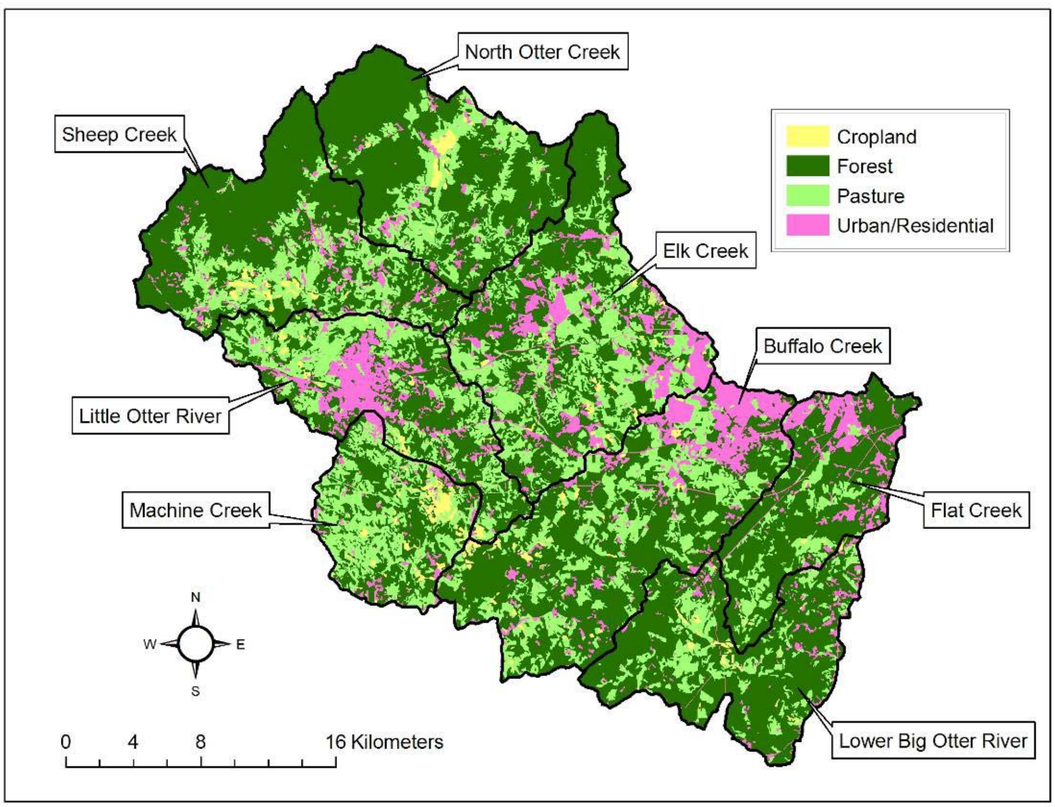

Figure 2. Landuse distribution in the Big Otter River Basin.

The five segments addressed in the BOR TMDL completed in 2000 showed violation rates of the fecal coliform bacteria standard single-sample criterion (1000cfu/100ml) for Sheep Creek, 60%; Elk Creek, 26%; Machine Creek, 61%; Little Otter River, 28%; and Lower Big Otter River, 23%.

The Hydrological Simulation Program-FORTRAN (HSPF) was used to simulate the fate and transport of fecal coliform bacteria in the BOR Basin. Modeling was conducted in phases. The headwater watersheds (Sheep Creek and Machine Creek) were modeled in the first phase, and downstream watersheds (Elk Creek, Little Otter River, and Big Otter River) were modeled in succeeding phases. The contributions from areas that were non-impaired at the time (North Otter Creek, Flat Creek, and Buffalo Creek) were also modeled.

Potential sources of bacteria considered included both point source and nonpoint source (NPS) contributions. Point sources in the BOR Basin include all municipal and industrial plants that treat human waste, as well as private residences that fall under general permits.

NPS pollution originates from diffuse sources on the landscape (e.g., agriculture and urban) and is strongly affected by precipitation events. 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 and contamination from leaking sewer lines or straight pipes). Nonpoint sources were assessed during TMDL development through an extensive analysis of land use with consideration for delivery mechanisms. In general, wildlife contribute bacteria to all land uses and to streams via direct deposition; livestock contribute bacteria to pasture areas and streams via direct deposition and indirectly to pasture and crop lands through manure application; humans contribute bacteria to residential areas via failing septic systems and to streams via straight pipes; and pets contribute bacteria directly to residential areas.

Various pollutant reduction scenarios were evaluated to meet the 30-day geometric mean target (190 cfu/100 mL) with zero violations (a requirement of the TMDL). A margin of safety (MOS) was incorporated into each TMDL by setting the target 5% below the geometric mean criterion of 200 cfu/100 mL. In addition to anthropogenic source reductions, the BOR TMDL plans call for reductions from wildlife sources in order to meet the TMDL. The final allocation scenarios from each watershed are shown in Table 3.

Table 3 – Final pollutant source reduction scenarios for the Big Otter River Basin

	Percent reduction in loads from existing conditions (2000)				
Watershed	Direct Deposit (Wildlife, natural)	Direct Deposit (Cattle)	Loads from Agricultural land uses	Straight Pipes	Percent of days with 30 day GM[c]>190 cfu/100 mL
Sheep Creek	80	100	60	100	0
Elk Creek	70	97	60	100	0
Machine Creek	65	100	60	0	0
Little Otter River[a]	70	100	60	100	0
Lower Big Otter River[b]	50	100	50	100	0

[a] A 100% reduction from the Bedford CSO is also required.
[b] 30% reduction in upstream loads from Buffalo Creek is also required.
[c] Geometric Mean

In addition to the final pollutant source reduction scenarios, a transitional (Phase 1) pollutant source reduction scenario was also developed. The Phase 1 scenario allows a 10% violation rate of the applicable single-sample fecal coliform criterion, 1000 cfu/100 mL, and reflects smaller pollutant source reductions. Implementation of the Phase 1 scenario will permit an evaluation of the modeling assumptions and the effectiveness of management practices. Approaches to achieving the Phase I goals are outlined in section 5.

3. Public Participation

An essential step in implementing a TMDL and putting together a plan for implementation is input from a broad range of stakeholders (individuals, agencies, organizations, and businesses with interest in water quality and the BOR and familiar with local conditions). Local stakeholders are best suited to identify and resolve sources of water quality problems. The stakeholders involved in developing the BOR IP included a Resource Team, a Steering Committee, Working Groups, and the general public. The Resource Team included staff with Virginia's Departments of Conservation and Recreation and Environmental Quality, and faculty and graduate students with the Center for TMDL and Watershed Studies in the Biological Systems Engineering Department at Virginia Tech.

A public meeting was held on May 19, 2005 to expand awareness about the goals of the IP and to solicit stakeholder participation. Two Working Groups were developed that included stakeholders with common interests and concerns about the implementation process. The Government/Residential Working Group focused on urban residential and public works issues, while the Agricultural Working Group focused on agriculture and rural/residential issues. The Working Groups provided stakeholders an opportunity to provide feedback to the Resource Team about potential sources of problems and appropriate solutions. Each Working Group was charged with discussing, analyzing, and prioritizing potential bacteria pollutant source reduction corrective measures. Working Group input was passed to the Steering Committee. The Steering Committee was responsible for balancing the interests and desires voiced in the Working Groups and for providing direction to the TMDL IP development Resource

Team. The Working Groups met three times between August 2005 and March 2006. Two Steering Committee meetings were held on January 10 and April 27, 2006. The second and final public meeting occurred on May 9, 2006 in Bedford, VA. The purpose of this final public meeting was to present the draft of the BOR TMDL IP to stakeholders and to solicit feedback. Detailed meeting summaries for the BOR IP planning process can be found in the BOR TMDL IP technical report.

4. Implementation Actions

The problems/pollutant sources that were identified in the BOR Basin TMDL study include unrestricted livestock access to streams, lack of streamside buffer/forest, agricultural runoff, and straight pipes and failing septic systems. As part of the IP development process, stakeholders were tasked with identifying potential actions and strategies to address each problem/pollutant source. Working Group and Steering Committee discussion and decision-making were facilitated through the use of a planning matrix. The planning matrix was organized by problem/pollutant source, with specific potential implementation actions (corrective measures) addressing each problem/pollutant source. The participants prioritized each implementation action by discussing the need for a particular action in the watershed and the likelihood of it being implemented. The resulting high priority actions are presented in Table 4. Table 4 includes several best management practices (BMPs) to control NPS pollution.

The Virginia Best Management Practice Cost-Share Program (BMPCSP) offers cost-share assistance as an incentive to implement selected BMPs.. This IP utilizes two primary practices from the BMPCSP to meet agricultural implementation needs: grazing land and stream protection. Grazing Land Protection (SL-6) systems include stream-side fencing, off-stream watering, cross fencing, and hardened crossings, when needed. The Stream Protection (WP-2T) practice includes stream-side fencing and a one time fence maintenance payment of $0.50 per foot of installed fence once the practice is approved. Fencing maintenance cost can also be offset with a tax credit using state's Maintenance of Stream Exclusion Fencing practice (WP-2D).

Cost-share assistance is also provided for the residential BMPs that are utilized in this IP. These practices include connection of failing septic system or straight pipe to public sewer (RB-2), septic tank system repair (RB-3), septic tank system installation/replacement (RB-4), and alternative on site waste treatment systems (RB-5).

Table 4. High priority implementation actions identified by the Big Otter River Working Groups and Steering Committee.

Problem/Pollutant Source	Implementation Action[a]	Type of Practice		
		Primary[b]	Policy	Education
1. Livestock access to streams	Fencing with off-stream watering (SL-6 Grazing Land Protection)	X		
	Permanent fencing (Stream protection DCR WP-2T)	X		
	Maintenance of stream exclusion fencing (WP-2D)	X		
	Off-stream water system (SL-6B Alternative Water System)	X		
	Stream crossing and hardened access (WP-2B)	X		
	Fencing alternatives that don't qualify for cost-share	X		
	Information to farmers about cost-share			X
	Reduce property tax or give tax credit for land taken out of production		X	
	Peer education about fencing: demonstrations and field days			X
2. Lack of streamside buffer/forest	Establish riparian buffers (CREP, FR-3)	X		
	Permanent preservation of streamside buffers from development		X	
	Incorporate stream buffers into development plans/projects	X	X	
	Increase awareness of CREP			X
3. Agricultural runoff	Rotational grazing system (SL-6)	X		
	Range and pasture management	X		
	Establish riparian buffers (CREP, FR-3)	X		
	Comprehensive information about biosolids supplied to stakeholders			X
	Educational programs on biosolids application			X
	Consistent enforcement of biosolids application regulations across jurisdictions		X	
4. Straight pipes and failing septic systems	Increase public awareness of cost share money to repair failing systems			X
	Integrate maintenance fees with property taxes; maybe through ordinance that requires regular maintenance of septic systems		X	
	Map straight pipes, sinkholes, wells, and septic systems			X
	Target high-risk areas for money to repair failing systems - older houses		X	
	Connect malfunctioning system to public sewer (RB-2)	X		
	Repair failing system (RB-3)	X		
	Septic tank installation/replacement (RB-4)	X		
	Install alternative on-site waste treatment systems: sand filters, elevated sand mounds, constructed wetlands, peat filters, vault privies, incinerator toilets, composting toilets (RB-5)	X		
	Develop and implement comprehensive monitoring program	X		X

[a] State cost-share program practice numbers are given in parentheses, where appropriate

[b] Primary practices are those implementation actions that are installed to control bacterial sources

The number and type of BMPs that are needed were determined by analysis of spatial data and by modeling various BMP implementation scenarios using the water quality model that was used to develop the Big Otter TMDLs. Input from stakeholders was considered throughout. Analysis indicated that stream exclusion fencing is needed to reduce bacteria pollution associated with agricultural landuses and that eliminating straight pipes and repairing/replacing failing septic systems must be addressed to reduce bacteria loads from residential landuses.

Fencing needs along streams were estimated using GIS data. For this implementation plan, it was conservatively assumed that cattle exist on all pasture areas. There are approximately 350 miles of perennial stream within the BOR Basin. Of this stream length, about 164 miles of stream are adjacent to pasture land. The GIS analysis was used to distinguish between stream segments that would likely be fenced on one side only (e.g., stream running along the edge of a pasture) versus on both sides (e.g., stream in the middle of a pasture). This analysis indicated that 241 miles of fencing is needed in the seven watersheds of interest in the BOR Basin.

The needed number of SL-6 systems was estimated for each watershed in the BOR Basin by considering: 1) the total fencing required, 2) the number of cattle in the watershed, and 3) the proximity of possible fencing locations to a stream. Based on data from the Peaks of Otter Soil and Water Conservation District (SWCD) in 2005, there were 11 SL-6 systems committed in the BOR Basin in 2005, which, on average, included 2500' of stream exclusion fencing. The total number of 2,500-ft contiguous fencing segments was estimated using GIS as a first estimate for the number of SL-6 systems needed. This number was then modified to reflect information about the number of cattle in each watershed (data available in the TMDL report). It was assumed that one SL-6 system was needed per 50-head of cattle. It is expected that the targeted implementation of the SL-6 systems will address the majority of the fencing needs for livestock exclusion in the watershed. The installation of these systems should be given a high priority as they are likely to achieve the greatest water quality improvement per dollar invested.

The stream length needing fencing that is not addressed with SL-6 systems should be addressed with the WP-2T fencing BMP. The quantity of hardened crossings associated with the WP-2T fencing was estimated by considering only the 2-sided fencing segments (pasture on both sides of the stream) and subtracting the length of 2-sided fencing provided by the SL-6 systems in the watershed. The 2-sided WP-2T fence length was divided by 1,500 ft (an estimate used in the Lower Blackwater River TMDL IP) to determine the needed number of hardened crossings. This may be conservative (i.e., an overestimate) since the length of contiguous stream segments was not considered in this analysis.

In the BOR Basin, the majority of the agricultural overland bacteria load to the stream is from pasture land. The most efficient and cost-effective practices to reduce overland bacteria loads from pasture include pasture land management and vegetative riparian buffers. Currently, Virginia's cost-share program requires a minimum of a 35-ft buffer between cost-shared fencing and the stream. This 35-ft set-back allows vegetation to grow and create a natural streamside buffer/riparian area that reduces bacteria loading to the stream. Therefore, cattle exclusion fencing reduces both cattle direct deposits as well as overland pasture loads.

The remainder of the overland load reductions will be obtained by incorporating pasture land management BMPs on a portion of the pasture area in each watershed. Pasture land management practices are BMPs or systems of BMPs that promote and protect vegetative cover on pastureland. The cross fencing and rotational grazing plan required for SL-6 systems account for an average of 50 acres in pasture land management per system (VADCR, 2006). Other actions that promote good pasture land management include seeding and reseeding pastures, ensuring proper stocking densities, and proper grazing management. The benefits of good pasture land management are discussed in Section 6. The quantities of agricultural BMPs that are needed to meet TMDL load reductions are summarized in Table 5.

Table 5 - Agricultural best management practice (BMP) quantities required to meet TMDL.

Sub-basin	Streams‡ needing Fencing (%)	Pastures needing PLM† (%)	Required Fencing (miles)	No. of SL-6 systems	WP-2T fencing (miles)	PLM† (acres)	No. of Hardened Crossings
Sheep Creek*	100	40	41.0	27	28.2	2,079	30
North Otter Creek	90	38	33.0	24	21.7	1,739	20
Elk Creek*	97	45	47.2	34	31.1	4,816	32
Machine Creek*	100	78	27.1	24	16.1	5,262	14
Little Otter River*	100	40	34.1	30	19.9	2,201	22
Buffalo Creek	70	14	21.2	38	3.2	0.0	4
Big Otter River*	100	20	23.2	21	13.3	0.0	11
Total			**226.8**	**198**	**133.5**	**16,097**	**133**

‡streams with pasture access

† PLM = Pasture Land Management

* Original TMDL watersheds

The TMDLs call for the removal of all straight pipes and combined sewer overflows (CSOs) in the impaired watersheds in order to meet the TMDL load reductions. While the TMDLs do not specifically call for a reduction in bacteria loads from residential runoff, addressing failing septic systems proximate to streams will help reduce the overall bacteria loading to the streams. Table 6 shows the number of unsewered homes, estimated failing septic systems, estimated failing septic systems within 300 ft of a stream, and estimated straight pipes for the seven watersheds of interest in this TMDL IP. It is expected that failing septic systems within 300 ft of the stream would have the greatest impact on water quality. The number of unsewered households was estimated using E-911 digital data (Bedford Co. Planning Dept., 1999). The numbers of failing septic systems and straight pipes were estimated using failure rates based on the age of the homes. While not quantified in this plan, there exists the potential for households to connect to municipal sewer systems when the system is within range. Often time connection and use fees are more economical than septic systems. Stakeholders in the BOR Basin may be able to take advantage of the state's Connection of Malfunctioning Septic to Public Sewer System cost-share practice (RB-2).

Table 6 - Estimated failing septic systems and straight pipes in Big Otter River watershed.

Watershed	Total Unsewered Homes	Estimated Failing Septic Systems	Estimated Failing Septic Systems within 300' of a Stream	Estimated Straight Pipes
Sheep Creek	913	194	58	8
Elk Creek	2,463	378	15	1
Machine Creek	728	163	14	0
Little Otter River	1,424	338	84	1
Lower Big Otter	983	304	22	1
North Otter River	532	117	30	3
Buffalo Creek	3,792	834	98	11
Total	**10,835**	**2,328**	**321**	**25**

At the time of the TMDL study, CSOs had occurred in the Little Otter River watershed, just outside the City of Bedford. Since the TMDL study, the sewage treatment plant in the City of Bedford has spent about $11 million on upgrades in order to prevent overflows. The City of Bedford has improved the sewer system over the past few years through replacement of approximately 300 manholes and about 60,000 feet of sewer line in the city. Also, cameras have been purchased for the purpose of inspecting sewer lines and keeping them maintained. The costs and actions that address the CSO in the Big Otter River Basin are not summarized in this implementation plan since they are already being implemented. The scenarios presented in the IP assume that CSOs have been eliminated.

Technical assistance is needed for design and installation of implementation actions, as well as for educational outreach. An average of 1.2 full-time-equivalent (FTE) employees per year is needed to address agricultural issues and 0.7 FTE per year for residential issues. These estimates were based on similar projects and experience and knowledge of the Steering Committee. Educational outreach will include strategies identified by stakeholders for facilitating the execution of implementation actions.

According to feedback from the Steering Committee and Working Groups, many of the available cost-shared practices are not being implemented because landowners in the watershed are not aware of the cost-share process or the benefits that result from implementing these practices. Various ideas were suggested to better educate agricultural landowners about the funds available to them. Some of these methods include peer-to-peer programs and watershed tours of model/demonstration farms. The Residential Working Group suggested using flyers to inform the public about the importance of maintaining their septic systems and the various cost-shares that are available to do so. These tasks will be the responsibility of the technical assistance personnel. A well executed educational program is viewed as very important if the goals laid out in this implementation plan are to be met.

5. Implementation

In general, the Commonwealth of Virginia intends for NPS pollutant TMDL reductions to be implemented in a staged or phased fashion. Through staged implementation, those sources and/or practices that are expected to produce the greatest water quality improvement are targeted first. Staged implementation includes on-going monitoring to assess progress toward attaining water quality standards.

Implementation milestones define the portion of implementation actions to be installed within certain time periods or stages. Water quality milestones establish the corresponding improvements in water quality that can be expected as the implementation milestones are met. Implementation objectives were developed in order to help clearly identify implementation and water quality milestones for the Big Otter River Basin implementation process.

Objective 1: *For each original TMDL watershed and the two recently listed watersheds (Buffalo Creek and North Otter), quantify corrective measures (fencing, pasture land management, eliminating straight pipes, etc.) to achieve no more than 10.5% violations of the instantaneous standard (1000 cfu /100 mL) at each watershed outlet.*

Objective 2: *For each original TMDL watershed, quantify corrective measures necessary to achieve load reductions specified in TMDL, excluding wildlife reductions (Table 3).*

The goal of Objective 1 is to reduce violations of the bacteria standard to less than 10.5%, the Phase 1 reductions called for in the TMDL. Currently, USEPA guidance allows VADEQ to remove a stream segment from the impaired waters list when the violation rate of the single sample water quality criterion violation rate is 10.5% or less during an assessment period. A combination of implementation actions that achieve Objective 1 was determined for each watershed through modeling. A summary of these actions is presented in Table 7. The BMPs needed to achieve Objective 2 (i.e., compliance with the TMDL), are summarized in Section 4, Tables 5 and 6. A summary of the goals for each milestone is given in Table 8.

Table 7 - Agricultural best management practices (BMPs) needed to meet implementation Objective 1 for the Big Otter River Basin.

Sub-basin	Streams‡ needing Fencing (%)	Pasture needing PLM† (%)	Required Fencing (miles)	No. of SL-6 systems	WP-2T fencing (miles)	PLM† (acres)	No. of Hardened Crossings
Sheep Creek*	95	16	39.0	27	26.2	0	25
North Otter Creek	90	38	33.0	24	21.2	1,739	20
Elk Creek*	63	12	30.6	34	14.6	0	15
Machine Creek*	90	78	24.4	24	13.0	5,262	12
Little Otter River*	85	16	29.0	30	14.8	0	15
Buffalo Creek	70	14	21.2	38	3.2	0	4
Big Otter River*	0	0	0.0	0	0.0	0	0
Total			**177.1**	**177**	**93.5**	**7,001**	**91**

‡ streams with pasture access
† PLM = Pasture Land Management
* Original TMDL watersheds

An implementation period of 15 years was established due to the size of the BOR Basin and the number of practices needed. Primary implementation will occur during the first 13 years. Water quality monitoring will continue through year 15 in order to allow for BMP maturation and stabilization of bacteria concentrations in the stream.

At the start of the implementation project, an effort will be made to implement BMPs in targeted watersheds rather than across the entire BOR Basin. The Little Otter River (L26b), Elk Creek (L25), Buffalo Creek (L27), and Sheep Creek (L24) watersheds were selected to be targeted for implementation during the first five years of the project (stage 1). These watersheds were selected based on their location in the basin, the quantity of BMPs needed in each watershed and what effect implementation in a given watershed will have on the bacteria concentration at the BOR Basin outlet.

Table 8 - Implementation milestones for the Big Otter River Basin TMDL Implementation Plan

Milestone	Goals
Stage 1 (Year 5)	Have implemented 50% of practices identified in Objective 1
Stage 2 (Year 8)	Have implemented 100% of practices identified in Objective 1
Stage 3 (Year 13)	Have implemented 100% of practices identified in Objectives 1 and 2
Stage 4 (Year 15)	De-listing

The quantities of agricultural practices that are to be implemented during each stage of implementation are summarized in Table 9. The timeline of residential practices to be implemented during each stage is summarized in Table 10. All straight pipes and 35% of failing septic systems are to be replaced or repaired in Stage 1 of implementation. The remaining failing septic systems will be addressed during the remaining stages of implementation.

Table 9 - Timeline of agricultural practices that are to be implemented during the TMDL implementation period.

		Implementation Stages			
Practice	**Unit**	**Year 1-5**	**Year 6-8**	**Year 9-13**	**Total**
SL-6 System	system	88	89	21	198
WP-2T (fencing)	mile	46.7	46.7	40.1	133.5
WP-2T (maintenance)	mile	46.7	46.7	40.1	133.5
Hardened Crossings	system	45	46	42	133
Pasture Management	acre	3,500	3,501	9,096	16,097
Technical Assistance	person/year	5	3	7.5	15.5

Table 10 - Timeline of residential practices that are to be implemented during the TMDL implementation period.

	Implementation Stages			
Practice	**Year 1-5**	**Year 6-8**	**Year 9-13**	**Total**
Conventional Septic Systems	105	84	72	261
Alternative Waste Treatment Systems	14	12	10	36
Septic System Repairs	17	17	15	49
Technical Assistance (FTEs)	5	1.5	2.5	9

Once the implementation milestones and stages are established, the water quality improvement at the BOR Basin outlet that should result from achieving each milestone can be predicted. The violations of the bacteria criterion were estimated for each implementation milestone using modeling. The water quality and implementation milestones are summarized together in Figure 3.

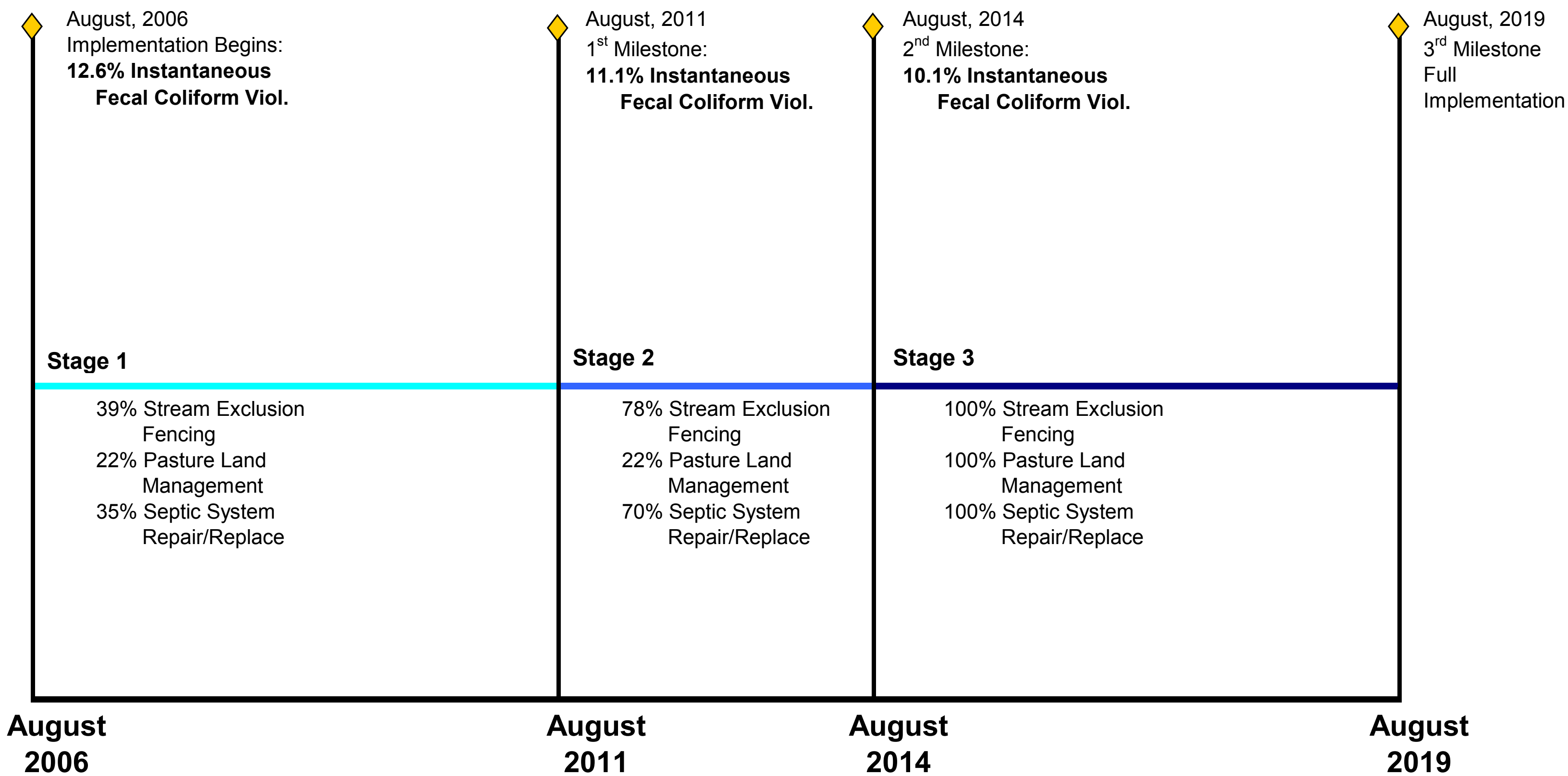

Figure 3 - Implementation and water quality milestones for the Big Otter River Basin TMDL IP.

6. Cost/Benefit Analysis

Based on average installation costs provided by the Peaks of Otter SWCD, the total cost for an SL-6 system in the basin for 2005 was $12,400. The Agricultural Working Group gave an average cost of fencing to be $3.50/linear foot and $0.50/linear foot for fence maintenance. These values were used to estimate costs for the WP-2T fencing installation. Costs for pasture land management were obtained from the Peaks of Otter SWCD. Costs for agricultural BMPs are shown in Table 11.

Table 11 - Total cost estimates for agricultural best management practices (BMPs) in the Big Otter River Basin.

Practice	Unit	Cost/Unit	Quantity	Total
SL-6 System	system	$12,400	198	$2,455,200
WP-2T (fencing install)	mile	$18,480	133.5	$2,467,080
WP-2T (maintenance)	mile	$2,640	133.5	$352,440
Hardened Crossings	system	$550	133	$73,150
Pastureland Management	acre	$85	16,097	$1,368,245
Tech. Assistance	person/year	$50,000	15.5	$775,000
Total				**$7,491,115**

The residential implementation actions consist of repairing or replacing failing septic systems and straight pipe discharges within the BOR Basin. Considerations are also made for alternative waste treatment systems where soils or groundwater conditions are not suitable for conventional septic systems. Based on data from implementation projects in Franklin County and consultation with the Virginia Department of Health (VDH), it was assumed that 10% of failing systems would need to be replaced with alternative waste treatment systems. Also based on these data, it was assumed that 15% of failing septic systems can be repaired without installing a new system. Typical costs in the region show that a septic system repair costs an estimated $2,000, a conventional septic system is estimated at $3,900 and an alternative waste treatment system is estimated at $15,000. Table 12 summarizes all costs associated with the residential improvements, including replacing all straight pipes in the Big Otter River Basin with either a conventional septic system or an alternative waste treatment system and replacing or repairing all failing septic systems within 300 feet of a stream.

Table 12 - Implementation estimates and costs for the Big Otter River Basin.

Practice	Estimated units needed	Average Cost ($) /Unit	Total Cost ($)
Conventional Septic System (to replace straight pipes)	22	$3,900	$85,800
Alternative Waste Treatment System (to replace straight pipes)	3	$15,000	$45,000
Straight Pipe Subtotal	**25**		**$130,800**
Septic System Repair	*49*	*$2,000*	*$98,000*
Conventional Septic System (to replace failing septic systems)	*239*	*$3,900*	*$932,100*
Alternative Waste Treatment System (to replace failing septic systems)	*33*	*$15,000*	*$495,000*
Failing Septic System Subtotal	**321**		**$1,525,100**
Staff-years	9	$50,000	$450,000
Total			**$2,105,900**

The total implementation cost for the BOR Basin is estimated to be $9.6 million. Table 13 shows the cost of installing the needed corrective measures broken down into the three implementation stages. However, streams in Virginia can be removed from the impaired waters list (de-listing) when violation of the single sample bacteria standard criterion are 10.5% of the time or less. The extent of implementation can therefore, potentially, be something less than 'full implementation' to achieve acceptable water quality improvement.

Table 13 - Staged timeline of costs associated with all practices that are to be implemented during the TMDL implementation period.

	Implementation Stages			
Practice	**Stage 1 (Year 1-5)**	**Stage 2 (Year 6-8)**	**Stage 3 (Year 9-13)**	**Total**
Agricultural:				
SL-6 System	$1,091,200	$1,103,600	$260,400	$2,455,200
WP-2T (fencing)	$863,016	$863,016	$741,048	$2,467,080
WP-2T (maintenance)	$123,228	$123,288	$105,864	$352,440
Hardened Crossings	$24,750	$25,300	$23,100	$73,150
Pasture Management	$297,500	$297,585	$773,160	$1,368,245
Technical Assistance	$250,000	$150,000	$375,000	$775,000
Residential:				
Conventional Septic System	$409,500	$327,600	$280,800	$1,017,900
Alt. Waste Treatment System	$210,000	$180,000	$150,000	$540,000
Septic System Repairs	$3,400	$3,400	$3,000	$9,800
Technical Assistance	$250,000	$75,000	$125,000	$450,000
Total	**$3,553,254**	**$3,179,389**	**$2,864,372**	**$9,597,015**

The primary benefit of implementation is improved water quality. Through BMP implementation, fecal contamination in the BOR Basin will be reduced to meet water quality standards and maintain high quality water for watershed residents and downstream uses. It is hard to gage the impact that reducing fecal contamination will have on public health, as most cases of waterborne infection are not reported or are mistakenly attributed to other sources. However, because of the reductions required, the incidence of infection from fecal sources through contact with surface waters should be reduced considerably. Additionally, because of stream-bank protection that will be provided through exclusion of livestock from streams, and restoration of the riparian area through implementation of the Conservation Reserve Enhancement Program (CREP) in some areas, the aquatic habitat will also be improved in these waters. The vegetated buffers that are established will also serve to reduce sediment and nutrient transport to the stream from upslope locations. In areas where pasture management is improved through implementation of grazing land protection BMPs, soil and nutrient losses should be reduced. Additionally, infiltration of precipitation should be increased, decreasing peak flows downstream.

An important objective of the implementation plan is to foster continued economic vitality and strength. The agricultural and residential practices recommended in this document will provide economic benefits to the landowner, as well as the expected environmental benefits onsite and downstream. Specifically, alternative (clean) water sources, exclusion of cattle from streams, intensive pasture management, and private sewage system maintenance or upgrades will each provide economic benefits.

A clean water source has been shown to improve weight gain and milk production in cattle. Fresh clean water is essential for livestock, with healthy cattle daily consumption close to 10% of their body weight during winter and 15% of their body weight in summer. Many livestock illnesses can be spread through contaminated water supplies. A clean water source can prevent illnesses that reduce production and incur the added expense of avoidable veterinary bills. In addition to reducing the likelihood of animals contracting waterborne illnesses by providing a clean water supply, streamside fencing excludes livestock from wet, swampy environments often found next to streams where cattle have regular access.

Taking the opportunity to implement an improved pasture management system in conjunction with installing clean water supplies will also provide economic benefits for the producer. Improved pasture management can allow a producer to feed less hay in winter months, increase livestock stocking rates by 30 - 40% and, consequently, improve the profitability of the operation. With feed costs typically responsible for 70-80% of the cost of growing or maintaining an animal, and pastures providing feed at a cost of 1 to 2 cents/lb of total digestible nutrients (TDN) compared to 4 to 6 cents/lb TDN for hay, increasing the amount of time that cattle are fed on pasture is clearly a financial benefit to producers (VACES, 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. A side benefit is that cattle are more closely confined, allowing for quicker checking and handling.

The residential programs will play an important role in improving water quality, since human waste can carry with it human viruses in addition to the bacterial and protozoan pathogens that all fecal matter can potentially carry. In terms of economic benefits to homeowners, an improved understanding of private sewage systems, including knowledge of what steps can be taken to keep them functioning properly and the need for regular maintenance, will give homeowners the tools needed for extending the life of their systems and reducing the overall cost of ownership. The average septic system will last 20-25 years or longer if properly maintained. Proper maintenance includes knowing the location of the system components and protecting them by not driving or parking on top of them, not planting trees where roots could damage the system, keeping hazardous chemicals (including water softening chemicals) out of the system, and pumping out the septic tank every 3 to 5 years. The cost of proper maintenance is relatively inexpensive in comparison to repairing or replacing an entire system. Additionally, improvements to private waste treatment systems can enhance property values in the watershed.

In addition to the benefits to the individual landowners, the economy of the local community will be stimulated through expenditures made during implementation and the infusion of dollars from funding sources outside the impaired areas. Building contractors and material suppliers who deal with septic system pump-outs, private sewage system repair and installation, fencing, and water system installation can expect to see an increase in business during implementation. Additionally, income from maintenance of these systems should continue long after implementation is complete.

Potential funding sources available for implementation were identified during plan development. It is anticipated that funding for agricultural BMPs will be provided through a combination of EPA 319 funds, Virginia Agricultural BMP Program and federal sources. Residential practices will most likely be funded through EPA 319 funds and grant funds that may be applied for during implementation. Specific funding sources identified during the plan development are described in detail in the technical document. Sources include:

- EPA 319 Incremental Funds
- Virginia Agricultural Best Management Practices Cost-Share/Tax-Credit Program
- Virginia Water Quality Improvement Fund
- USDA Conservation Reserve Enhancement Program (CREP)
- USDA Conservation Reserve Program (CRP)
- USDA Environmental Quality Incentives Program (EQIP)
- Wetland Reserve Program (WRP)
- Wildlife Habitat Incentive Program (WHIP)
- Southeast Rural Community Assistance Project
- Community Development Block Grant Program
- National Fish and Wildlife Foundation Grants

7. Water Quality Monitoring

Implementation progress will be evaluated through water quality monitoring conducted by VADEQ. VADEQ will monitor eight locations in the seven watersheds (Figure 5, Table 14). The ambient watershed and ambient trend stations will be sampled bi-monthly from January 2007 at the earliest and will continue through December 2014 (unless it is determined that additional sampling is needed). The following parameters will be collected at all stations: fecal coliform and *Escherichia coli* bacteria, temperature, dissolved oxygen, specific conductance, turbidity, total nitrogen, total phosphorus, total solids, and total suspended solids.

The BOR Basin IP Steering Committee suggested VADEQ monitoring could be supplemented with the use of Coliscan Easygel® monitoring kits and citizen monitors. These monitoring data may be used to collect current data and gage the success of implementation in reducing the amount of *E. coli* bacteria in the streams, but cannot be used for the purpose of listing or delisting the streams based on observed degradation or improvement.

Table 14 - VADEQ monitoring stations in the Big Otter River Basin.

DEQ Station ID	Station Location	Stream Name
4ASEE003.16	Rt. 680 Bridge	Sheep Cr.
4ANOT001.06	Rt. 644 Bridge	North Otter Cr.
4AECR003.02	Rt. 668 Bridge	Elk Cr.
4ALOR014.75	Rt. 718 Bridge - above Bedford STP	Little Otter R.
4AMCR004.60	Rt. 804 Bridge	Machine Cr.
4ABOR016.26	Rt. 24 Bridge	Big Otter R.
4ABWA002.00	Below Rt. 24 Bridge	Buffalo Cr.
4ABOR000.62	Rt. 712 Bridge near confluence with Roanoke (Staunton) River	Big Otter R.

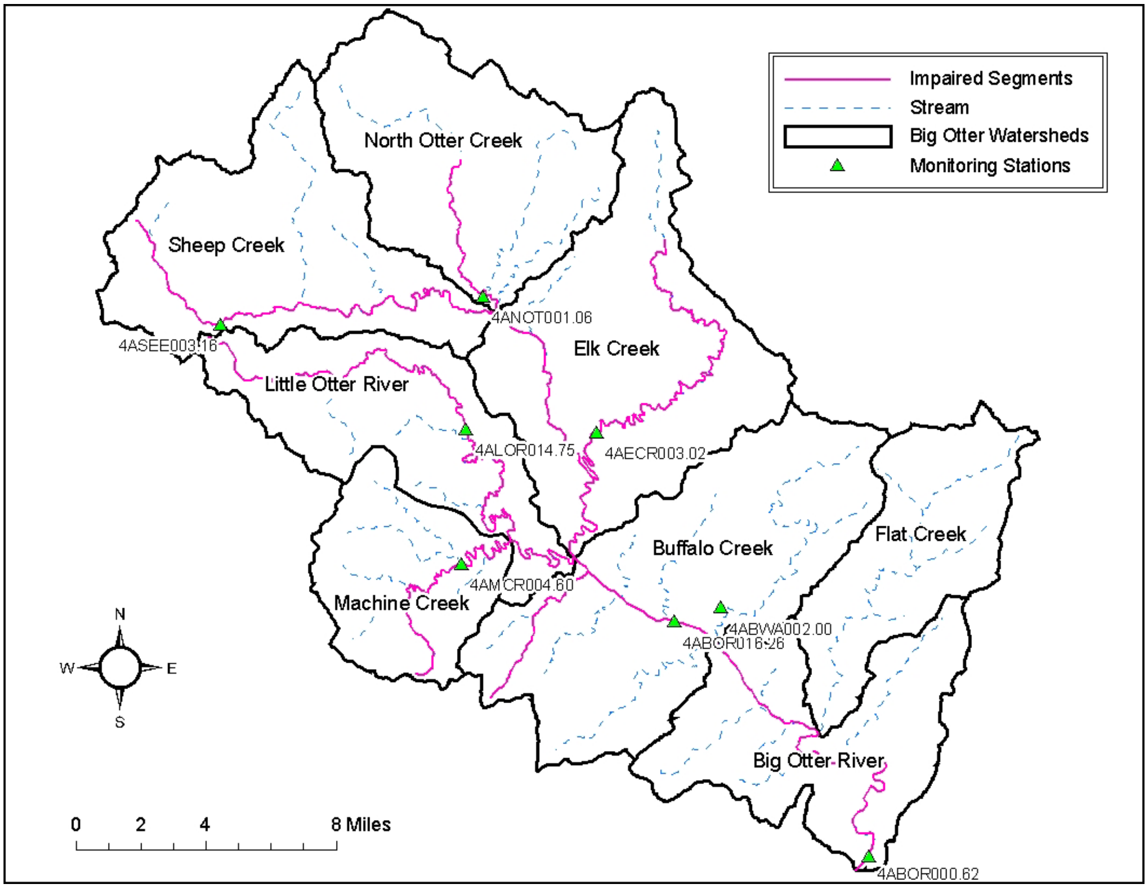

Figure 5 - Location of BOR Basin TMDL implementation plan monitoring stations.

8. Evaluation of Progress

VADCR will work with the Peaks of Otter and Robert E. Lee SWCDs to establish an agreement to oversee execution of the BOR TMDL IP. Tracking of agricultural and residential practices will be done by the Districts through the existing tracking program maintained by VADCR. Tracking information will include the locations and numbers of practices installed in the watershed. Strategies to facilitate implementation, such as educational programs and other outreach activities will also be tracked. The BOR IP Steering Committee will continue to provide oversight and direction as needed during implementation.

The ultimate goal of implementation is to meet water quality standards. Monitoring will be used to determine if water quality standards are met. Delisting of the water body 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.

If water quality standards are not met, progress toward implementation and water quality milestones will be evaluated on an annual basis. Several different conclusions could be reached during the annual review. Those conclusions and the resulting steps to be taken are described in Table 15.

Table 15 - Potential outcomes of annual review of implementation and water quality milestones and resulting actions to be taken by action committee.

Conclusion of milestone review	Actions to be taken
implementation milestones[1] met water quality milestones[2] met	Continue implementation as planned
implementation milestones met water quality milestones not met	First, determine if the expected water quality impact was in error. If the previous assessment of expected water quality impact is found to be in error, reassess the expected water quality impact and adjust water quality milestones, implementation milestones, and implementation schedule accordingly. It might also be necessary to adjust one or more of the implementation actions. Second, determine if additional time is needed for the implemented practices to have the expected impact on water quality. For example, some practices, such as riparian buffer zones, do not reach maximum effectiveness immediately upon implementation. If it is determined that the practices need to mature, then implementation will continue as planned. Third, if after completing the first two steps, it is determined that the TMDL is not attainable with the implementation of reasonable corrective measures, it might be necessary to conduct a Use Attainability Analysis (UAA). The Steering Committee would consult with VADEQ prior to deciding on this approach.
implementation milestones not met water quality milestones met	Revise the implementation schedule to reflect the accelerated progress that is being made. Establish new milestones and continue to evaluate progress.
implementation milestones not met water quality milestones not met	Determine what the deterrents to progress are. If external forces such as lack of funding or lag in stakeholder commitment are the problem, revise the implementation schedule accordingly and establish new milestones. If the implementation actions are determined to be the problem, then adjust the implementation actions, milestones, and schedule accordingly.

[1] Implementation milestones are provided in Tables 9 (Agriculture) and 10 (Residential)
[2] Water quality milestones are provided in Figure 4

9. Stakeholders' Roles and Responsibilities

Stakeholders are individuals who live or have land management responsibilities in the watershed, including government agencies, businesses, private individuals, and special interest groups. Stakeholder participation and support is essential for achieving the goals of this TMDL effort (i.e. improving water quality and removing streams from the impaired waters list). The purpose of this section is to identify and define the roles of the stakeholders who worked together to develop the IP. The roles and responsibilities of some of the major stakeholders are described below.

Peaks of Otter and Robert E. Lee Soil and Water Conservation Districts (SWCDs) are local units of government responsible for the 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.

Virginia Cooperative Extension (VCE) is another state entity with responsibilities for activities that impact water quality in the BOR Basin. 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 United States 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 several publications that deal specifically with TMDLs. For more information on these publications and to find the location of county extension offices, visit www.ext.vt.edu.

U.S. Environmental Protection Agency (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 falls largely to the states.

The U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) is the federal agency that works hand-in-hand with US citizens 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 rely heavily on the expertise of NRCS staff in the design of management practices. NRCS is also a major funding stakeholder for impaired water bodies through the Conservation Reserve Enhancement Program (CREP) and the Environmental Quality Incentive Program (EQIP). For more information on NRCS, visit http://www.nrcs.usda.gov/.

Virginia Department of Environmental Quality (VADEQ) is the lead agency in the TMDL process. Section 10.1-1183 of the Code of Virginia directs VADEQ to develop a list of impaired waters, develop TMDLs for these waters, and develop IPs for the TMDLs. VADEQ administers the TMDL process, including the public participation component, and formally submits the TMDLs to USEPA and the State Water Control Board for approval. VADEQ is also responsible for implementing point source WLAs, assessing water quality across the state, and conducting water quality standard related actions.

Virginia Department of Conservation and Recreation (VADCR) is authorized to administer Virginia's NPS pollution reduction programs in accordance with §10.1-104.1 of the Code of Virginia and §319 of the Clean Water Act. USEPA requires much of the §319 grant monies be used for the development of TMDLs. Because of the magnitude of the NPS component in the TMDL process, VADCR is a major participant in the TMDL process and is providing funding for the development of this IP. VADCR has a lead role in the development of IPs to address correction of NPSs contributing to water quality impairments. VADCR also provides available funding and technical support for the implementation of NPS components of IPs. The staff resources in VADCR's TMDL program focus primarily on providing technical assistance and funding to stakeholders to develop and carry out IPs, and support to VADEQ in TMDL development related to NPS impacts. VADCR staff will also be working with other state agencies, Soil and Water Conservation Districts, and watershed groups to gather support and to improve the implementation of TMDL plans through utilization of existing authorities and resources.

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 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.

The Virginia Department of Health (VDH) is responsible for maintaining safe drinking water measured by standards set by the EPA. Like VDACS, VDH is complaint driven. Their duties also include regulation of septic systems, straight pipes, and biosolids land application. In the course of developing this implementation plan, stakeholders expressed concerns about the type and amount of biosolids being applied in the BOR Basin. Concerns were also raised as to the level of land application regulation oversight (some citizens believed that biosolids were being applied at rates greater than permitted). At the October 15, 2005 Agricultural Working Group meeting one citizen alerted the group to the existence of a recent report from the Virginia Joint Legislative Audit and Review Commission that discusses biosolids application in Virginia (JLARC, 2005). Attendees were encouraged to seek out the report.

Regional and local government groups work closely with state and federal agencies throughout the TMDL process; these groups possess insights about their regional and local community that may help to ensure the success of TMDL implementation. These stakeholders have knowledge about a community's priorities, how decisions are made locally, and how the watershed's residents interact. While successful implementation depends on stakeholders taking responsibility for their role in the process, the primary role falls on the local groups that are most affected; that is, businesses, community watershed groups, and citizens.

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Glossary

Allocations - best estimates of current and future pollutant loads (both nonpoint and point sources) entering a waterbody. Pollutant load estimates can range from reasonably accurate measurements to gross estimates, depending on the availability of data, and the techniques used for predicting specific loads. (see Load Allocation and Waste Load Allocation)

Allocation Scenario - proposed combination of point source and nonpoint source pollutant loads being considered to meet a water quality goal.

Ambient water quality - level of water quality constituents collected as part of a routine monitoring program.

Anthropogenic - involving the impact of humans on nature; specifically items or actions induced, caused, or altered by the presence and activities of humans.

Best management practices (BMPs) - reasonable and cost-effective means to reduce the likelihood of pollutants entering a water body. BMPs include riparian buffer strips, filter strips, nutrient management plans, conservation tillage, etc.

Bioassessment - the process of evaluating the algal, benthic macroinvertebrate, and/or fish communities to determine whether a water body supports the state-defined designated use for aquatic life.

Calibration (of a model) - the process of adjusting model parameters within physically reasonable ranges until the resulting predictions give a best possible fit to observed data.

Clean Water Act (CWA) - is commonly used to describe the series of legislative acts that form the foundation for protection of the nation's water resources. Milestones in water quality legislation include the Water Quality Act of 1965; Federal Water Pollution Control Act of 1972 (PL92-500); the Clean Water Act, itself passed in 1977; and the Water Quality Act of 1987. Sections of the CWA address different types of water pollution in different ways. Section 305b and Section 303d of the CWA deal specifically with water quality assessment and TMDL development.

Coliform bacteria - a group of organisms (Colon bacilli) usually found in the digestive tract of all warm-blooded animals and humans. The presence of coliform bacteria in water is an indicator of possible pollution by fecal material and the presence of pathogenic bacteria that can cause diseases such as intestinal infections, dysentery, hepatitis, typhoid fever and cholera. Bacteria quantities are generally reported as colonies or colony forming units (cfu) per 100 milliliters (ml) of sample. (see fecal coliform)

Criteria - elements of water quality standards expressed as constituent concentrations, levels, or narrative statements, representing the quality of water that supports a particular use. When criteria are met, water quality will generally support the designated use.

Delisting - the process by which an impaired waterbody is removed from the Section 303(d) Impaired Waters List. To remove a waterbody from the Section 303(d) list, the state must demonstrate to EPA, using monitoring or other data, that the waterbody is no longer impaired.

Designated use - those uses specified in water quality standards for each water body or segment. All Virginia waters are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish. Taken together, these uses are generally stated as "fishable and swimable." Through the protection of these uses, other uses such as industrial water supply, irrigation and navigation also are protected.

Die-off (of fecal coliform) - reduction in the fecal coliform population due to predation by other bacteria as well as by adverse environmental conditions (e.g.UV radiation, high or low pH, etc.).

Direct nonpoint sources - nonpoint sources that discharge directly into the stream, such as direct deposits of fecal material to streams from livestock and wildlife.

Drainage basin - the land area that drains to, or contributes water to, a particular point, stream, river, lake or, ocean. Drainage basins range in size from a few acres for a small stream, to large areas of the country like the Chesapeake Bay Basin that includes parts of six states. (see watershed)

E-911 digital data - emergency response database prepared by counties in Virginia that contains graphical data on road centerlines and buildings. The database contains approximate outlines of buildings, including dwellings and poultry houses.

E. coli (Escherichia coli) - a subgroup of fecal coliform bacteria that are present in the intestinal tracts and feces of warm-blooded animals. E. coli are used as an indicator of the potential presence of pathogens.

Effluent - (1) Something that flows out or forth, (2) Discharged wastewater such as the treated wastes from animal production facilities, industrial facilities, or wastewater treatment plants.

Endpoint - a measurable goal or target. Assessment endpoints and measurement endpoints are

Exceedence - a violation, e.g., of a permit limit or a water quality standard.

Existing Use - the use actually attained in the water body on or after November 28, 1975, whether or not the use is included in the water quality standards.

Failing septic system - septic systems in which the drain field has failed such that effluent (wastewater) that is supposed to percolate into the soil, rises to the surface and ponds on the surface where it can run into streams or rivers and pollute them.

Fate of pollutants - physical, chemical, and biological changes that pollutants experience once in the environment.

Fecal coliform - an organism of the coliform bacteria group originating in the intestinal tract of warm-blooded animals that passes into the environment in feces. Fecal coliform bacteria are often used as an indicator of pathogens in water. Generally reported as colonies or colony forming units (cfu) per 100 milliliters (ml) of water sample.

Geometric mean - the nth root of the product of n values. Mathematically the geometric mean is expressed as:

$$Geometric\ Mean = \sqrt[n]{x_1 \times x_2 \times ... x_n}$$

where n is the number of samples, and x1, x2, etc. are the values of some parameter, i.e. E. coli concentrations. Compared to an average or simple mean, the geometric mean lessens the impact of extremely high or low values greater than zero. For example, consider the following set of five E. coli measurements with units of cfu/100ml, 150, 600, 50, 120, 195. A simple mean of these values produces:

$$\text{Simple Mean} = \frac{150+600+50+120+195}{5} = 223\ \text{cfu/100ml}$$

The geometric mean for these measurements would be:

$$Geometric\ Mean = \sqrt[5]{150 \times 600 \times 50 \times 120 \times 195} = 160\, cfu / 100ml$$

Geographic Information System (GIS) - a system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. An example of a GIS is the use of spatial data for Emergency Services response (E-911). Dispatchers use GIS to locate the caller's house, identify the closest responder, and even determine the shortest route. All these activities are automated using the electronic spatial data in the GIS.

Hydrology - the study of the distribution, properties, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Impaired waters - those waters with chronic or recurring monitored violations of the applicable numeric and/or narrative water quality criteria.

Implementation Plan - a document required by Virginia statute (see WQMIRA) detailing the suite of pollution control measures needed to remediate an impaired water body. Once fully implemented, the plan should result in the previously impaired water achieving a "fully supporting" status. (see use support)

Indicator - a qualitative or quantitative surrogate measure that can be used to evaluate the relationship between pollutant sources and their impact on water quality. For example, the number and type of fish in a stream may be indicative of the stream's water quality.

Indicator organism - (1) any organism that by its presence or absence, its frequency, or its vigor indicates a particular property of its surrounding environment. (2) an organism used to indicate the potential presence of other (usually pathogenic) organisms. Indicator organisms are usually associated with the other organisms, but are usually more easily sampled and measured.

Load, Loading, Loading rate - the total amount of material (pollutants) entering a water body from one or multiple sources. Measured as a rate in weight per unit time or per unit area (e.g., pounds/year, pounds/acre).

Load allocation (LA) - the portion of the loading capacity attributed to 1) the existing or future nonpoint sources of pollution, and 2) natural background sources. Wherever possible, nonpoint source loads and natural loads should be distinguished.

Loading capacity (LC) - the greatest amount of pollutant loading a waterbody can receive without violating water quality standards. (see assimilative capacity)

Margin of safety (MOS) - a required component of the TMDL that accounts for the uncertainty in calculations of pollutant loading from point, nonpoint, and background sources.

Mean - the simple mean is the sum of the values in a data set divided by the number of values in the data set.

Micrograms per liter (µg/l) - a measure of concentration, equivalent to parts per billion (ppb). One thousand micrograms per liter is equivalent to 1 milligram per liter.

Model - a system of mathematical expressions that describe both hydrologic and water quality processes. When used for the development of TMDLs, models can estimate the load of a specific pollutant to a water body and make predictions about how the load would change as remediation steps are implemented. Examples of models being used to develop TMDLs in Virginia include HSPF (Hydrological Simulation Program-Fortran) and GWLF (Generalized Watershed Loading Function).

Monitoring - periodic or continuous sampling and measurement to determine the physical, chemical, and biological status of a particular media like air, soil, or water.

Nonpoint source (NPS) pollution - pollution originating from diffuse sources on and above the landscape. Examples include runoff from fields, stormwater runoff from urban landscapes, roadbed erosion in forestry, and atmospheric deposition. Estimates indicate that NPS pollution accounts for more than one-half of the water pollution in the United States today. (contrast with point source pollution)

Numeric criteria - a measurable value determined for the pollutant of concern which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.

Pathogen - a disease-causing agent, especially microorganisms such as bacteria, protozoa, and viruses.

Phased approach - under the phased approach, pollutant load reduction management strategies are implemented gradually with the most cost effective best management practices being implemented first. Monitoring continues throughout the implementation process to assess water quality improvement. This approach can be used where great uncertainty exists, either in load estimation or in the effectiveness of a chosen management strategy. (See also Staged Implementation)

Point source pollution - pollutant loads discharged through a discreet conveyance. Point source discharges are generally regulated through the Virginia Pollution Discharge Elimination System (VPDES) permitting procedures. Point sources can also include pollutant loads contributed by tributaries to the main receiving stream or river. During TMDL development, permitted point sources are assigned a waste load allocation for the pollutant in question.

Pollutant - any substance of such character and in such quantities that when it reaches a body of water, it degrades the receiving water, rendering it unfit for some specified designated use. Specifically as defined in Section 502(6) of the CWA a pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water

Pollution - alteration of the physical, biological, chemical, and radiological integrity of water due to human activities any unwanted contaminating property that renders a water supply unfit for its designated use. Specifically as defined in Section 502(19) of the CWA, pollution means the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water.

Public comment period - the time allowed for the public to express its views and concerns regarding action proposed by a state or federal agency.

Reach - a section of a river or stream that generally extends from the confluence of one tributary with another, or sometimes from a tributary to an outlet, lake, or other feature.

Receiving water - creeks, streams, rivers, lakes, estuaries, groundwater formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged.

Riparian - pertaining to the banks of a river, stream, pond, lake, etc., as well as to the plant and animal communities along such bodies of water

Runoff - that part of rainfall or snowmelt that does not infiltrate but flows over the land surface, eventually making its way to a stream, river, lake or an ocean. It can carry pollutants into receiving waters.

Section 305(b) - section of the Clean Water Act that requires states to submit a biennial report in even numbered years to USEPA describing the quality of the state's waters. The 305(b) report describes the overall water quality conditions and trends in the state.

Section 303(d) - section of the Clean Water Act that requires states to periodically identify waters that do not or are not expected to meet applicable water quality standards. These waters are identified on the 303(d) Impaired Waters List. A TMDL must be developed for each water on the 303(d) list. If a listed water has multiple impairments (multiple reasons for degraded water quality), a TMDL must be developed for each impairment.

Septic system - an on-site system designed to treat and dispose of domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically.

Sewer - a channel or conduit that carries wastewater and storm water runoff from the source to a treatment plant or receiving stream. Sanitary sewers carry household, industrial, and commercial waste. Storm sewers carry runoff from rain or snow. Combined sewers handle both.

Simulation - with respect to water quality, simulation is the use of mathematical models to approximate the behavior of a natural water system in response to a specific set of known inputs or conditions. Once validated, simulation models can be used to predict the response of a natural water system to specific changes to model inputs, i.e. changes in land use.

Staged Implementation - a process that allows for the evaluation of the adequacy of the TMDL in achieving the water quality standard. As stream monitoring continues to occur, staged or phased implementation allows for water quality improvements to be recorded as they are being achieved. It also provides a measure of quality control, and it helps to ensure that the most cost effective practices are implemented first.

Stakeholder - (in this context) any person or organization with a vested interest in TMDL development and implementation in a specific watershed.

Straight pipe - delivers wastewater directly (without treatment) from a building, e.g., house, or milking parlor, to a nearby stream, pond, lake, or river.

Surface water - all water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.

Technology-based effluent limitations - effluent limitations for permitted point sources calculated from technology-based controls. Technology-based controls include best practicable control technology currently available as defined in the Clean Water Act.

Total Maximum Daily Load (TMDL) - a pollution "budget" that is used to determine the maximum amount of pollution a water body can assimilate without violating water quality standards. The TMDL includes pollution from permitted point sources (Waste Load Allocations, WLAs), and nonpoint and natural background sources (Load Allocations, LAs). In addition to the load allocations, the TMDL includes a margin of safety (MOS). The MOS accounts for any uncertainty associated with estimating the load allocations. Mathematically, a TMDL is written as follows

TMDL = LC = WLAs + LAs + MOS

A TMDL is developed for a specific pollutant and can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to the water quality standard being violated.

TMDL Implementation Plan - a document required by Virginia statute (see WQMIRA) detailing the suite of pollution control measures needed to remediate an impaired stream segment. The plans are also required to include a schedule of actions, costs, and monitoring. Once implemented, the plan should result in the previously impaired water meeting water quality standards and achieving a "fully supporting" use support status.

Transport of pollutants (in water) - involves two main processes: (1) advection, resulting from the flow of water itself, and (2) dispersion, or transport due to turbulence in the water.

Tributary - a lower order-stream compared to a receiving waterbody. A tributary will be upstream from, and flow into, the receiving waterbody, i.e. the Missouri is a tributary to the Mississippi.

Use Attainability Analysis (UAA) - a structured scientific assessment of the physical, chemical, biological, and economic factors that affect the attainment of a designated use. If a UAA shows that attaining a designated use is not feasible, the state, after considering public opinion, may choose to modify the use to make it less stringent.

Use support - the degree to which a water body will support its designated use. Use support criteria vary depending on the designated use. The degree of use support is reported in the Section 305(b) and Section 303(d) reports. The four use support categories are Fully Supporting, Fully Supporting but Threatened, Partially Supporting, Not Supporting. Waters classified as Partially Supporting or Not Supporting are deemed to be "impaired."

Validation (of a model) - process of determining how well the predictions of a mathematical model describe the actual behavior and physical process under investigation.

WQMIRA - the Water Quality Monitoring, Information, and Restoration Act of 1997. This Virginia statute directs the Virginia Department of Environmental Quality (DEQ) to produce a list of impaired waters and develop TMDLs for these waters. The statute also directs DEQ to develop Implementation Plans for the TMDLs.

Wasteload allocation (WLA) - the portion of a receiving water's loading capacity that is allocated to one of its existing or future permitted point sources of pollution. WLAs constitute a type of water quality-based effluent limitation.

Wastewater treatment - chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants. Treatment facilities are often referred to by the acronyms STP (sewage treatment plant) or POTW (publicly owned treatment works) or WWTP (waste water treatment plants).

Water quality - the biological, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.

Water quality criteria - include general narrative statements that describe good water quality and specific numeric criteria that are based on specific levels of pollutants that, if exceeded, would result in a water body not supporting a desginated use. The numerical and narrative criteria taken together describe water quality necessary to protect designated uses.

Water quality standards - a group of statements that constitute a regulation describing specific water quality requirements. Virginia's water quality standards have the following three components: designated uses, water quality criteria to protect designated uses, and an antidegredation policy.

Watershed - area that drains to, or contributes water to, a particular point, stream, river, lake or ocean. Larger watersheds are also referred to as basins. Watersheds range in size from a few acres for a small stream, to large areas of the country like the Chesapeake Bay Basin that includes parts of six states (see, drainage basin).