Smith Creek Watershed

TMDL Implementation Plan;

Rockingham and Shenandoah Counties, City of Harrisonburg, and Town of New Market, Virginia

Submitted to:

The Stakeholders of the Smith Creek Watershed

Prepared by:

Virginia Tech Department of Biological Systems Engineering, and
University of Virginia Institute for Environmental Negotiation

In Cooperation With:

Virginia Department of Environmental Quality
and
Virginia Department of Conservation and Recreation

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Project Personnel

Smith Creek Project Resource Team

Gene Yagow, Virginia Tech Biological Systems Engineering Department
Brian Benham, Virginia Tech Biological Systems Engineering Department
Tara Sieber, Virginia Department of Environmental Quality
Nesha Mizel, Virginia Department of Conservation and Recreation (VADCR)
Faye Cooper, VADCR Highlands Action Program
Frank Dukes, University of Virginia, Institute for Environmental Negotiation
Caroline Wilkinson, University of Virginia, Institute for Environmental Negotiation

Agricultural Focus Group

Growth & Development Focus Group

For additional information, please contact:

Virginia Department of Environmental Quality (VADEQ)
Valley Regional Office, Harrisonburg: Tara Sieber, (540) 574-7870
Virginia Department of Conservation and Recreation (VADCR)
Staunton Office: Nesha Mizel, (540) 332-9238

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List of Abbreviations

The following abbreviations are used throughout this document. To better aid the reader in comprehension of the document each abbreviation is defined here.

BMP – Best Management Practice
BSE – Biological Systems Engineering Department (Virginia Tech)
CWA – Clean Water Act, the origin of the Total Maximum Daily Load Program
E&S – erosion and sediment
EPA – United States Environmental Protection Agency
EPT – three classes of sensitive stream organisms, *Ephemeroptera*, *Plecoptera*, and *Tricoptera*
GWLF – Generalized Watershed Loading Functions, a nonpoint source simulation model
IP – Implementation Plan
LA – Load Allocation, the load allocated to nonpoint and background sources
LID – low impact development, a general class of urban infiltration management practices
MFBI – Modified Family Biotic Index, one of the biological metrics
MOS – Margin of Safety, a load reflecting uncertainty in the modeling process
MS4 – Municipal Separate Storm Sewer Systems, Phase II Stormwater Management Program
N - nitrogen
NPS – nonpoint source, referring to diffuse sources of pollution, such as from runoff
NRCS – Natural Resources Conservation Service
P - phosphorus
RBP – Rapid Bioassessment Protocols, the procedures used for biological monitoring and assessment
SCI – Stream Condition Index, an index under development for use in assessing stream health in Virginia
SSO – sanitary sewer overflow
SWCB – State Water Control Board
SWCD –Soil and Water Conservation District
SWM – storm water management
TAA – Technical Assistance and Administration
TBD – to be determined
TMDL – Total Maximum Daily Load (Study)
TOB – Town of Blacksburg
VAC – Virginia Administrative Code
VCE – Virginia Cooperative Extension
VADCR – Virginia Department of Conservation and Recreation
VADEQ – Virginia Department of Environmental Quality
VDOF – Virginia Department of Forestry
VDOT – Virginia Department of Transportation
VPDES – Virginia Pollutant Detection and Elimination System

VT – Virginia Tech
WLA – Waste Load Allocation, the load allocated to point sources
WQIF – Water Quality Improvement Fund
WQMIRA – Water Quality Monitoring, Information and Restoration Act

EXECUTIVE SUMMARY

Introduction

Background : Total Maximum Daily Loads (TMDLs)

The Clean Water Act (CWA) that became law in 1972 requires that all U.S. streams, rivers, and lakes meet their state's water quality standards. The CWA also requires that states conduct monitoring to identify polluted waters or those that do not meet standards. Through this required program, the state of Virginia has found that many streams do not meet state water quality standards for protection of the five beneficial uses: fishing, swimming, shellfish, aquatic life, and drinking. When streams fail to meet standards they are placed on the state's impaired waters list, and the state must then develop a Total Maximum Daily Load (TMDL) for each pollutant. A TMDL is a "pollution budget" for a stream. That is, it sets limits on the amount of pollution that a stream can tolerate and still maintain water quality standards. In order to develop a TMDL, background concentrations, point source loadings, and non-point source loadings are considered. Non-point source pollution occurs when pollutants are transported across the land to a body of water when it rains. Point source pollution occurs when pollutants are directly discharged into a stream. Through the TMDL process, states establish water-quality based controls to reduce pollution and meet water quality standards.

Water Quality Problems in Smith Creek

A TMDL was developed for Smith Creek in June 2004 when water quality monitoring showed:

1) Smith Creek was violating the State's water quality standard for bacteria, which is based on the concentration of *E. coli* in the water (the *E.coli* bacteria count should not exceed a geometric mean of 126 cfu per 100 mL of water for two or more samples taken over a 30-day period, and it should not exceed 235 cfu per 100 mL at any time).

2) Smith Creek was also violating the general standard for aquatic life use. This standard states that all state waters should support "the propagation and growth of a balanced indigenous population of aquatic life..." Based on biological monitoring conducted by the Virginia Department of Environmental Quality, it was concluded that Smith Creek was not meeting this designation. The primary stressor on the aquatic community was identified as sediment.

The Smith Creek TMDL specified the maximum bacteria and sediment loads that the stream can handle and still meet the water quality standard for bacteria while also supporting a healthy and diverse aquatic population.

Smith Creek TMDL Implementation Plan

Once a TMDL is developed, measures must be taken to reduce pollutant levels in the stream. A TMDL Implementation Plan (IP) describes control measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), to be implemented in order to meet the water quality goals established by the TMDL. There are nine different components included in the Smith Creek IP:

1. Identification of the causes and sources of bacteria and sediment that will need to be controlled to meet the water quality standards.
2. Reductions in bacteria and sediment needed to achieve water quality standards.
3. Management measures (BMPs) that will need to be implemented to achieve the pollutant reductions.
4. The technical and financial assistance needs, associated costs, and/or the sources and authorities that will be relied upon to implement the watershed-based plan.
5. 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.
6. A schedule for implementing the management measures identified in the plan
7. Goals and milestones for implementing management measures or other control actions.
8. A set of criteria for determining if bacteria and sediment reductions are being achieved and if progress is being made towards attaining water quality standards.

9. A monitoring program to evaluate the effectiveness of the implementation effort.

The Smith Creek IP was developed with the goal of achieving the reductions stated in the TMDL report and restoring these waters to a fully supporting status.

Review of TMDL Development

The Smith Creek TMDL was prepared by George Mason University and Tetra Tech, Inc. and submitted to the Virginia Department of Environmental Quality in April 2004 and approved by EPA in June 2004.

Characteristics of the Smith Creek Watershed

The Smith Creek watershed is located in the Shenandoah River Basin in Shenandoah and Rockingham counties, with a small portion of the headwaters located in the City of Harrisonburg, Virginia (Figure ES- 1). The watershed is approximately 67,900 acres in size and land use is predominantly forest and agricultural. Approximately 50% of the watershed is forested and 47% is agricultural. Residential and commercial development account for less than 4% of the watershed. Smith Creek flows north from its headwaters to its confluence with the North Fork Shenandoah River. Digital layers of categorized land use, soils, elevation, watershed boundaries, and streams were used together with related attribute data to represent the watershed in the models used to simulate in-stream pollutant loads and/or concentrations.

Sources of Bacteria in Smith Creek

Point and nonpoint sources of bacteria in the Smith Creek watershed were considered in development of the TMDL study. All sources of bacteria in the watershed were identified and quantified and then used as inputs to the Loading Simulation Program C++ (LSPC) model to simulate fecal coliform concentrations, which were subsequently translated to *Escherichia coli* (*E. coli*) concentrations using VADEQ guidelines (2003). The hydrology in the model was calibrated using observed hourly streamflow for the period 1980 through 2002 from USGS gage 01632900 on Smith Creek, while in-stream fecal coliform concentrations were calibrated to available

periodic observed data. Agricultural runoff and wildlife have been identified as the primary sources of bacteria. Nonpoint sources of bacteria include failing septic systems and straight pipes, livestock (including manure application loads), wildlife, and domestic pets. Point sources, such as municipal sewage treatment plants, can contribute bacteria loads to surface waters through effluent discharges. At the time of the TMDL study, there were 38 point source permits in the Smith Creek watershed, including a Municipal Separate Storm Sewer System (MS4) permit that was issued to the City of Harrisonburg to help control impacts caused by stormwater runoff from urban areas. Modeling for existing conditions in Smith Creek was driven by rainfall inputs for the representative period, January 1, 1990 through December 31, 2002.

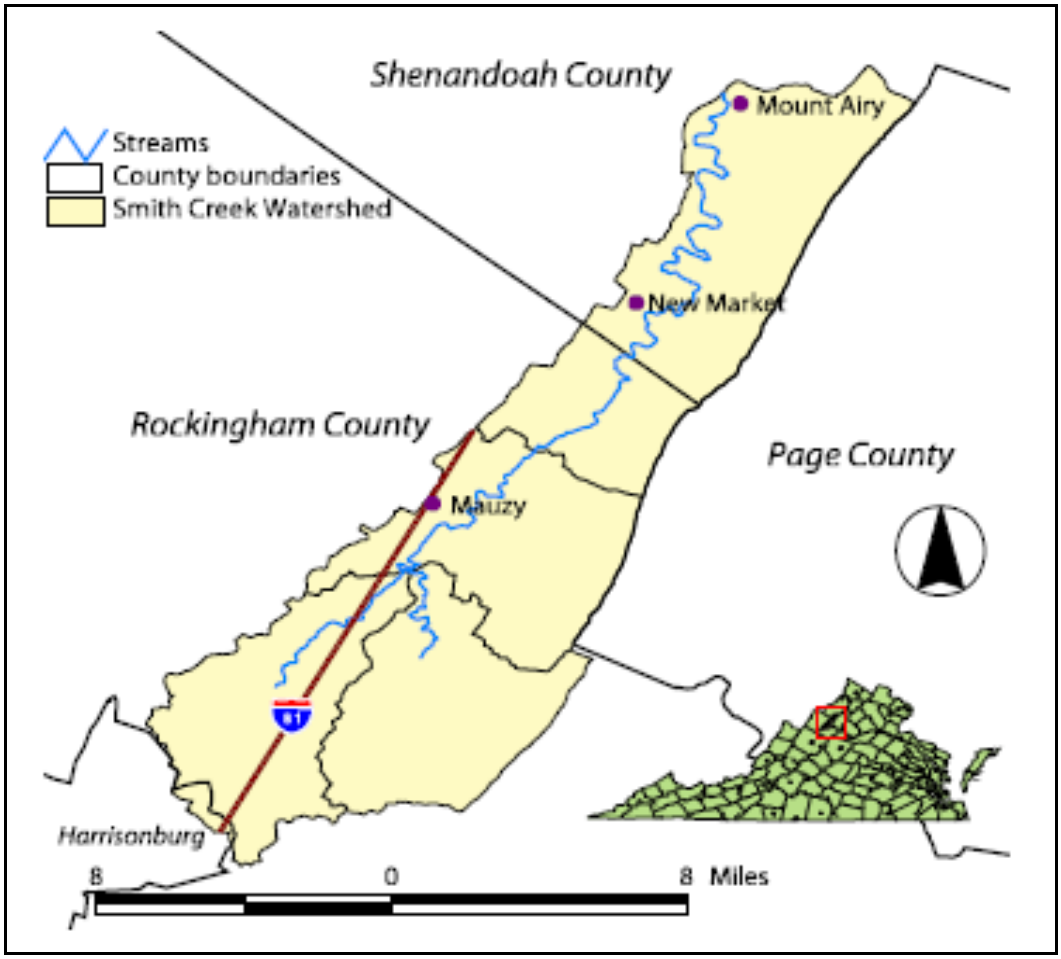

Figure ES- 1. Smith Creek Watershed

Sources of Sediment in Smith Creek

A stressor analysis of available data was performed and sediment was identified as the primary stressor causing the aquatic life use impairment in Smith Creek. Sediment sources can be divided into point and nonpoint sources. Sediment loads are primarily contributed by nonpoint sources in the Smith Creek watershed. The major sources of sediment are agricultural land and urban land. Agricultural lands, such as cropland and pasture/hay areas, can contribute excessive sediment loads through erosion, while urban areas contribute sediment from construction sites and from build-up/washoff of dry deposition on impervious areas. Agricultural and transitional lands are particularly susceptible to erosion due to less vegetative coverage. At the time of the TMDL study, the 38 point source permits in the Smith Creek watershed, including a Municipal Separate Storm Sewer System (MS4) permit to help control impacts caused by stormwater runoff from urban areas are all potential dischargers of sediment to Smith Creek and its tributaries.

A reference watershed approach was used to establish the sediment TMDL for Smith Creek. Sediment reductions required for the Smith Creek watershed were based on the reference sediment load that was calculated through modeling of the Hays Creek watershed, and modeling was performed with a modified version of the BasinSim version of the Generalized Watershed Loading Functions (GWLF) model. Daily streamflow data were used to calibrate watershed hydrologic parameters in the model. The USGS streamflow gage (01632900), located on Smith Creek near New Market, VA, was used to calibrate hydrology for the impaired watershed (Smith Creek); USGS gage station 02022500, located on Kerrs Creek near Lexington, VA, was used to calibrate hydrology for the reference watershed (Hays Creek). The calibration periods were April 1, 1991 - September 30, 2002 for the impaired watershed and April 1, 1991 through March 31, 1997 for the reference watershed.

For the TMDL calculation, GWLF models of the calibrated impaired and reference watersheds were run for a 12-year period from 4/1/1990 to 3/31/2002. The total area for the reference watershed was reduced to be equal to Smith Creek watershed. This was necessary because watershed size influences sediment delivery to the stream and other

model variables. The 11-year means for sediment were determined for each land use/source category in the reference and the impaired watersheds, respectively.

The Bacteria TMDL, Existing and Allocated Loads

The TMDL consists of a point source waste load allocation (WLA), a nonpoint source load allocation (LA), and an implicit margin of safety (MOS), as shown in Table ES-1. The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis.

Table ES-1. *E. coli* TMDL for Smith Creek (cfu/yr)

WLA	LA	MOS	TMDL
8.53E+11	1.24E+13	Implicit	1.33E+13

The TMDL loads were calculated by first simulating bacteria concentrations for existing conditions, and then iteratively reducing input bacteria loads from the various source categories until both the geometric mean and instantaneous *E. coli* concentration criteria (126 and 400 cfu/100 mL, respectively) were never exceeded. Loads corresponding to the initial existing and TMDL (Allocated) conditions were then calculated for each of the component source categories, as shown in Table ES-2. Reductions in load contributions from in-stream sources had the greatest impact on *E. coli* concentrations. Significant reductions from land-based loadings were also required to meet the geometric mean standard.

Interim Staged Goal for Reducing Bacteria

Since nonpoint source dominated TMDLs often require extreme load reductions and since the requirements for listing a stream as “impaired” allow a 10% violation rate of a water quality criterion, while de-listing requires 0% violations, a staged approach was used to provide an interim goal (Stage I) that is consistent with the less restrictive listing criterion. The percent reductions and the corresponding loads for all source

categories contributing to the Load Allocation are also shown in Table ES-2. No Stage I reductions were specified for sources contributing to the Waste Load Allocation.

Table ES-2. Existing and TMDL (Allocation) Loads of *E. coli* for Smith Creek

Sources		Existing Loads (cfu/yr)	TMDL (Allocated) Loads (cfu/yr)	Percent Reduction	Stage I Loads (cfu/yr)	Percent Reduction
Direct	Straight Pipes	< 1.00E+ 04	< 1.00E+ 04	100%	< 1.00E+ 04	100%
	Livestock	1.68E+ 13	8.38E+ 11	95%	6.72E+ 12	60%
	Wildlife	2.64E+ 12	2.64E+ 12	0%	2.64E+ 12	0%
Indirect	Cropland*	3.45E+ 13	2.76E+ 12	92%	1.73E+ 13	50%
	Pasture**	5.93E+ 13	4.74E+ 12	92%	2.97E+ 13	50%
	BuiltUp***	1.15E+ 13	5.77E+ 11	95%	4.60E+ 12	60%
	Forest****	8.65E+ 11	8.65E+ 11	0%	8.65E+ 11	0%
Load Allocation (LA) sub-total		**1.26E+ 14**	**1.24E+ 13**	**90%**	**6.17E+ 13**	**51%**
Permitted	Permits*****	7.09E+ 11	7.09E+ 11	0%		
	MS4 - VAR040075	2.88E+ 12	1.44E+ 11	95%		
Waste Load Allocation (WLA) sub-total		**3.59E+ 12**	**8.53E+ 11**	**76%**		

* Includes Barren
** Includes Hayland
*** Non-MS4 Urban Pervious and Impervious
**** Includes Wetland
***** Total for all permits, excluding the Harrisonburg MS4 permit.

The Sediment TMDL, Existing and Allocated Loads

Since sediment was identified as the primary pollutant stressing the benthic community in Smith Creek which led to the aquatic life use impairment, sediment reduction goals were developed for the Smith Creek TMDL. The sediment TMDL was based on the total load calculated for the Hays Creek watershed (area-adjusted to the impaired watershed).

The TMDL is comprised of a Load Allocation (LA) portion representing nonpoint sources, a Waste Load Allocation (WLA) portion equal to the total load from permitted sources, and a margin of safety (MOS) that accounts for uncertainty in the data and the computational methodology used for the analysis. The TMDL (annual load) was calculated by adding reference watershed sediment loads together with point source sediment loads and adding in a 10% margin of safety, as shown in Table ES-3.

Table ES-3. Sediment TMDL for the Smith Creek watershed

TMDL (lbs/yr)	WLA (lbs/yr) (including MS4)	LA (lbs/yr)	MOS (lbs/yr)
27,062,901	353,867	24,002,222	2,706,812

Sediment loads were allocated to each source category in the Smith Creek watershed, as shown in Table ES-4. This recommended scenario for Smith Creek is based on equal percent load reductions from each source category, with the following exceptions. No reductions were required from forest, point sources, and water categories. Sediment loads from forest lands represent the natural condition that would be expected to exist, and therefore, were not reduced. Also, sediment loads from point sources were not reduced because these facilities are currently permitted, meeting their pollutant discharge limits, and expected to result in attainment of the WLAs as required by the TMDL. Note that the sediment WLA value presented in Table ES-4 represents the sum of all permitted sources (point sources and MS4). The estimated sediment loads contributed to the watershed by all permitted facilities are shown in Table ES-5.

Table ES-4. Recommended sediment allocations for Smith Creek

Source Category	Sediment Load Allocation (lbs/yr)	Sediment % Reduction
Forest	299,718	0.0%
Water	0	0.0%
Pasture/Hay	19,040,555	22.0%
Cropland	4,221,267	22.0%
Transitional	363,059	22.0%
Urban (pervious & impervious)	77,623	22.0%
Groundwater	0	0.0%
Point Sources	334,069	0.0%
MS4	19,798	22.0%
TMDL Load (minus MOS)	24,356,089	21.6%

Table ES-5. Sediment waste load allocation for the Smith Creek watershed

VPDES Permit No.	Facility Name	Discharge Type	Design Flow (MGD)	Permitted Concentration (mg/L) or Load (kg/day)	TSS load (lbs/yr)
VA0027626	Valley View Mobile Home Court	General	0.02	45	2,735.9
VA0054453	New Market Poultry Products	General	0.3	147	134,382.8
VA0071846	Endless Caverns Inc	General	0.0046	117	1,641.6
VA0080535	Two Hills Inc STP	General	0.0054	45	740.3
VA0077399	Lacey Spring Elementary School STP	General	0.0075	45	1,030.0
VA0090794	Holtzman Express-Mauzy	General	0.006	45	820.8
VA0091235	Shenandoah Fisheries, Ltd	General	N/A	0.46 kg/day average (final permit limit)	370.2
VA0088994	Harrisonburg-New Market KOA	General	0.01	45	1,368.0
VA0083305	Camp Overlook	General	0.03	45	4,112.0
VAG408049	Private Residence	Stormwater	N/A	30	91.4
VAG401001	Private Residence	Stormwater	N/A	30	91.4
VAG401128	Private Residence	Stormwater	N/A	30	91.4
VAG401201	Private Residence	Stormwater	N/A	30	91.4
VAG401179	Private Residence	Stormwater	N/A	30	91.4
VAG401363	Private Residence	Stormwater	N/A	30	91.4
VAG401492	Private Residence	Stormwater	N/A	30	91.4
VAG401537	Private Residence	Stormwater	N/A	30	91.4
VAG401551	Private Residence	Stormwater	N/A	30	91.4
VAG401405	Private Residence	Stormwater	N/A	30	91.4
VAG401890	Private Residence	Stormwater	N/A	30	91.4
VAG401956	Private Residence	Stormwater	N/A	30	91.4
VAG401966	Private Residence	Stormwater	N/A	30	91.4
VAG401961	Private Residence	Stormwater	N/A	30	91.4
VAG401805	Private Residence	Stormwater	N/A	30	91.4
VAG401920	Private Residence	Stormwater	N/A	30	91.4
VAG401432	Private Residence	Stormwater	N/A	30	91.4
VAG401988	Private Residence	Stormwater	N/A	30	91.4
VAG401998	Private Residence	Stormwater	N/A	30	91.4
VAG408026	Private Residence	Stormwater	N/A	30	91.4
VAG408028	Private Residence	Stormwater	N/A	30	91.4
VAG408029	Private Residence	Stormwater	N/A	30	91.4
VAG408030	Private Residence	Stormwater	N/A	30	91.4
VAG408035	Private Residence	Stormwater	N/A	30	91.4
VAG110131	Superior Concrete Central Plant	Stormwater	N/A	30	91.4
VAR100591	Rockingham Redi-Mix Inc	Stormwater	N/A	100	98,000.1
VAR102386	Holtzman Express-Mauzy	Stormwater	N/A	100	69,253.4
VAR051331	Harper's Lawn Ornaments	Stormwater	N/A	100	17,329.7
VAR040075	City of Harrisonburg MS4	Stormwater	N/A	N/A	19,797.6
				Total Load	**353,867.0**

Changes and Progress since the TMDL Study

BMP Implementation

Within the Smith Creek watershed, a number of best management practices (BMPs), supported by private and public funding, have been installed since completion of the TMDL study, resulting in new installations of riparian buffers and various other conservation practices, along with the establishment of several conservation easements. These BMP sites are distributed along Smith Creek from its headwaters at

Fridley's Gap to its confluence with the North Fork of the Shenandoah River near Mt. Jackson, providing a geographical opportunity for extensive education and the possibility of literally "connecting the dots" with new projects. These restored and protected sites include:

- 65 acres of newly planted forest buffer on two properties restoring four miles of creek frontage near the headwaters at Fridley's Gap, resulting in restored native brook trout. This innovative work was undertaken under the auspices of the Eastern Brook Trout Joint Venture, U.S. Forest Service, DGIF, and James Madison University students and faculty.
- 334 contiguous acres adjoining Smith Creek just downstream from the brook trout projects listed above are permanently conserved through three conservation easements held by the VOF with support from VCC. Each of the three properties is either enrolled in the Conservation Reserve Enhancement Program (CREP) or has riparian forest buffer protection within the easement.
- Four farm owners have enrolled approximately 150 acres in CREP restoring the buffer and stream banks for approximately 2.5 miles. These sites have been used for the last few years by middle school and high school groups for watershed field studies and restoration projects.
- More than 80 farms, distributed throughout the watershed, are participating in various cost share programs offered by USDA/NRCS.
- 53 acres located on downstream segments in Shenandoah County have received support from several Federal and state cost share programs and from Ducks Unlimited to restore stream banks and wetlands and to create wildlife habitat. This landowner continues to welcome studies and tours for educational purposes.

New Monitoring Sites

Four additional new monitoring sites have been sampled in the watershed since completion of the TMDL study. Two probabilistic biological stations were sampled on Smith Creek since the TMDL study, one in 2008 near the outlet at SMT001.53 and the other in 2007 near the Shenandoah / Rockingham county line – SMT009.08; a new water quality station near the watershed outlet – SMT001.42; and an interim water quality monitoring station in 2005-2006 on War Branch – WAR003.38.

TMDL Modifications

The Cedar Lane Trailer Court (VA0092363), located in the Smith Creek watershed, recently submitted an application to DEQ for a VPDES discharge permit. This facility is currently served by on site septic systems that are failing. The failing

septic systems will be replaced with a small wastewater treatment facility designed to treat 0.004 mgd. Since this is a new discharge permit, the Smith Creek bacteria and sediment TMDLs do not currently include a WLA for this facility. The TMDLs also have no built-in allocations for growth. DEQ proposes to accommodate this increase, without increasing the overall WLA or the TMDL, by reallocating the WLA assigned to another facility that is no longer discharging. The Valley View Mobile Home Court (VA0027626), which was discharging in the Smith Creek watershed at the time of TMDL development, is no longer discharging. This facility has connected to a regional sewer system that discharges outside of the Smith Creek basin. The facility has successfully completed an approved closure plan, and the permit has been terminated, making the assigned waste load allocations of 3.48×10^{10} cfu/100ml bacteria and 2,735.9 lbs/yr TSS available for reallocation. These available allocations are more than enough to accommodate the new Cedar Lane Trailer Court discharge. Additionally, since the TMDL, 16 new domestic sewage permits have been approved, 4 domestic sewage permits have been terminated, and 4 additional NPDES permits have been approved.

Every facility that proposes to discharge into an impaired stream goes through a Permit Review to ensure it is in compliance with all applicable water quality management plans. All new permits are evaluated to be sure that the discharge of this point source is not more than 1% of the TMDL, and is therefore an insignificant load. The new discharges are also totaled to ensure the combined load of all discharges does not approach the 1% threshold. Updating the WLA tables in the Smith Creek bacteria and sediment TMDLs in accordance with these changes will not cause a water quality violation because the overall WLA and TMDL are not being modified. This revision merely reallocates the existing WLA among dischargers and establishes an allocation for future growth.

Revisions to Categorized Watershed Land Use Areas

An error in the watershed boundary was noticed during the implementation planning process that arose most likely from the use of digital elevation model (DEM) elevation data to define the drainage area during the TMDL study. Since this boundary was not consistent with the state 6-digit watershed boundaries, but only affected sub-watershed 15 and the Harrisonburg MS4 areas in Smith Creek watershed, the TMDL

watershed boundary was adjusted to the 6-digit watershed boundary in that sub-watershed. Sub-watershed 15, total watershed, and MS4 acreages were revised accordingly, as shown in Figure ES- 2.

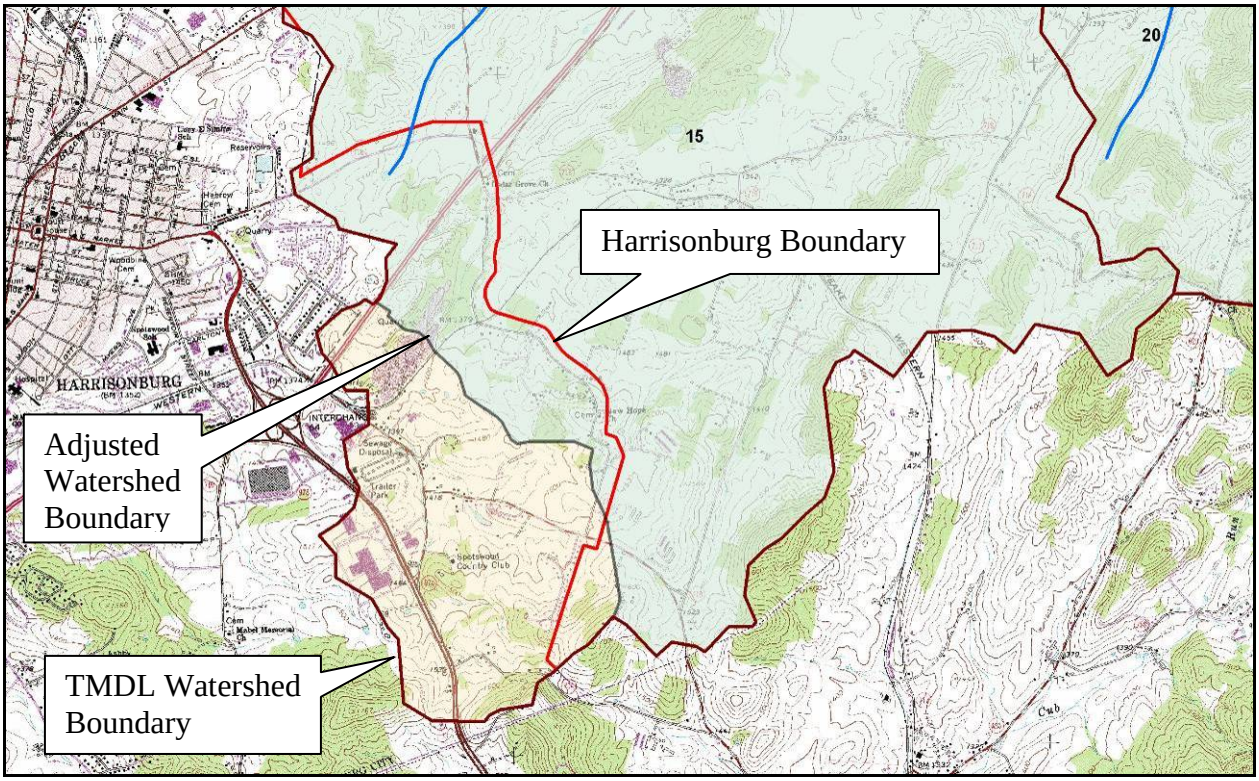

Figure ES- 2. Adjustment to the Smith Creek TMDL Watershed Boundary

Also during analysis of land use data from the TMDL study, a small amount (24.83 acres) of land classified as transitional in the Gap Creek area (sub-watershed 3) was re-assessed as mixed forest areas with rock-outcrops. An additional correction was made to reassign this area to the forest land use category. A summary of the land use changes from both the re-classification and the boundary change are given in Table ES-6, as used for bacteria modeling.

Table ES-6. Summary of Corrections to the TMDL Categorized Land Uses

Land Use Category	TMDL Area (acres)	Revised Area (acres)
Barren	172.87	90.49
Cropland	2,585.62	2,551.65
Forest	33,193.96	33,075.82
Pasture	29,444.97	29,190.89
Urban Non-MS4	1,914.34	1,914.34
Urban (MS4)	477.09	101.61
Wetlands	36.25	36.25
Water	88.01	84.94
Total	**67,913.10**	**67,045.98**

Along with the boundary change, the length of roads available for street sweeping within the City of Harrisonburg in the Smith Creek watershed was reduced from 17.82 miles to 5.71 miles, and the perennial stream length in the Harrisonburg portion of Smith Creek watershed was reduced from 1.517 miles to 0.206 miles.

Adjustments to TMDL Target Loads

The implementation plan preserves the bacteria percent reductions by land use category called for in the TMDL study. However, since adjustments were necessary in the contributing areas of the various land uses, the unit-area loads (UALs) associated with the allocated loads and their associated percent reductions were applied to the revised categorized land use areas to define revised target loads for the implementation plan. A summary of the original and revised loads for bacteria are shown in Table ES-7.

Table ES-7. Summary of Original and Revised Bacteria Loads for Implementation Planning

Sources	Existing Load		Allocated Load		% Reductions in Allocated Loads
	Original	Revised	Original	Revised	
Direct NPS Sources					
Straight Pipes	<1.00E+14	NC	0	NC	0.00%
Livestock	1.68E+13	NC	8.38E+11	NC	0.00%
Wildlife	2.64E+12	NC	2.64E+12	NC	0.00%
Indirect NPS Sources					
Cropland**	3.45E+13	3.44E+13	2.76E+12	2.75E+12	0.35%
Pasture	5.93E+13	5.91E+13	4.74E+12	4.72E+12	0.32%
Urban Non-MS4	1.15E+13	NC	5.77E+11	NC	0.00%
Urban MS4	2.88E+12	2.51E+12	1.44E+11	1.25E+11	12.85%
Forest	8.65E+11	8.64E+11	8.65E+11	8.64E+11	0.14%

NC = no change.
** Cropland includes minor bacteria loads from transitional areas.

The implementation plan also preserves the sediment percent reductions by land use category called for in the TMDL study. Since the total watershed area used for the original sediment modeling was slightly different from that used for bacteria modeling, the areas of the original modeled sediment land use categories were used as a starting point and the decreased acreage from the boundary adjustment subtracted from the original areas. As with the bacteria load adjustments, the unit-area loads (UALs) associated with the allocated sediment loads and associated percent reductions were applied to the revised categorized land use areas to define the revised target loads for the implementation plan. In the original TMDL study, the MS4 load was calculated as the total load from urban lands times the percentage of urban lands within the City of Harrisonburg (20%). Since the boundary change reduced the included area of the City, the percentage of the load attributable to the MS4 area was recalculated as 7.2%. A summary of the categorized areas, sediment loads, and target sediment loads used for implementation planning are shown in Table ES-8.

Table ES-8. Summary of Categorized Areas, Sediment Loads, and IP Target Loads based on the Original and Revised Watershed Boundaries

NPS Sediment Load Categories	Sediment					
	Area (acres)		Load (tons/yr)		IP Target Load (tons/yr)	
	Original	Revised	Original	Revised	Original	Revised
Forest	33,598.43	33,480.32	149.86	149.33	149.9	149.3
Water	100.82	97.67	0.00	0.00	0.0	0.0
Pasture	28,985.32	28,731.34	12,205.55	12,098.56	9,520.3	9,436.9
Cropland	2,656.08	2,622.03	2,705.87	2,671.26	2,110.6	2,083.6
Transitional	158.64	76.18	232.62	111.76	181.4	87.2
Urban Non-MS4	1,999.73	1,972.41	51.53	12.93	40.2	10.1
MS4	499.93	153.03	12.88	3.23	10.0	2.5
MS4 as %Urban	20.0%	7.2%				
NPS Totals	**67,999.0**	**67,133.0**	**15,358.3**	**15,047.1**	**12,012.5**	**11,769.6**

Revisions to Pet Waste Contribution

The TMDL originally estimated the pet population in the MS4 area as 20% of the total watershed pet population. The total pet population was 2,687 and the initial MS4 pet population was 537. Since the MS4 area decreased by 62.5% of its original area with the boundary correction, the pet population in both the MS4 and the watershed

areas were reduced by 537 times 0.625 (336), giving new pet populations in the MS4 area of 201, and in the total watershed of 2,351. The pet population in the Non-MS4 Urban area was not changed.

Load Reductions due to Control Measures Implemented since TMDL

Because many BMPs have already been installed in Smith Creek since the completion of the TMDL study, as summarized in section 4.1, the associated load reductions have given the watershed a head start toward meeting the load reduction target goals for both bacteria and sediment. An estimate of the associated bacteria load reductions due to these implemented control measures for agricultural source categories are given in Figure ES- 3.

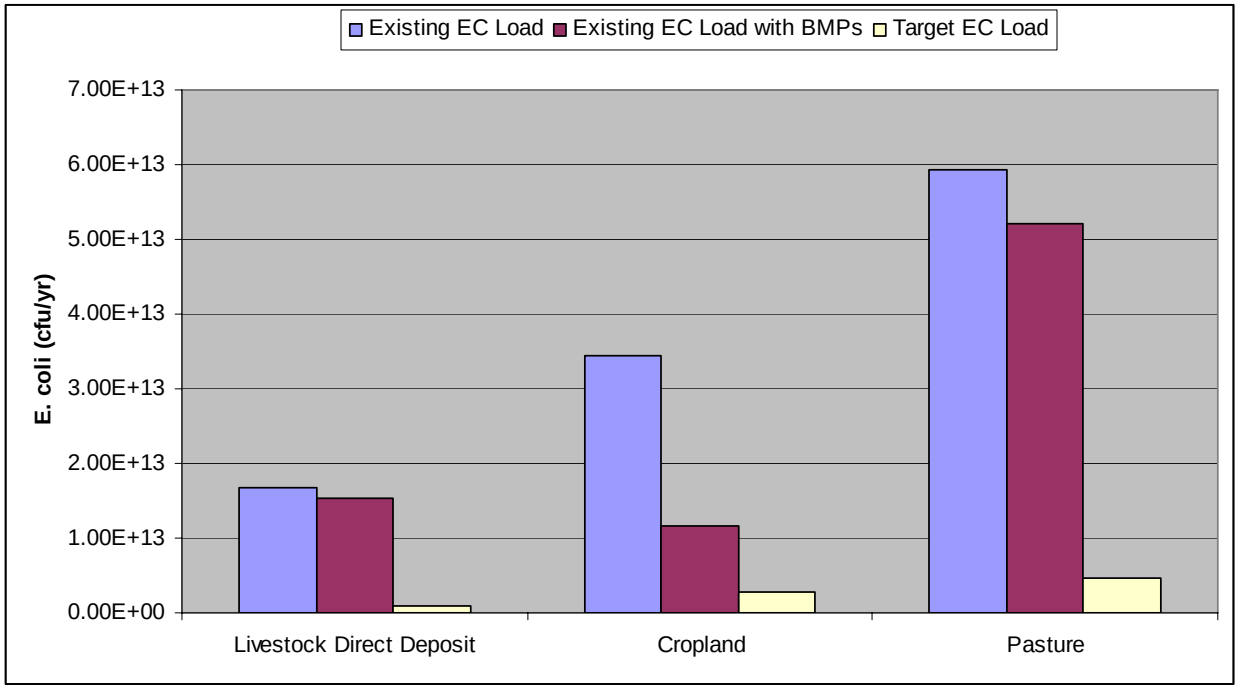

Figure ES- 3. Progress in Bacteria Load Reductions in Smith Creek Watershed

Public Participation

An essential step in developing and carrying out a TMDL IP is gathering input from a broad range of individuals, agencies, organizations and businesses with interest in and familiarity with local water quality needs and conditions. Watershed stakeholders are best suited to identify and resolve sources of water quality problems within their own communities. Public participation facilitates dialogue between local stakeholders and government agencies, encourages the commitment of resources for TMDL implementation, such as funding and technical support, and facilitates implementation of feasible solutions to water quality problems.

The Resource Team for this project included members of Virginia Tech's Biological Systems Engineering (BSE) Department, University of Virginia's Institute for Environmental Negotiation, the Healthy Waters Initiative, VADEQ, and the Virginia Department of Conservation and Recreation (VADCR).

Public participation in the development of the IP was achieved through a series of Focus Groups under the facilitation of the Resource Team.

An informational meeting was held on May 27, 2008 at the Town Hall in New Market, Virginia to discuss the development of a watershed plan (the Smith Creek TMDL Implementation Plan) to reduce identified pollutants in the Smith Creek watershed. The focus of this meeting was a review of details from the TMDL study, information about current activities in the watershed, information on the implementation planning process, and an invitation to the public to be involved in the IP development by participating in Focus Group discussions.

An informational booth describing the Smith Creek Watershed Partnership was set up and manned during the Tenth Legion Ruritan Lawn Parties on June 13-14 and July 25-26 by members of the Resource Team. Information was provided about clean-up efforts in the Smith Creek watershed and invitations were given to participate in the implementation planning process.

The first public meeting for developing the TMDL Implementation Plan for Smith Creek was held in August 2008, at the New Market Town Hall, during which Focus Groups were developed to represent the major interests in the watershed, and named

the Agricultural Focus Group and the Growth & Development Focus Group. Each Focus Group was given the following tasks related to identified problems in Smith Creek relevant to their focus area:

1. Discuss the extent and probable locations of problems.
2. Discuss best management practices (BMPs) or other ways to reduce pollutant loads from the various sources.
3. Review watershed information related to simulating planned pollutant reductions.
4. Discuss constraints faced by stakeholders in implementing BMPs.
5. Discuss strategies to educate and involve stakeholders in implementing the needed changes.

A second and third set of Focus Group meetings were held in September and November to review alternative control measures and strategies to meet the source-specific bacteria and sediment reductions called for in the TMDL. The discussions and feedback resulted in changes in the proposed list of BMPs and in the relative extents of each that were expected to be achievable in the watershed, and to finalize the list of control measures and extents included in the IP.

The final public meeting for the Smith Creek TMDL Implementation Plan was held at 6:00 pm on February 22, 2009 at the Tenth Legion Ruritan Hall, in Tenth Legion, Virginia. Over 70 people attended the Celebration Event, which was advertised by letters and phone calls to landowners, watershed signs at stream crossings and email newsletters. A BBQ dinner was provided for all participants by the Highlands Action Program, a project partner. After dinner, the TMDL and IP were summarized, and a guest speaker was introduced. Corey Guilliams, District Conservationist for NRCS in Rockingham County, spoke about the relationship between herd health and water quality. After his short program, attendees were able to visit over 14 exhibits set up by project partners about how their organizations are improving water quality in Smith Creek.

A Steering Committee is in the process of being formed through invitation from the Resource Team. The Committee is envisioned as a combination of governmental agency personnel, representatives from each of the Focus Groups, the Support Team, and stakeholders with existing responsibilities related to the various pollutant source

reduction categories. A joint meeting of the Steering Committee and the Resource Team is planned to be held after the Final Public Meeting.

Implementation Actions

The Smith Creek TMDL identified bacteria and sediment as the pollutants responsible for the impairment in Smith Creek. Table ES-9 summarizes the pollutant sources and reductions called for in the TMDL for both bacteria and sediment. Since many of the control measures or best management practices (BMPs) installed for bacteria reductions also reduce sediment and since the needed bacteria reductions are much greater than those needed for sediment, a separate set of Stage I sediment reduction targets were not specified in the TMDL.

Table ES-9. Summary of Smith Creek TMDL Reductions

Sources	Bacteria		Sediment
	TMDL	Stage I	
Direct Stream Sources			
Livestock - direct deposit	95%	60%	NA
Straight pipes and failing septic systems	100%	100%	NA
Indirect Land Sources			
Cropland	92%	50%	22%
Pasture	92%	50%	22%
BuiltUp Areas			
Non-MS4 Urban	95%	60%	22%
Transitional			22%
MS4 Urban	95%	60%	22%

Load reductions were based on source loads simulated for the TMDL study, changes in land use, filtering effects of applicable control measures, and the application of effectiveness estimates. Implementation plan load reductions for bacteria and sediment required for each of the source categories identified in the TMDL are given below together with control measures and extents quantified to address each source.

Livestock Direct Deposit

Eliminating unrestricted livestock access to streams (100% livestock exclusion) is assumed to provide 100% reduction in livestock direct deposits. “Livestock exclusion fencing” is defined as fencing that meets DCR cost-share requirements with a minimum

35 ft. buffer, while "adaptive fencing" is defined as poly-wire fencing with a narrower buffer width, estimated as 10 ft. for planning purposes. The option of "adaptive fencing" was included to accommodate the flexibility desired by some farmers in the type of fencing and the amount of buffer width they are willing to exclude from their pasture areas. Table ES-10 summarizes the control measures and extents estimated to achieve the 95% reduction in bacteria loads from livestock direct deposits, specified in the TMDL. Based on the distribution of stream locations, 68.1% of the required control measures are needed in Rockingham County and 31.9% in Shenandoah County.

Table ES-10. Livestock Exclusion Control Measures, Extents, and Reductions

Livestock Exclusion Measures	Units	Extent installed since TMDL	Add'l. Extent Required	In-stream Bacteria Load Reduction (cfu/yr)	% Reduction
Livestock exclusion fencing[a]	lin.ft.	52,458	671,748	1.19E+ 13	71.3%
Adaptive fencing[a]	lin.ft.		241,402	3.98E+ 12	23.8%
Hardened crossings[c]	no.		36		
Alternative water systems[c]	no.		150		
			IP EC Reductions =	1.59E+ 13	95.0%
			TMDL EC Reduction Goals =	**1.59E+ 13**	**95%**
			IP EC Load =	8.38E+ 11	

[a] Fencing unit cost includes charger and an allowance for cross-fencing.
[c] Components of livestock exclusion fencing systems.

Conversations with DCR and local SWCD personnel were used to determine characteristics of typical livestock exclusion systems in order to quantify the number of expected cost-shared BMPs. The typical cost-shared BMPs for livestock exclusion are the SL-6 and WP-2T systems of practices. The SL-6 practice (Grazing Land Protection Systems) includes streamside fencing, cross fencing, alternative watering system(s), and a 35-ft buffer from the stream. According to the VADCR Agricultural BMP Database, ten of these systems have been installed with an average streamside fencing length of 710 feet and an average cost of $20,300. However discussions with local SWCD personnel reported that the cost of just installing an alternative watering system in the area would run $20,000 and average system streamside fencing lengths are typically longer. Based on these discussions, an SL-6 system was defined as fencing along both sides of 2,000 feet of stream, an additional 50% of length allowed for cross-fencing, an alternative watering system, and a 35-ft stream buffer, at an average system cost of

$36,456. Since some operations requiring fencing already have alternative watering systems in place, the WP-2T practice (Stream Protection Systems) will be more appropriate. The WP-2T system in Smith Creek was defined as fencing along both sides of 1,200 feet of stream, a hardened stream crossing, and a 35-ft stream buffer, at an average system cost of $11,864. Each WP-2T system was defined for a shorter length of stream, as crossings were more likely to be needed along perennial streams, whereas SL-6 installations were considered to include a combination of perennial and intermittent streams.

During the Agricultural Focus Group discussions, it was concluded that some farmers would be unwilling to install fencing with a 35-ft setback. The pilot fencing program that is currently being implemented by the Shenandoah RC&D was used as a model to demonstrate how we might be able to work with other landowners in the watershed to exclude livestock from streams with adaptive fencing, a practice that is not currently eligible for cost-sharing through DCR. Approximately 10% of the extent of required stream fencing was estimated as being installed through the WP-2T practice, 25% as adaptive fencing, and the remaining amount through the SL-6 practice. In the Smith Creek watershed, this amounts to 150 SL-6 systems, 36 WP-2T systems, and 45.7 miles of adaptive fencing. This IP focuses on fencing along both perennial and intermittent streams because the TMDL requires stringent reductions of fecal bacteria from direct livestock and agricultural nonpoint sources.

Straight Pipes and Failing Septic Systems

The percentages of the non-sewered population with failing septic systems and straight pipes in Smith Creek watershed were estimated as 4% and 0.5%, respectively, in each sub-watershed, according to the TMDL report. During a follow-up analysis of sewered areas in the watershed, a portion of the sewered population surrounding the town of New Market was identified that had not been included in the TMDL analysis. Therefore, the non-sewered population and associated numbers of failing septic systems and straight pipes were reduced in two of the affected sub-watersheds. Since this source of bacteria loading is not permitted, 100% reduction of this source is required in the TMDL. Table ES-11 gives a summary of control measures estimated to remediate

this source of bacteria, together with control measures installed since completion of the TMDL. "System pump outs" may not necessarily solve existing problems, but are control measures needed for routine maintenance. These pump outs will likely prevent future problems and will also provide a means to begin a dialogue with homeowners whose systems may need one of the other control measures. Some alternative septic systems are needed because of soil and bedrock limitations in the watershed. In addition to these control measures, an educational effort will be important for successful implementation. Based on the distribution of population, 72.2% of the needed control measures are in Rockingham County and 27.8% are in Shenandoah County.

Table ES-11. The Extent of Residential Wastewater Control Measures

Control Measures	BMP Code	No. Needed	Extent Installed since TMDL~	Addt'l Extent Required
System Pumpouts	RB-1	1,169	61	1,108
New Sewer Hookups	RB-2	7	0	7
System Repairs	RB-3	17	9	8
New Septic Systems	RB-4	13	0	13
New Septic Systems w/ pumps	RB-4P	6	0	6
Alternative Septic Systems	RB-5	72	2	70

RB-1 estimated as 60% of total number minus other repairs.
RB-2 estimated from existing homes near sewered area boundaries.
RB-3 estimated as 20% of failing septic systems.
RB-4 estimated as systems needed to replace straight pipes.
RB-4P estimated as ≈1/2 of RB-4 systems.
RB-5 estimated as 80% of failing septic systems.
~ Control measures installed by FNFSR in 2003-2004.

Cropland

Control measures that have been installed since the TMDL or that had been installed prior to the TMDL but were not credited in the TMDL were identified and their load reductions quantified. Additional measures were then identified and pollutant load reductions quantified so that the required cropland TMDL load reductions were met (Table ES-12).

Since proximity to streams is a factor in pollutant delivery to streams, a GIS analysis was performed to identify cropland that was adjacent to, or included, perennial

stream segments. Grass buffers were included to reduce the pollutant loads associated with cropland adjacent to streams. Two of the Smith Creek sub-watersheds have slopes that are significantly steeper than the rest of the watershed. Pollutant loads from the very small amounts of cropland in these sub-watersheds may best be reduced by converting it to some type of permanent cover, forest, or pasture. While the "manure injection" control measure currently appears to be too expensive for widespread application, this control measure is specified on a small fraction of the cropland acreage (0.8%) to acknowledge an existing demonstration effort and to encourage future consideration of this measure in the watershed. A large number of animal waste facilities have been installed in the watershed, so the capacity for a large amount of bacteria source reduction is already in place. Together with the other measures, only a few additional beef and poultry waste storage facilities will be needed to achieve the 92% bacteria load reduction required from cropland. Because many of the bacteria control measures also reduce sediment, and because the 22% required sediment load reduction from cropland was much smaller than that specified for bacteria, no further control measures are needed to explicitly control sediment losses from cropland. Based on the distribution of cropland in Smith Creek, 66.7% of the needed control measures are needed in Rockingham County and 33.3% in Shenandoah County.

Pasture

The control measures needed to meet TMDL load reductions from pasture for both bacteria and sediment are shown in Table ES-13. After accounting for load reductions from currently installed control measures, load reductions resulting from filtering effects of buffers associated with livestock exclusion fencing were quantified. Load reductions realized by reforestation of 5% of the pastures in the 2 steepest sub-watersheds were also quantified. Bacteria load reductions to the pasture surface due to the application of stored manure were also credited. Upon the recommendation of local SWCD personnel, winter feeding facilities were added as a control measure option. Finally, improved pasture management was included on 71% of the pasture acreage as a companion to livestock exclusion control measures. This collective set of control measures provided the needed 92% bacteria load reductions. As with cropland, because many of the bacteria control measures also reduce sediment, and because the

22% required sediment load reduction from pasture was much smaller than that needed for bacteria, no further control measures are needed explicitly for sediment control from pasture. Throughout the Smith Creek watershed, 207 sinkholes have been identified on pasture areas through a GIS overlay of county soil surveys and the NLCD land use layers. The agricultural sinkhole protection control measure is new and its pollutant reduction effects have not been specifically quantified and were not included in any of the modeling. Nevertheless, this practice was identified as a needed control measure and included to address approximately 20% of the identified sinkholes, based on discussions with local and state agency personnel. Based on the distribution of pasture, 77.4% of the needed control measures are needed in Rockingham County and 22.6% in Shenandoah County.

Table ES-12. The Extent of Cropland Control Measures and Reductions

Cropland Control Measures	Units	Extent installed since TMDL	Add'l. Extent Required	Land-Applied Bacteria Load Reduction (cfu/yr)	% Reduction	Sediment Load Reduction (tons/yr)	% Reduction
Grass riparian buffers[b]	acres	24.12	3.5	8.01E+ 13	0.29%	58.7	2.2%
Forested riparian buffers[b]	acres	323.4	0	8.90E+ 14	3.3%	692.1	25.9%
Critical area stabilization	acres	177.2	3.22	2.46E+ 14	0.9%	192.3	7.2%
Contour stripcropping	acres		53.1	2.45E+ 14	0.9%	33.8	1.3%
Cover crops	acres	3,433.1	0			735.4	27.5%
Manure injection	acres		20.0	1.86E+ 14	0.7%	-- NA --	
Manure storage facility - beef	no.	3	4	5.68E+ 15	20.7%	-- NA --	
- dairy	no.	5	1	6.74E+ 15	24.6%	-- NA --	
- poultry	no.	12	3	1.08E+ 16	39.6%	-- NA --	
- turkey	no.	2	0	2.58E+ 14	0.9%	-- NA --	
			IP FC Reductions =	2.52E+ 16	92.0%	1,712.3	64.1%
			TMDL FC Reduction Goals =	**2.52E+ 16**	**92%**	**587.7**	**22%**
			IP EC Load =	2.76E+ 12			

Table ES-13. The Extent of Pasture Control Measures and Reductions

Pasture Control Measures	Units	Extent installed since TMDL	Add'l. Extent Required	Land-Applied Bacteria Load Reduction (cfu/yr)	% Reduction	Sediment Load Reduction (tons/yr)	% Reduction
Livestock exclusion buffers[b]	acres	42.1	436	1.50E+ 15	2.6%	237.9	2.0%
Reforestation of erodible pasture	acres	23	21.0	8.45E+ 13	0.1%	37.0	0.3%
Improved pasture management	acres	677.7	20,235	3.89E+ 16	67.4%	4,534.4	37.5%
Winter feeding facility	no.		15	4.80E+ 15	8.3%	-- NA --	
Agricultural sinkhole protection	no.		40				
Manure storage facility - beef	no.	3	4	1.89E+ 15	3.3%	-- NA --	
- dairy	no.	5	1	2.25E+ 15	3.9%	-- NA --	
- poultry	no.	12	3	3.61E+ 15	6.3%	-- NA --	
- turkey	no.	2		8.61E+ 13	0.1%	-- NA --	
			IP FC Reductions =	5.31E+ 16	92.0%	4,809.4	39.8%
			TMDL FC Reduction Goals =	**5.31E+ 16**	**92%**	**2,661.7**	**22%**
			IP EC Load =	4.71E+ 12			

Built-Up Areas

Pet waste is the dominant source of bacteria loading on Built-Up areas in the Smith Creek watershed, while land disturbing activities on transitional areas are the largest source of sediment. Built-Up areas include urban/residential areas and transitional areas. Some urban areas are subject to stormwater regulations under the Municipal Separate Storm Sewer System (MS4) program. Therefore, urban areas located in a permitted urban stormwater area are designated as MS4 areas, while others are designated as Non-MS4 areas. The portion of the City of Harrisonburg in Smith Creek watershed is an MS4 area. Several control measures used to reduce pollutant loads in Built-Up areas were determined only to be practical in areas of concentrated populations, such as cities and towns. These concentrated population centers in the Smith Creek watershed include the portion of the City of Harrisonburg (the MS4 area) and the town of New Market in the Non-MS4 area. The control measures applicable to these population centers include forested riparian buffers, pet waste programs, and street sweeping.

The extent of control measures needing to be installed to meet TMDL load reduction requirements for Urban Non-MS4 areas are shown in Table ES-14. The Urban Non-MS4 areas in Smith Creek watershed are all urban/residential areas outside of the City of Harrisonburg. Forested riparian buffers are proposed for the streams in and around the town of New Market, consistent with a future stream corridor greenway included in the town's comprehensive plan. Stream lengths were delineated using GIS, with 35 ft. buffers used for extent quantification. Load reductions from a Pet Waste Program in the town of New Market were based on the associated pet population and bacteria production rates given in the TMDL. Street sweeping is already practiced in the New Market area and is performed 6 times a year. The other two specified control measures (rain gardens and bioretention filters) are suitable for diffuse land uses such as rural residential areas, as well as for individual residences. Since many of these bacteria control measures also reduce sediment, and because the 22% required sediment load reduction from urban/residential areas was much smaller than for bacteria, no further control measures are needed explicitly for sediment control from these areas. Based on the distribution of urban and residential areas, 77.9% of the

needed Urban Non-MS4 control measures are needed in Rockingham County and 22.1% in Shenandoah County.

Control measures needed to meet the required TMDL pollutant load reductions in the TMDL Urban MS4 areas are shown in Table ES-15. In the urban/residential areas in the Smith Creek watershed within the City of Harrisonburg city limits (the MS4 area), forested riparian buffers are proposed for all included streams and waterbodies. Load reductions from a Pet Waste Program in the city were based on the associated pet population and bacteria production rates given in the TMDL. Street sweeping is already practiced in the city of Harrisonburg and is performed 4 times a year. This implementation plan calls for an additional 50% increase in loads removed through street sweeping, which can be met either by increasing the area swept, by increasing the efficiency of the sweepers, or by increasing the sweeping frequency. Rain gardens are suited for individual residences, while bioretention filters are more suited for more public spaces such as road drainageways. The extents of these practices were increased until the TMDL requirements for a 95% reduction in bacteria loads were met. Since many of these bacteria control measures also reduce sediment, and because the 22% required sediment load reduction from urban/residential areas was much smaller than for bacteria, no further control measures are needed explicitly for sediment control from these areas. All of the Urban MS4 control measures will be applied in that portion of Smith Creek within the City of Harrisonburg.

Table ES-14. The Extent of Urban Non-MS4 Control Measures and Reductions

Urban Non-MS4 Control Measures	Units	Extent installed since TMDL	Addt'l Extent Required	Land-Applied Bacteria Load Reduction (cfu/yr)	% Reduction	Sediment Load Reduction (tons/yr)	% Reduction
Forested riparian buffers[b]	acres		42.4	8.63E+ 13	5.1%	1.5	11.8%
Pet waste program	no.		1	2.91E+ 14	17.3%	-- NA --	
Street sweeping	acres	22.76	0	7.64E+ 12	0.5%	0.1	1.1%
Rain gardens[b]	acres		100.7	5.22E+ 14	31.0%	13.8	106.7%
Bioretention filters[b]	acres		40	6.92E+ 14	41.1%	18.3	141.3%
			IP FC Reductions =	1.60E+ 15	95.0%	33.7	260.9%
			TMDL FC Reduction Goals =	**1.60E+ 15**	**95%**	**2.8**	**22%**
			IP EC Load =	5.77E+ 11			

[b] Filtering includes additional reductions from upstream runoff loads: buffers - 4x buffer area; rain gardens - 6x; bioretention filters - 20x.

Table ES-15. The Extent of Urban MS4 Control Measures and Reductions

Urban MS4 Control Measures	Units	Extent installed since TMDL	Addt'l Extent Required	Land-Applied Bacteria Load Reduction (cfu/yr)	% Reduction	Sediment Load Reduction (tons/yr)	% Reduction
Forested riparian buffers[b]	acres		1.7	3.56E+ 12	1.0%	0.1	2.4%
Pet waste program	no.	1		2.10E+ 14	57.3%	-- NA --	
Street sweeping	acres	13.84	6.92	4.64E+ 12	1.3%	0.1	2.7%
Rain gardens[b]	acres		8.45	4.38E+ 13	11.9%	1.2	35.8%
Bioretention filters[b]	acres		5.0	8.64E+ 13	23.6%	2.3	70.6%
			IP FC Reductions =	3.48E+ 14	95.0%	3.6	111.5%
			TMDL FC Reduction Goals =	**3.48E+ 14**	**95%**	**0.7**	**22%**
			IP EC Load =	1.25E+ 11			

[b] Filtering includes additional reductions from upstream runoff loads: buffers - 4x buffer area; rain gardens - 6x; bioretention filters - 20x.

Sediment loads from transitional areas in the Smith Creek watershed arise primarily from stormwater runoff over areas where land has been disturbed and vegetative cover removed. The small reductions called for to meet the required 22% sediment load reductions are expected to be met through an increased efficiency with existing resources within individual local E&S programs and educational programs targeted at developers and contractors (Table ES-16). The enhanced E&S practices that will result in increased efficiency may include additional Virginia Stormwater Management Program (VSMP) permit requirements, such as increased setback distances, faster establishment of vegetation in setback areas, or for increased plantings in setback areas.

Table ES-16. Transitional Area Control Measures Needed

Control Measures	Units	Addt'l Extent Required*	Sediment Load Reduction (tons/yr)	% Reduction
Enhanced E&S Mgmt. (Rockingham)	acres	5.1	3.0	2.7%
Enhanced E&S Mgmt. (Shenandoah)	acres	28.9	17.0	15.2%
Enhanced E&S Mgmt. (Harrisonburg)	acres	7.9	4.6	4.2%
		IP Reductions =	24.6	22.1%
		TMDL Reduction Goals =	**24.6**	**22%**

* - Increased efficiency with existing resources.

Education and Technical Assistance

Through discussions with stakeholder focus groups, a variety of educational tasks were identified for the Smith Creek watershed that fell into categories of: Residential; Schools/Youth; Developer, Engineer, and Contractors; and Municipal Officials. Most of the educational opportunities rely on the many and varied available watershed partners and existing organizations or agencies for their accomplishment.

Technical assistance is required to assist with stakeholder recruitment, to coordinate with control measure contractors, to provide public education about the implementation plan, and to track installation of implementation control measures and corresponding water quality improvements. The amount of, and costs for, technical assistance were estimated in consultation with personnel from the Shenandoah Valley and Lord Fairfax SWCDs and the Public Works Planner from the City of Harrisonburg.

Costs of Implementation

Agricultural Control Measures

The extent of the agricultural control measures quantified for meeting TMDL pollutant reductions are summarized in Table ES-17, together with their unit costs and implementation costs. The total estimated cost for full implementation of agricultural control measures in the Smith Creek watershed is $9.21 M.

Table ES-17. Agricultural Control Measures Costs

Livestock Exclusion Measures	Units	Cost / Unit	Cost Source	Extent installed since TMDL	Add'l. Extent Required	IP Cost ($)
SL-6 Systems	no.	$36,456	16	10	150	$5,468,438
WP-2T Systems	no.	$11,864	16	1	36	$427,104
Adaptive fencing[a]	lin.ft.	$1.50	16		241,402	$362,103
					Livestock Exclusion Total Cost =	**$6,257,645**
Cropland Control Measures	**Units**	**Cost / Unit**	**Cost Source**	**Extent installed since TMDL**	**Add'l. Extent Required**	**IP Cost ($)**
Grass riparian buffers[b]	acres	$237	12	24.12	3.5	$831
Forested riparian buffers[b]	acres	$1,284	15	323.4	0	$0
Critical area stabilization	acres	$1,355	12	177.2	3.22	$4,363
Contour stripcropping	acres	$175	12		53.1	$9,290
Manure injection	acres	$146	16		20.0	$2,920
Manure storage facility - beef	no.	$27,139	17	3	4	$108,555
- dairy	no.	$88,736	17	5	1	$88,736
- poultry	no.	$25,833	17	12	3	$77,498
					Cropland Total Cost =	**$292,191**
Pasture Control Measures	**Units**	**Cost / Unit**	**Cost Source**	**Extent installed since TMDL**	**Add'l. Extent Required**	**IP Cost ($)**
Livestock exclusion buffers[b]	acres			42.1	436	
Reforestation of erodible pasture	acres	$1,355	12	23	21.0	$28,432
Improved pasture management	acres	$107	8	677.7	20,235	$2,165,156
Winter feeding facility	no.	$24,192	14, 16		15	$362,880
Agricultural sinkhole protection	no.	$2,500			40	$100,000
					Pasture Total Cost =	**$2,656,468**

[a] Fencing unit cost includes an allowance for cross-fencing.

[b] Filtering provides additional reductions from upstream runoff loads: buffers - 4x buffer area.

[c] Components of livestock exclusion fencing systems.

8 - MapTech, Inc., 2006.

12 - USDA-NRCS, 2007.

14 - Southwestern Illinois RC&D, Inc., 2004.

16 - SWCD estimate.

17 - DCR agricultural cost-share database.

Urban MS4 and Non-MS4 Control Measures

The extent of Urban MS4 and Urban Non-MS4 control measures quantified for meeting their TMDL pollutant reductions are summarized in Table ES-18, together with unit costs, and total implementation costs. The total estimated cost for full implementation of the Urban Non-MS4 measures is $0.96M, and the cost for the Urban MS4 measures is approximately $0.09M.

Table ES-18. Urban Control Measures Costs

Urban Non-MS4 Control Measures	Units	Cost / Unit	Cost Source	Extent installed since TMDL	Addt'l Extent Required	IP Cost ($)
Forested riparian buffers[b]	acres	$1,284	15		42.4	$54,473
Pet waste program	no.	$3,750	8		1	$3,750
Street sweeping	acres	-- NA --		22.76	0	
Rain gardens[b]	acres	$5,000	8		100.7	$503,600
Bioretention filters[b]	acres	$10,000	8		40	$400,000
					Urban Non-MS4 Total Costs =	**$961,823**
Urban MS4 Control Measures	**Units**	**Cost / Unit**	**Cost Source**	**Extent installed since TMDL**	**Addt'l Extent Required**	**IP Cost ($)**
Forested riparian buffers[b]	acres	$1,284	15		1.7	$2,245
Pet waste program	no.	$3,750	8	1		
Street sweeping	acres	-- NA --		13.84	6.92	
Rain gardens[b]	acres	$5,000	8		8.45	$42,250
Bioretention filters[b]	acres	$10,000	8		5.0	$50,000
					Urban MS4 Total Costs =	**$94,495**

8 - MapTech, Inc. 2006.

15 – Commonwealth of Virginia, 2005 Shenandoah River Tributary Strategy.

Residential Wastewater Control Measures

The extents of residential wastewater control measures quantified to meet TMDL pollutant reductions are summarized in Table ES-19, together with unit costs and implementation costs. The estimated implementation cost for residential wastewater control measures in the Smith Creek watershed is $1.91M.

Table ES-19. Residential Wastewater Control Measure Costs

Control Measures	BMP Code	Units	Cost / Unit*	No. Needed	Extent Installed since TMDL~	Add'l. Extent Required	IP Cost ($)
System Pumpouts	RB-1	no.	$275	1,169	61	1,108	$304,679
New Sewer Hookups	RB-2	no.	$5,600	7	0	7	$39,200
System Repairs	RB-3	no.	$3,000	17	9	8	$24,000
New Septic Systems	RB-4	systems	$7,000	13	0	13	$91,000
New Septic Systems w/ pumps	RB-4P	systems	$9,000	6	0	6	$54,000
Alternative Septic Systems	RB-5	systems	$20,000	72	2	70	$1,400,000
						Residential Wastewater Total Costs =	**$1,912,879**

The total estimated cost for the needed control measures in the Smith Creek watershed is $12.18M, with approximately $8.73M needed in Rockingham County, $3.35M in Shenandoah County, and $0.09M in the City of Harrisonburg.

Technical assistance needs were calculated based on the personnel required for installation of the agricultural control measures in each SWCD, the residential wastewater and Urban Non-MS4 control measures, and the Urban MS4 control measures. Agricultural technical assistance was estimated as 1.0 FTE for the Shenandoah Valley SWCD and 0.5 FTE for the Lord Fairfax SWCD over the 10 years of implementation, amounting to $75,000 per year. The residential wastewater and Urban Non-MS4 technical assistance was estimated to require 0.75 FTE for the first 5 years of implementation, and 0.375 FTE during the second 5 years, amounting to $37,500 per year in Stage I, and $18,750 per year in Stage II. Urban MS4 technical assistance was estimated as 0.05 FTE ($2,500/yr) for the first five years, and increased to twice that amount in Stage II. Although most of the implementation requirements in the MS4 area would not be required until Stage II, the City may find it beneficial to consolidate its improvements in Stage I.

Therefore, the total costs for technical assistance amount to $115,000 per year for Stage I, $98,750 per year for Stage II, or a total Technical Assistance cost of $1,068,750. The full cost for implementation of this plan in the Smith Creek watershed, including technical assistance will be $13.24M.

Measurable Goals and Milestones

Implementation Goals

The goals of TMDL implementation are to restore the water quality in the impaired stream segments in Smith Creek watershed so that it complies with water quality standards and to de-list these segments from the Commonwealth of Virginia's 303(d) List of Impaired Waters. Progress towards these goals can be assessed during the implementation process by tracking the number/type of control measures that are installed and programs or policies developed and executed (implementation actions) and continued water quality monitoring. Improvements in water quality will be measured through monitoring of bacteria concentrations and biological metrics that are used to calculate the Virginia Stream Condition Index (VaSCI).

Implementation and Water Quality Milestones

Implementation milestones establish the fraction of implementation actions to be taken within certain timeframes. Water quality milestones establish the corresponding improvements in water quality that can be expected as the implementation milestones are achieved.

Many implementation activities are already underway in the watershed. The Smith Creek Resource Team strongly supports these activities and recommends that the Smith Creek TMDL IP Steering Committee continue those efforts that are complementary to this plan. Implementation of bacteria control measures that also reduce sediment and nutrient loads are encouraged, as this reduces the need for additional sediment and nutrient control measures that may be called for under the Shenandoah River Tributary Strategy.

The implementation of control measures will be accomplished in stages. In general, the Commonwealth intends that the needed control measures be implemented in a progressive process that first addresses the pollutant sources with the largest impact on water quality. This staged approach is based on meeting water quality goals over a fifteen-year period. The TMDL lists an interim set of Stage I goals for bacteria

load reductions and will serve as the first implementation milestone at the 5-year mark. These goals specify the following pollutant source load reductions: livestock direct deposit – 60%; straight pipes and failing septic systems – 100%; crop and pasture – 50%; and Built-Up areas – 60%. Implementation of Stage I control measures is expected to reduce the bacteria loadings from controllable sources so that violations of the single sample maximum *E. coli* criterion (235 cfu/100mL) are less than 10%.The remaining control measures will be installed during the next 5-year period (Stage II). After installation of all control measures during the first two stages, full maturation of the control measures, full attainment of water quality goals (zero violations of the *E. coli* single sample maximum criterion), and de-listing from the Section 303(d) list will occur by the end of the last 5-year period (Stage III). The list and extent of control measures that are currently in place, and those scheduled to be implemented in Stage I and Stage II are shown in Table ES-20.

Monitoring will continue throughout the process to document progress towards goals and to provide a mechanism for evaluating the effectiveness of the implementation actions 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 implementation plan; 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 adequacy of the TMDL in achieving the water quality standard.

Table ES-20. Staged Implementation Goals for Smith Creek

Type of Control Measure	Units	Since TMDL	Stage I	Stage II
Livestock Exclusion Measures				
SL-6 Systems	no.	10	90	60
WP-2T Systems	no.	1	21	15
Adaptive fencing	lin.ft.	0	144,079	97,323
Cropland Control Measures				
Grass riparian buffers	acres	24.1	0.0	3.5
Critical area stabilization	acres	177.2	0.0	3.2
Contour stripcropping	acres	0.0	21.2	31.8
Manure injection	acres	0.0	0.0	20.0
Manure storage facility - beef	no.	3	0	4
- dairy	no.	5	0	1
- poultry	no.	12	0	3
- turkey	no.	2	0	0
Pasture Control Measures				
Reforestation of erodible pasture	acres	23.0	10.5	10.5
Improved pasture management	acres	677.7	10,117.6	10,117.6
Winter feeding facility	no.	0	8	7
Agricultural sinkhole protection	no.	0	20	20
Urban Non-MS4 Control Measures				
Forested riparian buffers	acres	0.0	18.7	23.8
Pet waste program	no.	0	1	0
Street sweeping	acres	22.8	0.0	0.0
Rain gardensb	acres	0.0	44.3	56.4
Bioretention filtersb	acres	0.0	17.6	22.4
Urban MS4 Control Measures				
Forested riparian buffers	acres	0.0	0.0	1.7
Pet waste program	no.	1	0	0
Street sweeping	acres	13.8	0.0	6.9
Rain gardensb	acres	0.0	0.0	8.5
Bioretention filtersb	acres	0.0	0.0	5.0
Residential Wastewater Control Measures				
System Pumpouts	no.	61	277	831
New Sewer Hookups	no.	0	7	0
System Repairs	no.	9	8	0
New Septic Systems	systems	0	13	0
New Septic Systems w/ pumps	systems	0	6	0
Alternative Septic Systems	systems	2	70	0

The costs associated with Stage I and Stage II implementation efforts are summarized in Table ES-21. Since Smith Creek lies partially within three different administrative entities – two SWCDs and the City of Harrisonburg, the costs are broken down to better reflect the relative effort needed in the various parts of the watershed.

Rockingham County lies within the Shenandoah Valley SWCD, while Shenandoah County is part of the Lord Fairfax SWCD.

Table ES-21. Staged Implementation Costs for Smith Creek

Type of Control Measure	TMDL Stage I Reductions	Stage I Implementation Costs			
		Rockingham County	Shenandoah County	Harrisonburg	IP Cost ($)
Livestock Exclusion Measures	60%	$2,550,564	$1,193,970	$0	$3,744,534
Cropland Control Measures	50%	$3,650	$65	$0	$3,716
Pasture Control Measures	50%	$1,072,082	$268,248	$0	$1,340,330
Urban Non-MS4 Control Measures	60%	$327,165	$98,137	$0	$425,302
Urban MS4 Control Measures	60%	$0	$0	$0	$0
Residential Wastewater Control Measures	100%	$1,216,736	$467,634	$0	$1,684,370
Technical Assistance					
agricultural BMPs		$250,000	$125,000		$375,000
urban and residential BMPs		$125,000	$62,500	$12,500	$200,000
Total Stage I Costs		**$5,545,196**	**$2,215,555**	**$12,500**	**$7,773,251**
		Stage II Implementation Costs			
Type of Control Measure		**Rockingham County**	**Shenandoah County**	**Harrisonburg**	**IP Cost ($)**
Livestock Exclusion Measures		$1,711,788	$801,323	$0	$2,513,111
Cropland Control Measures		$207,219	$81,256	$0	$288,475
Pasture Control Measures		$1,047,890	$268,248	$0	$1,316,138
Urban Non-MS4 Control Measures		$416,391	$120,130	$0	$536,521
Urban MS4 Control Measures		$0	$0	$94,495	$94,495
Residential Wastewater Control Measures		$160,469	$68,041	$0	$228,510
Technical Assistance					
agricultural BMPs		$250,000	$125,000		$375,000
urban and residential BMPs		$62,500	$31,250	$25,000	$118,750
Total Stage II Costs		**$3,856,258**	**$1,495,247**	**$119,495**	**$5,470,999**
Total Implementation Costs		**$9,401,454**	**$3,710,802**	**$131,995**	**$13,244,251**

Implementation Tracking and Monitoring

Implementation Tracking

Agricultural control measures will be tracked through the Virginia Agricultural Cost-Share Program. Residential Wastewater control measures will be tracked cooperatively through individual SWCDs. Urban Non-MS4 control measures will be tracked through individual SWCDs and in cooperation with the town of New Market. Urban MS4 control measures will be tracked through the City of Harrisonburg's MS4

program, while the enhanced E&S management for Transitional areas will be tracked through the Rockingham County and Shenandoah County E&S Programs.

Water Quality Monitoring

The monitoring program to assess implementation progress will be based on state DEQ bacteria and biological monitoring at the existing monitoring sites shown in Figure ES- 4 and listed in Table ES-22. The Friends of the North Fork Shenandoah River have indicated their willingness to assist with volunteer monitoring in additional locations, if needed.

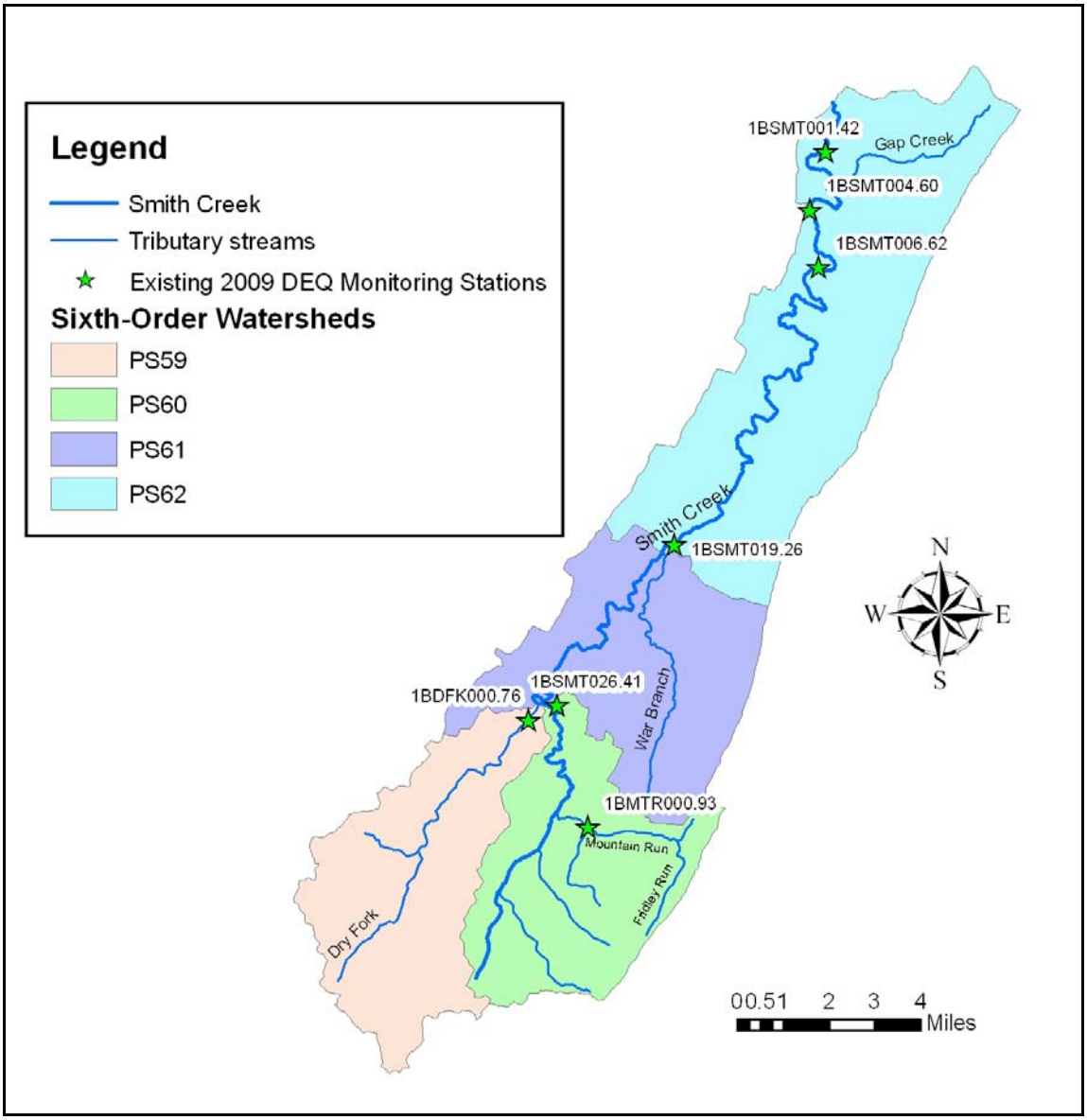

Figure ES- 4. Existing 2009 DEQ Water Quality Monitoring Station Locations

Table ES-22. Existing 2009 DEQ Water Quality Monitoring Stations

Station ID	Stream Name	Location	Monitoring Type
1BDFK000.76	Dry Fork	Rt. 806 Bridge	bacteria
1BMTR000.93	Mountain Run	Rt. 620 Bridge	bacteria
1BSMT001.42	Smith Creek	Rt. 730 Bridge	bacteria
1BSMT004.60	Smith Creek	Rt. 620 Bridge	bacteria
1BSMT006.62	Smith Creek	Rt. 620 Bridge	biological
1BSMT019.26	Smith Creek	Rt. 796 Bridge	bacteria
1BSMT026.41	Smith Creek	Rt. 717 Bridge	bacteria

DEQ will conduct monthly or bi-monthly ambient and bacteria sampling for *E. coli* at each of the existing bacteria monitoring sites in Smith Creek. Sampling at the one DEQ biological station will be performed at least every other year spring and fall. Metrics will be calculated for these samples for evaluation of the VaSCI and RBP II indices. Since many habitat metrics are particularly relevant to the impact of sediment, DEQ will be requested to perform the habitat evaluation every spring and fall at the biological site, regardless of whether biological samples are taken.

The Staged Implementation Approach and Targeting

During each annual evaluation of implementation progress on Smith Creek, a reassessment of implementation priorities will be made by the Steering Committee to readjust and fine-tune the targeting approach in concert with the staged implementation approach. Periodic re-evaluation is especially critical during these times of economic uncertainty, where increasing energy prices and fluctuating market prices are bound to affect stakeholders in the agricultural sector and their willingness to commit resources for conservation, especially if they are struggling to maintain their viability as a farming enterprise.

If reasonable progress toward implementing the management practices is not demonstrated, the Steering Committee will consider additional implementation actions. If it is demonstrated that reasonable and feasible management measures have been implemented for a sufficient period of time and TMDL targets are still not being met, the TMDL will be reevaluated and revised accordingly. If after five years the Steering Committee determines that load reductions are being achieved as management measures are implemented, then the recommended appropriate course of action would

be to continue management measure implementation and compliance oversight. If it is determined that all proposed control measures have been implemented, yet the TMDL is not achieved, further investigations will be made to determine whether: 1) the control measures are not effective; 2) sediment loads are due to sources not previously addressed; or 3) the TMDL is unattainable.

Reasonable Assurance

Public participation is an integral part of the IP development and is critical in gaining support for both the voluntary and MS4 compliant implementation activities that are being planned. During the public participation process, the major stakeholders in the watershed and a wide variety of local conservation agency personnel were involved in Focus Groups and public meetings, and provided additional information through email and phone conversations. This participation by the major watershed stakeholders provides a reasonable assurance that the public was contributing to the TMDL process and had input into the selection of management and implementation practices recommended by this IP.

A Smith Creek TMDL IP Steering Committee will be formed following development of the implementation plan with guidance provided by agency members of the Resource Team, ensuring continuity of leadership and vision. Smith Creek is already receiving funding through the EPA's Healthy Waters Initiative, and the Smith Creek Partnership has submitted proposals for additional grant funding, ensuring their continuing interest, participation, and support.

As part of EPA's Healthy Waters Initiative, an extra effort was made to incorporate local government planning departments in the development of the Smith Creek IP. In addition to participation by the localities in the public meetings, IP Resource Team members have met individually with planning department staff in order to get the most up to date information about land planning goals and local government water quality initiatives and to discuss future collaborative efforts among the jurisdictions pertaining to Smith Creek water quality improvements. The Smith Creek watershed includes part of four local jurisdictions – Rockingham and Shenandoah Counties, the

City of Harrisonburg, and the Town of New Market. Each of the four local government comprehensive plans contain strong goals and objectives that give priority to water quality improvements and land conservation in areas that overlap with the Smith Creek watershed.

Implementation to address the bacteria and sediment-related biological impairments on Smith Creek will be carried out primarily through the use of voluntary and MS4 compliant best management practices and education. While available cost-share programs will be utilized to the extent possible to provide incentives (typically at 75% of installation costs) to targeted watershed stakeholders, it is recognized that it may be necessary in some instances to raise the level of incentives to 100% to ensure participation by some stakeholders. Grant funding will be sought to provide this additional incentive, which we expect will increase participation from specific targeted stakeholders that would otherwise be reticent to participate.

Taken together, all of these planning components comprise a reasonable assurance that implementation will progress as planned and will lead to restoration of water quality in Smith Creek.

1.0 INTRODUCTION

A Total Maximum Daily Load (TMDL) study for Smith Creek was submitted to DEQ in April 2004 and approved by EPA in June 2004 (Tetra Tech et al., 2004). The TMDL specified the maximum bacteria load that Smith Creek can handle in a manner that is protective of the state water quality standard for bacteria. The TMDL also specified a maximum sediment load that would be protective of benthic macroinvertebrates in order to meet the state Aquatic Life Use water quality standard. This document serves as the Total Maximum Daily Load (TMDL) implementation plan (IP) for Smith Creek located in Rockingham and Shenandoah Counties with a small portion located within the City of Harrisonburg, Virginia.

A previous TMDL was developed for organic solids in the Lacey Spring Branch tributary to Smith Creek. Identified pH impairments in Mountain Run and Fridley Run have not yet been addressed with TMDLs and a total phosphorus (TP) threatened condition also exists in the lower Smith Creek. The implementation plan is the next step in the TMDL process and will address sources of organic solids, sediment, and bacteria identified in approved TMDLs for restoration of water quality in Smith Creek.

1.1. *Regulatory Background of the TMDL Study*

In 1972, the US Congress enacted the Federal Water Pollution Control Act known as the "Clean Water Act" (CWA). The founding objective of that legislation was well defined in its opening paragraph,

> *"to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."*

The legislation covers a range of water quality efforts aimed at reaching this objective. Immediately relevant to this project are the requirements that states develop and promulgate water quality standards for waters within their jurisdictions. In section 303(d) of the Act, the federal government requires states to identify those water bodies not meeting the published water quality standards for any given pollutant. This list is often

called the "303(d) list" or the "impaired waters list." Virginia's first impaired waters list was published and reported to EPA in 1994. Recently, the 303(d) list has been combined with the 305(b) water quality assessment report which describes the overall quality of a state's waters. This "305(b)/303(d) Integrated Report" is published and submitted to EPA every two years.

An additional section 303(d) condition requires that, if a particular water body is listed as "impaired," the state must develop a "total maximum daily load" for the exceeded standard for the water body. The "total maximum daily load" or TMDL is essentially a "water pollution budget." A TMDL study defines the amount of pollutant each source in the watershed can contribute to the water body while still allowing the water body to comply with applicable water quality standards.

The Commonwealth of Virginia was also a signatory to the June 11, 1999 consent decree settling federal case no. 98-979-A "American Canoe Association, Inc. and the American Littoral Society v. EPA and EPA – Region III." By signing the consent decree, Virginia committed to develop TMDL studies by 2010 for all Virginia water segments listed on the 1998 303(d) Impaired Waters list.

The "Designation of Uses" of all waters in Virginia is defined in the Code of Virginia (9 VAC 25-260-10) as follows:

> All state 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). (SWCB, 2003)

The water quality standard supported through biological monitoring is Virginia's narrative General Standard (9 VAC 25-260-20, also known as the Aquatic Life Use standard) which states in part:

> All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are … harmful to human, animal, plant, or aquatic life.

> Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled. (SWCB, 2003)

The biological monitoring program in Virginia used to evaluate compliance with the above standard is run by the Virginia Department of Environmental Quality (VADEQ). Evaluations of monitoring data from this program focus on the benthic (bottom-dwelling) macro (large enough to see) invertebrates (insects, mollusks, crustaceans, and annelid worms) and are used to determine whether or not a stream segment has a benthic impairment. Changes in water quality generally result in alterations to the quantity and diversity of the benthic organisms that live in streams and other water bodies. In addition to being the major intermediate constituent of the aquatic food chain, benthic macroinvertebrates are "living recorders" of past and present water quality conditions. This is due to their relative immobility and their variable resistance to the diverse contaminants that are introduced into streams. The community structure of these organisms provides the basis for the biological evaluation of water quality.

The applicable water quality criteria for fecal bacteria impairments are contained in Section 9 VAC 25-260-170. At the time Smith Creek was placed on the 303(d) list, the criteria for fecal coliform bacteria included two parts: (1) the fecal coliform bacteria count shall not exceed a geometric mean of 200 per 100 mL of water for two or more samples taken over a 30-day period, and (2) the fecal coliform bacteria count shall not exceed 1,000 per 100 mL at any time. Most of VADEQ's ambient water quality monitoring is done on a monthly or quarterly basis. This sampling frequency does not provide the two or more samples within 30 days needed for use of the geometric mean part of the standard. Therefore, VADEQ used the 1,000 per 100 mL part of the standard in the assessment of the fecal coliform bacteria monitoring data.

EPA recommended that all states adopt either an *Escherichia coli* (*E. coli)* or Enterococci standard for fresh water and a Enterococci criteria for marine waters by 2003 because there is a stronger correlation between the concentration of these

organisms (*E. coli* and Enterococci) and the incidence of gastrointestinal illness than between fecal bacteria and gastrointestinal illness. *E. coli* and Enterococci are both bacteriological organisms that can be found in the intestinal tract of warm-blooded animals. Like fecal bacteria, these organisms indicate the presence of fecal contamination. In line with this recommendation, Virginia adopted and published revised bacteria criteria on June 17, 2002. The revised criteria became effective on January 15, 2003. As of that date, the *E. coli* standard (Table 1.1) applied to all freshwater streams in Virginia.

Table 1.1. *E. coli* standard for fresh water outlined in 9 VAC 25-260-170.A.2

Water Quality Parameter (units)	Geometric Mean[1]	Single Sample Maximum
E.coli (cfu/100 mL)	126	235

[1]For two or more samples taken during any calendar month.

Prior to June 30, 2008, an interim fecal coliform standard was also applied at any sampling station that had fewer than 12 samples of *E. coli*. The interim fecal coliform standard stated that fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 mL of water for two or more samples over a calendar month nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 mL of water. Since, fewer than 12 samples had been collected at the time of the original listing of Smith Creek TMDL, Smith Creek had been originally listed as being in violation of the fecal coliform standard. However, to ensure compliance with the new revised standard, the bacteria TMDLs for the impaired stream segments of the Smith Creek watershed were developed to meet the *E. coli* criteria in Table 1.1, including both the geometric mean and the single sample maximum.

2.0 STATE AND FEDERAL REQUIREMENTS FOR TMDL IMPLEMENTATION PLANS

2.1. *Background*

Once a water body is listed as impaired and a subsequent TMDL study has been conducted, the watershed stakeholders must develop and implement a strategy that will limit the pollutant loadings to those levels allocated in the TMDL study. Such a strategy, also known as an Implementation Plan (IP), must contain actions that will work to achieve the reduced pollutant loadings needed to bring the water body into compliance with the standard. Although such Implementation Plans are alluded to in the federal CWA legislation, they are not a requirement of that act. Such Implementation Plans are, however, a state requirement.

2.2. *State Requirements*

The TMDL Implementation Plan (IP) is a requirement of 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. WQMIRA directs the Virginia Department of Environmental Quality (VADEQ) to "develop and implement a plan to achieve fully supporting status for impaired waters." For an IP to be approved by the State Water Control Board, the IP **must** include the following required components, as outlined in the WQMIRA:

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

2.3. *Federal Recommendations*

Section 303(d) of the CWA and current EPA regulations do not require the development of implementation strategies, though their guidance clearly describes this as the next step leading to the attainment of water quality objectives. In the 1999

"Guidance for Water Quality-Based Decisions: The TMDL Process", EPA recommends the following minimum elements for an approvable IP:

- a description of the implementation actions and management measures,
- a time line for implementing these actions and measures,
- legal or regulatory controls,
- a monitoring plan to determine the effectiveness of actions and measures; and
- an estimate of the time required to attain water quality standards.

These recommendations closely track the State's WQMIRA requirements.

2.4. *Requirements for Section 319 Fund Eligibility*

Beyond the regulatory requirements listed above, the CWA was amended in 1987 to establish the Nonpoint Source Management Program in §319 of that act. Through that program, States, Territories, and Native American Tribes can receive grant monies for a variety of activities, including the restoration of impaired stream segments. Although there are various alternative sources of money to assist with the TMDL implementation process, §319 funds are substantial and most relevant to TMDL implementation. Therefore, the requirements to obtain these funds are discussed in this chapter. The Virginia Department of Conservation and Recreation strongly suggests that the requirements for §319 funds be addressed in the IP (in addition to the required components as described by the WQMIRA).

The EPA develops guidelines that describe the process and criteria to be used to award CWA §319 nonpoint source grants to States. The guidance is subject to revision and the most recent version should be considered for IP development. The "Supplemental Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories in FY 2003" identifies the following nine elements that must be included in the IP to meet the 319 requirements:

1. 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;
2. Estimate the load reductions expected from NPS management measures;
3. Describe the NPS management measures that will need to be implemented to achieve the identified load reductions;
4. 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;

5. 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;
6. Provide a schedule for implementing the NPS management measures identified in the watershed-based plan;
7. Describe interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented;
8. Identify a set of criteria for determining if loading reductions are being achieved and progress is being made towards attaining water quality standards, and if not, the criteria for determining if the watershed-based plan needs to be revised; and
9. Establish a monitoring component to evaluate the effectiveness of the implementation efforts.

2.5. *Staged Implementation*

In general, the Commonwealth of Virginia intends for nonpoint source pollutant TMDL reductions to be implemented in a staged fashion. Staged implementation is an iterative process that incrementally implements management measures, initially targeting those sources and/or practices with the largest impact on water quality, coupled with a monitoring plan to continuously assess progress toward full attainment of designated uses.

There are many benefits of staged implementation, including:

1. Through stream monitoring, water quality improvements are recorded as they are accomplished;
2. Quality control is achieved to offset the uncertainties that exist in any watershed simulation model;
3. A mechanism for developing public support is developed;
4. The most cost effective practices are implemented initially; and
5. The adequacy of the TMDL to achieve the water quality standard is ensured.

With successful development and implementation of IPs, Virginia will be well on the way to restoring impaired waters and enhancing the value of the Commonwealth's aquatic resources. Additionally, development of an approved IP will increase the opportunities for a locality to obtain monetary assistance during implementation.

3.0 REVIEW OF THE SMITH CREEK TMDL STUDY

The following summary of the Smith Creek TMDL was excerpted from the final report submitted to the Virginia Department of Environmental Quality in April 2004 entitled, "Total Maximum Daily Load (TMDL) Development for Smith Creek: Aquatic Life Use (Benthic) and *E. coli* (Bacteria) Impairments" as prepared by George Mason University and Tetra Tech, Inc.

3.1. *Watershed Characteristics*

The Smith Creek watershed (Virginia Waterbody Identification Code, VAV-B47R) is located in the Potomac River Basin in Shenandoah and Rockingham counties, with a small portion of the headwaters located in the City of Harrisonburg, Virginia (USGS Hydrologic Unit Code, 02070006) (Figure 3.1). The Smith Creek watershed is approximately 67,900 acres in size and land use is predominantly forest and agricultural. Smith Creek was listed as impaired on Virginia's Section 303(d) Total Maximum Daily Load Priority List and Report due to violations of the State's Water Quality Standards for fecal coliform bacteria and violations of the General Standard (Benthics) (VADEQ 1998, 2002). Mountain Run and Fridley Run are also listed as impaired due to violations of the General Standard (VADEQ 2002). Mountain Run was also listed with a bacteria impairment in 2006 (VADEQ, 2006), after the Smith Creek TMDL was completed. Since this tributary was already included in the Smith Creek TMDL and would be included in the Smith Creek Implementation Plan, a separate TMDL was not required for this impairment. Fridley Run is tributary to Mountain Run, and Mountain Run is tributary to Smith Creek. The Smith Creek Watershed is also part of the North Fork of the Shenandoah River (VAV-B45R-04, 52.97 miles) watershed impaired for bacteria. A TMDL was completed for the bacteria impairment for North Fork Shenandoah in April 2006.

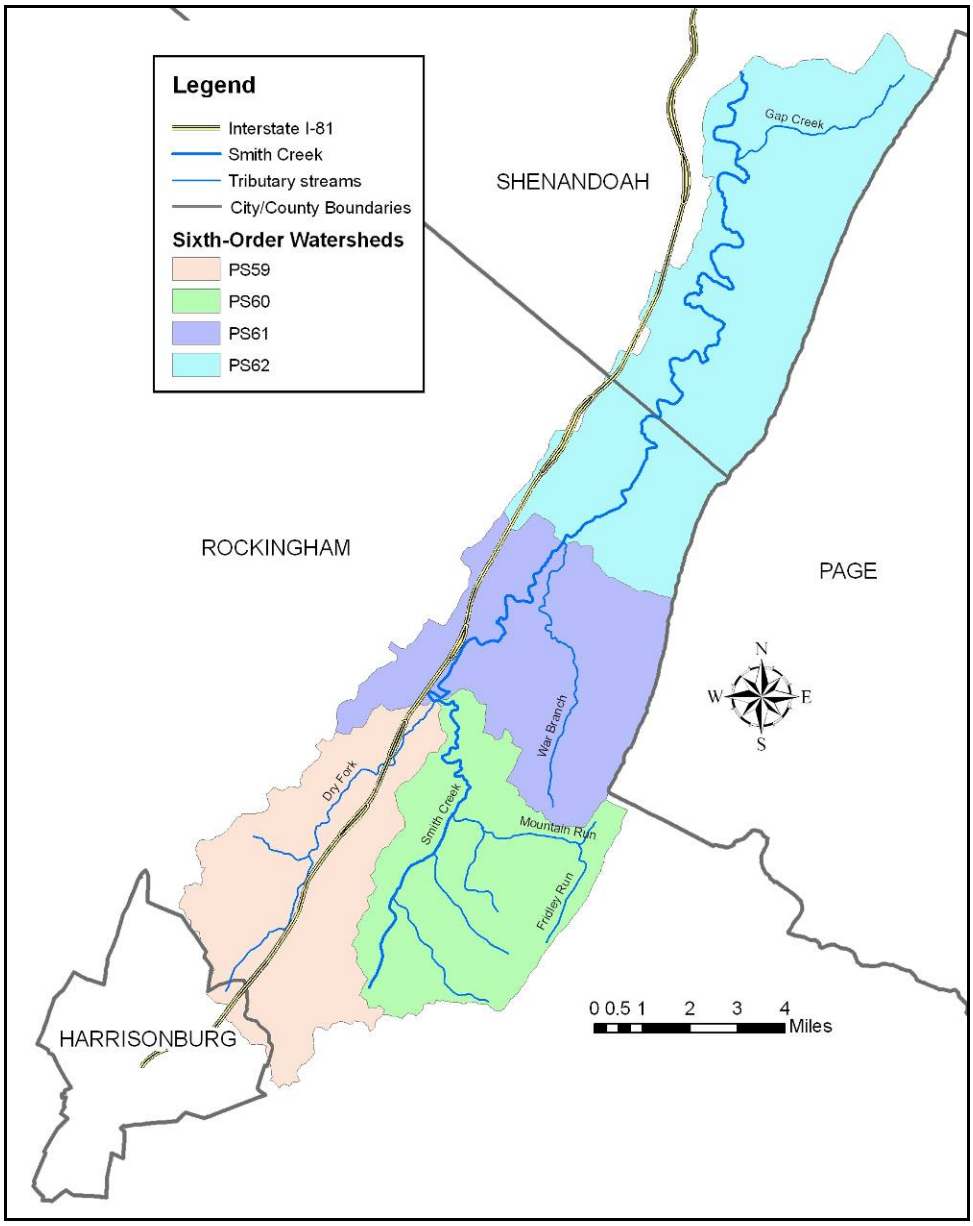

Figure 3.1. Location of the Smith Creek watershed

The Smith Creek watershed is located in the Shenandoah Valley of Virginia, which is part of the Valley and Ridge physiographic province. The Valley and Ridge physiographic province is a belt of folded and faulted clastic and carbonate sedimentary rocks situated west of the Blue Ridge crystalline rocks and east of the Appalachian Plateaus. The Shenandoah Valley makes up part of the Great Valley sub-province, which extends from New York southwest to Alabama. This area is characterized by broad valleys with low to moderate slopes underlain by carbonate rocks. Limestone and

dolomite (which are carbonate rocks) occur beneath the surface forming the most productive aquifers in Virginia's consolidated rock formations. The gently rolling lowland of the valley floor lies at an elevation of approximately 1000 feet above sea level. Sinkholes, caves, and caverns are common in the valley due to its karst geology.

Smith Creek flows north from its headwaters to its confluence with the North Fork Shenandoah River. Smith Creek flows predominantly thorough pasture/hay and forest lands. There is a transition in stream gradient and substrate type between the upper and lower portions of the watershed. Mountain Run and Fridley Run are located in high gradient sandstone geology; whereas, Smith Creek and Dry Fork are located in lower gradient limestone/dolomite geology. Streams in the lower watershed flow through large expanses of pasture land and are utilized for livestock watering in some areas and other agricultural production activities.

The main general soil map units found in the Smith Creek watershed are the Berks-Weikert, Carbo-Chilhowie and Frederick associations. The Berks series consists of moderately deep, well drained soils formed in residuum weathered from shale, siltstone and fine grained sandstone on rounded and dissected uplands. Permeability is moderate or moderately rapid and slopes range from 0 to 80 percent. Both the Carbo and Chilhowie series consist of moderately deep, well drained, and slowly permeable soils. The Carbo series are formed in material weathered from limestone bedrock. These soils are located on nearly level to very steep soils on uplands in the Appalachian Ridges and Valleys. Slopes range from 2 to 65 percent. Chilhowie soils are formed in residuum from interbedded shale and limestone. Slopes range from 0 to 60 percent. The Frederick series consists of very deep, well-drained soils formed in residuum derived mainly from dolomitic limestone with interbeds of sandstone, siltstone, and shale. These soils are on nearly level to very steep uplands and slopes range from 0 to 66 percent. Permeability is moderate.

For watershed modeling purposes during the TMDL study, the climate of the watershed was represented by meteorological observations made at the Timberville 3 E meteorological station (NCDC), which is located approximately 1.89 miles west of the watershed (period of record: 1948-1990). The area's climate is typical of other regions in the Shenandoah Valley. The growing season lasts from May 5 through October 10 in

a typical year (SERCC, 2003). Average annual precipitation is 35.48 inches with August having the highest average precipitation (3.90 inches). Average annual snowfall is 22.9 inches, most of which occurs in January and February. The average annual maximum and minimum daily temperature is 65.8°F and 41.7°F, respectively. The highest monthly temperatures are recorded in July (86.6°F - average maximum) and the lowest temperatures are recorded in January (21.8°F - average minimum).

General land use/land cover data for the Smith Creek watershed for the TMDL study were extracted from the Multi-Resolution Land Characterization (MRLC) database for the state of Virginia (EPA, 1992) and is shown in Figure 3.2. This database was derived from satellite imagery taken during the early 1990s and is the most current detailed land use data available. Land uses in the Smith Creek watershed include various urban, agricultural, and forest categories. Approximately 50% of the watershed is forested and 47% is agricultural. Residential and commercial land uses account for less than 4% of the watershed.

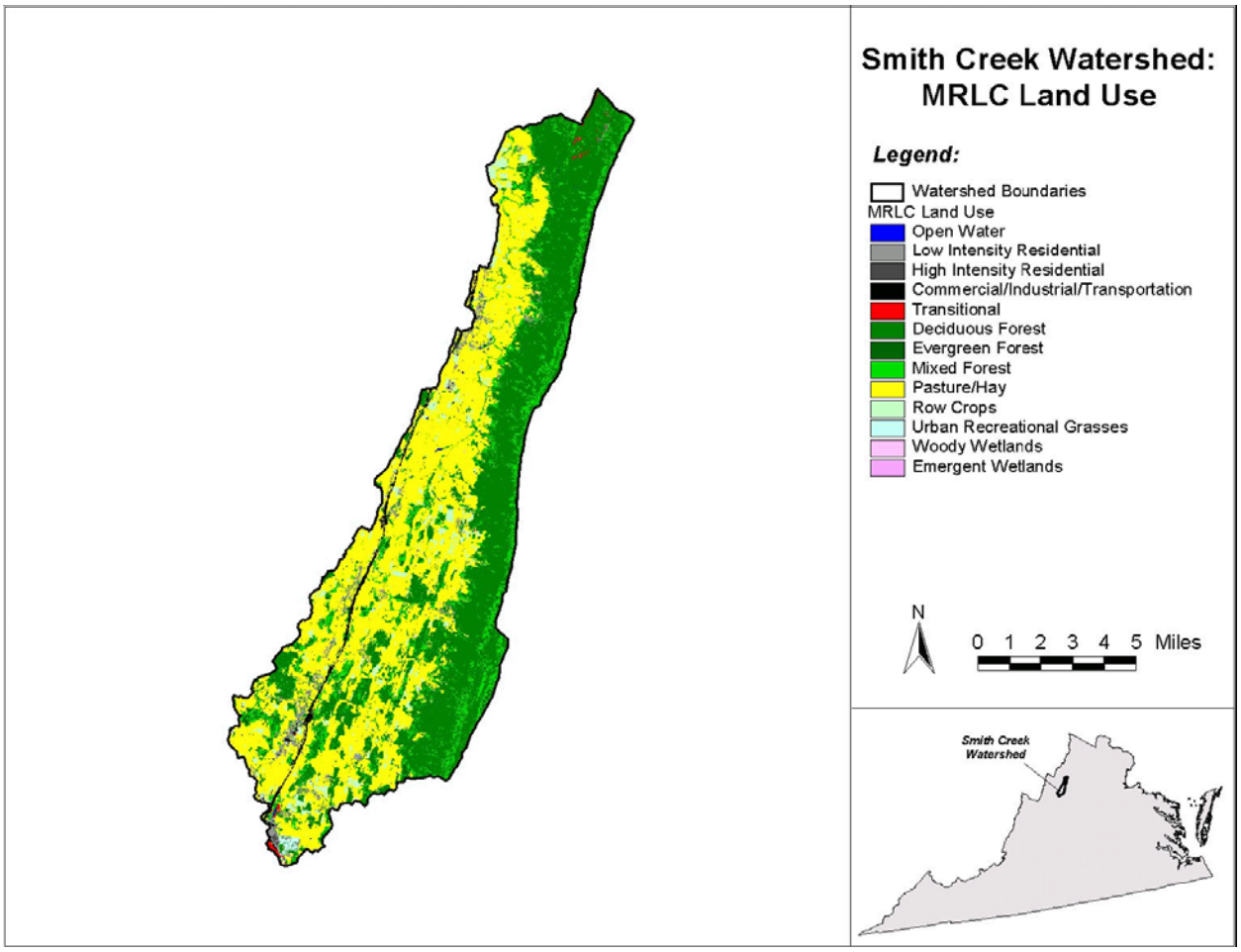

Figure 3.2. Existing Land Use in Smith Creek Watershed

3.2. *Chemical and Biological Monitoring*

There were thirteen current and historical VADEQ water quality monitoring stations located in the Smith Creek watershed at the time of the TMDL study. Biomonitoring data collected at the VADEQ stations 1BSMT005.71 and 1BSMT006.62 on Smith Creek, VADEQ station 1BLAC000.14 on Lacey Spring Branch, and several U.S. Forest Service (USFS) stations on Mountain Run and Fridley Run. Data from these biomonitoring stations were used to assess Smith Creek, Mountain Run, and Fridley Run as impaired. As part of the benthic TMDL study, George Mason University (GMU) personnel conducted water quality and biomonitoring at thirteen stations on Smith Creek, Mountain Run, and Fridley Run. Several of the GMU stations are co-located with VADEQ monitoring stations. VADEQ, USFS, and GMU monitoring stations located in

the Smith Creek watershed are presented in Table 3.1 and shown in Figure 3.3. The water quality data periods shown in Table 3.1 include field parameters collected during biomonitoring site visits. The bacteria data collected at each VADEQ monitoring station are summarized in Table 3.2.

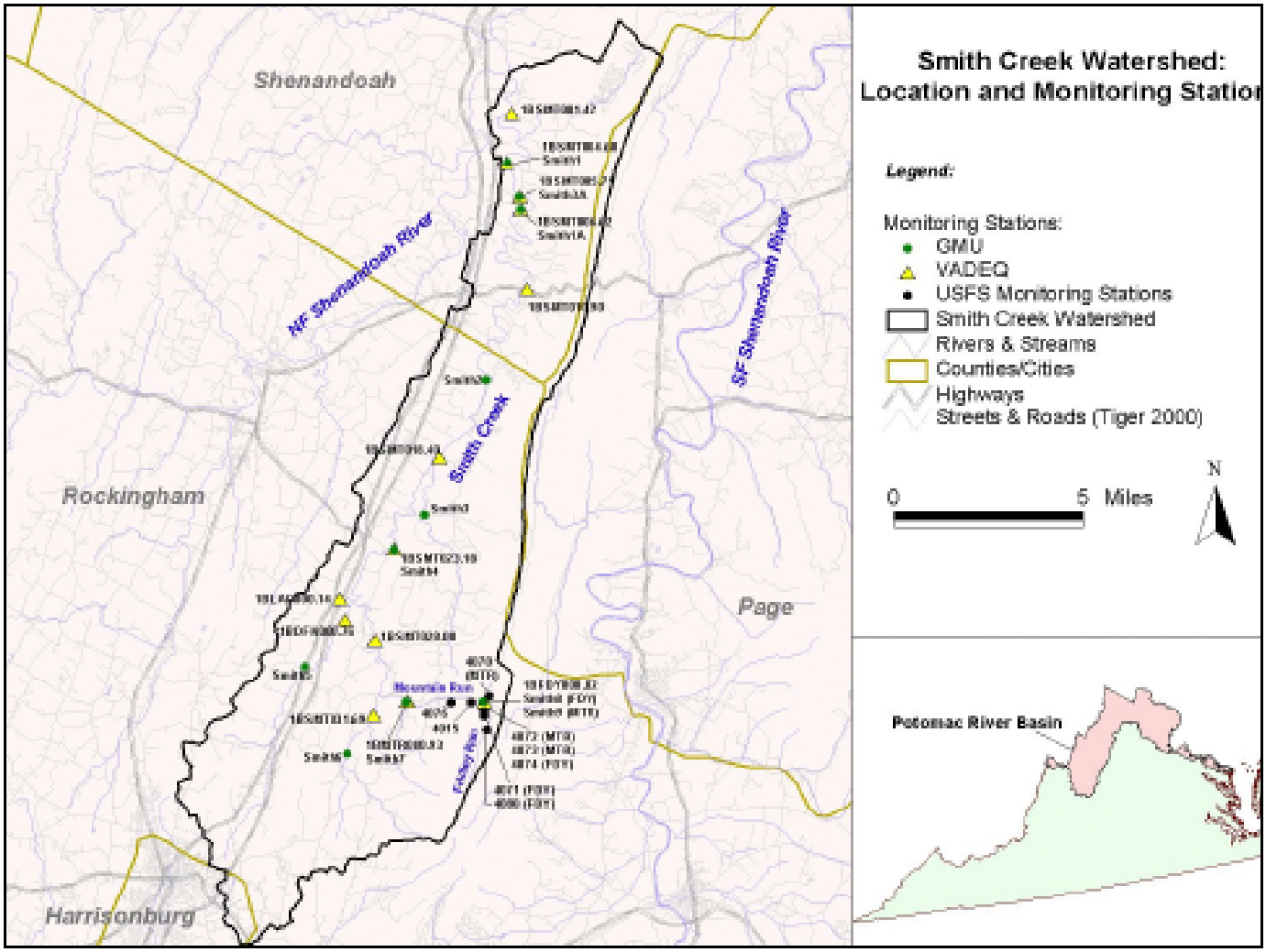

Figure 3.3. Monitoring Stations assessed in the Smith Creek TMDL

Table 3.1. Monitoring Station Data assessed in the Smith Creek TMDL

Station	Organization	Station Type	Location	Data Period
1BSMT001.42	VADEQ	WQ	Rt. 730 bridge	No data available
1BSMT004.60	VADEQ	WQ	Rt. 620 bridge	1/18/90 - 6/2/03 (Samples not incl. in this report: 4/23/79 – 12/5/89 & 8/6/03 – 10/23/03)
1BSMT005.71	VADEQ	Bio	Down stream of Rt. 620 bridge	10/5/94 - 10/20/98 (after 1998, this station was moved to 1BSMT006.62 due to bridge reconstruction)
1BSMT006.62	VADEQ	Bio	Rt. 620 bridge	5/18/99 – 9/27/01
1BSMT010.90	VADEQ	WQ	Rt. 211 bridge	3/3/70 - 2/22/79
1BSMT018.40	VADEQ	WQ	Rt. 798 bridge	3/3/70 - 6/12/74
1BSMT023.18	VADEQ	WQ	Rt. 608 bridge	12/18/91 - 6/4/01
1BSMT028.00	VADEQ	WQ	Rt. 806 bridge	7/26/01 - 5/27/03
1BSMT031.69	VADEQ	WQ	Rt. 724 bridge	7/26/01 - 5/27/03
1BMTR000.93	VADEQ	WQ, SS	Mountain Run, Rt. 620 bridge	6/30/2003 (Samples not incl. in this report : 7/24/03 – 10/27/03)
1BFDY000.02	VADEQ	WQ, SS	Fridley Run, At Fridley Gap in GW National Forest	6/30/2003 (Samples not incl. in this report : 7/24/03 – 10/27/03)
1BDFK000.76	VADEQ	WQ	Dry Fork, Rt. 806 bridge	7/30/01 - 5/27/03
1BLAC000.14	VADEQ	Bio	Lacey Spring Branch, Just upstream of Rt. 81 culvert	Samples not incl. in this report: 8/8/00 & 3/23/01
4015	USFS	WQ	Mountain Run	10/2/92 – 12/11/96
4070	USFS	WQ	Mountain Run	No data available
4071	USFS	WQ	Fridley Run	10/2/92 – 12/11/96
4072	USFS	WQ	Mountain Run	10/2/92 – 12/11/96
4073	USFS	WQ	Mountain Run	10/2/92 – 12/11/96
4074	USFS	WQ, Bio	Fridley Run	10/2/92 – 12/11/96, 1/30/2002 (WQ only); 5/10/01 (Bio only)
4076	USFS	WQ, Bio	Mountain Run	1/30/2002 (WQ only); 5/18/00 & 5/10/01 (Bio only)
4080	USFS	WQ	Fridley Run	11/3/92-12/11/96
Smith1	GMU	WQ, Bio	At 616/USGS gauge (DEQ 4.60)	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)
Smith1A	GMU	WQ, Bio	At Rt. 620 (DEQ 6.62)	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)
Smith2	GMU	WQ, Bio	At Rt. 794	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)
Smith3	GMU	WQ, Bio	At Rt. 798 (Arkton Rd.)	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)
Smith3A	GMU	WQ	At Rt. 620 (7157) (DEQ 5.71)	4/25/03 (WQ only)
Smith4	GMU	WQ, Bio	At Rt. 608 (Mauzy-Athlone Rd.)	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)
Smith5	GMU	WQ, Bio	Dry Fork, At Rt. 11S (near 721)	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)

Table 3.1 (cont.) Monitoring Station Data assessed in the Smith Creek TMDL

Station	Organization	Station Type	Location	Data Period
Smith6	GMU	WQ, Bio	At Rt. 724 near 717 (Fluke Rd.)	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)
Smith7	GMU	WQ, Bio	Mt. Run @ Mt. Valley Rd. (100 ft. from Rt. 811 (Fridley Gap Rd.))	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)
Smith8	GMU	WQ, Bio	Fridley Run just above confl w/Mtn. Run extended (George Washington Forest)	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)
Smith9	GMU	WQ, Bio	Mt. Run extended just above confl w/Fridley Run (George Washington Forest)	5/29/03, 10/5-10/6/03 (WQ & Bio); 7/25/03 (Bio only)
MtnRun1 (not in Figure 2.2)	GMU	WQ	At trailhead; at Rt. 620 (USFS 4015)	4/25/03 (WQ only)
MtnRun2 (not in Figure 2.2)	GMU	WQ	At Rt. 620 (Fridley Gap Rd.)	4/25/03 (WQ only)

Table 3.2. VADEQ Bacteria Monitoring Summary

Station	Date	Sample Type[1]	Count	Min-Max	Instantaneous Criteria FC: 400 cfu EC: 235 cfu (% Violations)
1BSMT004.60 (Smith Creek)	1/18/90 -12/29/03	FC	139	25-8,000	27
	8/5/02 -12/29/03	EC	15	20-820	40
1BSMT023.18 (Smith Creek)	12/18/91 - 6/4/01	FC	42	100-8,000	57
		EC	no data		
1BSMT028.00 (Smith Creek)	1/22/02 - 5/30/02	FC	12	100-900	33
		EC	no data		
1BSMT031.69 (Smith Creek)	7/26/01 - 5/27/03	FC	12	100-1,300	33
		EC	no data		
1BDFK000.76 (Dry Fork)	7/30/01 - 5/27/03	FC	11	100-8,000	73
		EC	no data		
1BMTR000.93 (Mountain Run)	6/30/03 - 10/27/03	FC	5	25-380	20
		EC	no data		
1BFDY000.02 (Fridley Run)	6/30/03 - 10/27/03	FC	5	25-320	0
		EC	no data		

[1] Sample type: FC = Fecal Coliform Bacteria, EC = *E. coli*

Several samples had a fecal count of 8,000 cfu/100 ml. The upper limit of laboratory analysis was typically 8,000 cfu/100 ml, depending on collection date. Therefore, many of these samples likely represent concentrations much higher than these limits. The percent violation analysis provides insight into the magnitude of the fecal contamination problems in these streams. Violations occurred in all flow regimes.

VADEQ collected BST data at station 1BSMT004.60 from 5/6/03 through 10/27/03 (6 monthly samples) to help identify the predominant sources of bacteria in the watershed (Table 3.3). Fecal coliform bacteria and *E. coli* concentrations were measured and the Antibiotic Resistance Analysis (ARA) methodology was used to determine the likely sources of bacteria in each sample. This methodology provides information on the presence or absence of human, pet, livestock, and wildlife sources in the watershed. No information was provided for upstream areas of the watershed.

Table 3.3. BST results for Station 1BSMT004.60

Date	Fecal concentration (cfu/100ml)	*E. coli* concentration (cfu/100ml)	Wildlife (%)	Human (%)	Livestock (%)	Pets (%)
5/6/03	300	270	13	4	62	21
6/30/03	3,600	340	45	0	13	42
7/21/03	580	340	21	4	75	0
8/11/03	5,400	820	46	0	64	0
9/15/03	250	210	29	0	46	25
10/27/03	140	108	25	0	67	8

* bold values were statistically significant

The Rapid Bioassessment Protocol II (RBP II) was the protocol used to assess compliance with the general standard in Virginia through the 2006 statewide assessment. The RBP II procedure evaluates the benthic macroinvertebrate community by comparing individual network biomonitoring stations with reference biomonitoring stations. Reference biomonitoring stations have been identified by regional biologists that are both representative of regional physiographic and ecological conditions and have a healthy, unimpaired benthic community. VADEQ stations 1BSMT005.71 and 1BSMT006.62 on Smith Creek were sampled on several occasions from 1994 through

2001. USFS stations 4074 and 4072 on Fridley Run were sampled from 1992 through 2001 and 1992 through 1996, respectively. USFS station 4015 on Mountain Run was sampled from 1992 through 1996. These data indicated a moderate impairment of the benthic macroinvertebrate community on each stream, which resulted in the impairment listing.

Available biomonitoring data were summarized to help characterize the benthic community in the Smith Creek watershed. The Virginia Stream Condition Index (VaSCI) was adopted as the new bioassessment protocol in Virginia starting with the 2008 statewide assessment. The VaSCI was also retroactively applied to available benthic macroinvertebrate data to provide an additional assessment of the biological community in each stream. The benthic multimetric scores provided by this index allow for a more detailed and reliable assessment of the benthic macroinvertebrate community in Virginia's non-coastal, wadeable streams (Tetra Tech, 2002). VADEQ and GMU biomonitoring data were used to calculate the VaSCI score for each station (Table 3.4). Data for GMU sampling sites are included in the scores based on correspondence with VADEQ station locations. The VaSCI scores for Smith Creek, Mountain Run, and Fridley Run were less than the recommended impairment threshold of 61 on several occasions. These scores were also lower than comparable scores at several reference stations in the region.

Table 3.4. VaSCI standardized scores for Smith Creek, Mountain Run, and Fridley Run

StationID	Organization	Stream	Location	Sample Date	VaSCI Index Score
SMT005.71	DEQ	Smith Creek	Downstream of Rt. 620 bridge	10/05/1994	52
				05/22/1995	72
				09/28/1995	64
				05/23/1996	57
				05/27/1997	56
				09/23/1997	63
				10/20/1998	71
				Average	62
SMT006.62	DEQ	Smith Creek	Rt. 620 bridge	05/18/1999	60
				10/14/1999	68
				04/17/2000	57
				11/02/2000	71
				09/27/2001	48
Smith1A	GMU	Smith Creek		05/29/2003	44
				Average	58
Smith1	GMU	Smith Creek	At Rt. 616, DEQ station 1BSMT004.60	05/29/2003	56
Smith2	GMU	Smith Creek	At Rt. 794	07/25/2003	45
Smith4	GMU	Smith Creek	At Rt. 608, DEQ station 1BSMT023.18	07/25/2003	41
Smith7	GMU	Mountain Run	At Mt. Valley Rd.	05/29/2003	53
Smith8	GMU	Fridley Run	Just above confluence w/Mountain Run ext.	05/29/2003	53
Smith9	GMU	Mountain Run ext.	Just above confluence w/Fridley Run	05/29/2003	70
				Overall Average	58

Rapid Bioassessment Protocol (RBP) habitat data for Smith Creek VADEQ and GMU biomonitoring stations are shown in Table 3.4 and Table 3.5. These data were used to examine possible sedimentation and other habitat impacts to the benthic community, along with the TSS and turbidity data. All habitat scores were evaluated and rated by observation (0-20, with higher scores being better).

Table 3.5. RBP habitat scores for the Smith Creek watershed

StationID	Coll Date	Total Habitat Scores	Bank condition	Bank vegetative protection	Channel alteration (anthropocentric)	Channel flow status	Embeddedness of stream	Epifaunal substrate (benthic macroinvertebrate)
SMT005.71	10/05/1994	120	8	10	16	18	8	8
SMT005.71	05/22/1995	164	16	16	16	20	12	12
SMT005.71	09/28/1995	146	14	16	18	20	10	10
SMT005.71	05/23/1996	160	16	14	18	20	12	14
SMT005.71	05/27/1997	144	12	8	16	20	12	14
SMT005.71	09/23/1997	134	16	10	10	20	10	12
SMT005.71	10/20/1998	102	6	9	15	19	10	16
Average		138.57	12.57	11.86	15.57	19.57	10.57	12.29
SMT006.62	05/18/1999	136	15	14	17	20	12	17
SMT006.62	10/14/1999	162	16	18	18	19	16	18
SMT006.62	04/17/2000	148	17	15	17	18	17	15
SMT006.62	11/02/2000	154	14	19	18	18	15	17
SMT006.62	09/27/2001	136	17	15	18	16	11	16
Average		147.20	15.80	16.20	17.60	18.20	14.20	16.60

StationID	Coll Date	Grazing or other bank disruptive pressure	Instream cover	Riffle frequency of stream	Riparian vegetation zone width	Sediment deposition in stream	Velocity-depth regimes of stream
SMT005.71	10/05/1994	8	10	8	4	10	12
SMT005.71	05/22/1995	16	12	12	6	12	14
SMT005.71	09/28/1995	10	12	8	4	12	12
SMT005.71	05/23/1996	10	14	10	6	12	14
SMT005.71	05/27/1997	10	12	8	6	14	12
SMT005.71	09/23/1997	6	12	8	4	10	16
SMT005.71	10/20/1998			3	2	7	15
Average		10.00	12.00	8.14	4.57	11.00	13.57
SMT006.62	05/18/1999			11	3	12	15
SMT006.62	10/14/1999			10	12	18	17
SMT006.62	04/17/2000			10	10	14	15
SMT006.62	11/02/2000			13	7	16	17
SMT006.62	09/27/2001			11	6	8	18
Average				11.00	7.60	13.60	16.40

Table 3.6. GMU RBP habitat scores for the Smith Creek watershed

StationID	CollDate	Total Habitat Score	Epifaunal substrate/ Available cover	Embed-dedness	Velocity/ Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles	Bank Stability	Vegetative Protection	Riparian Vegetative Zone Width
Smith1	5/29/2003	123	14	14	14	14	16	15	15	8	8	5
Smith1A	5/29/2003	130	16	16	15	15	16	15	17	6.5	9	4.5
Smith3	5/29/2003	127.5	15	18	16	13	18	15	13	7.5	7	5
Smith7	5/29/2003	152	19	19	15	18	18	18	20	9	9	7
Smith8	5/29/2003	157.5	20	20	15	17	19	19	19	9	10	9.5

3.3. *Benthic Stressor Analysis*

TMDLs must be developed for a specific pollutant. Since a benthic impairment is based on a biological inventory, rather than on a physical or chemical water quality parameter, the pollutant is not identified in the assessment, as it is with physical and

chemical parameters. The process outlined in EPA's Stressor Identification Guidance Document (EPA, 2000) was used to identify the critical stressor for Smith Creek. Elements of the stressor identification process were used to evaluate and identify the primary stressors of the benthic community in Smith Creek, Mountain Run, and Fridley Run. Watershed and water quality data from these streams, reference watershed data, and field observations were used to help identify candidate causes.

Station 1BSMT004.60/GMU1 often showed the poorest water quality of all sampling stations in the Smith Creek watershed. This station had the highest BOD5, total phosphorus, orthophosphate, nitrate, total Kjeldahl nitrogen (TKN), TSS, and turbidity concentrations and recorded the lowest DO level. This station is located in the lower portion of the watershed in a highly agricultural area and downstream of most of the agricultural area within the watershed. Land use in the Smith Creek watershed was shown in Figure 3.2. The watershed primarily consists of forest and pasture/hay land.

Based on the results of the stressor analysis, it was hypothesized that excessive sedimentation and organic inputs caused degraded habitat conditions that were primarily responsible for the benthic impairment in Smith Creek. GMU data indicate lower habitat scores at the DEQ biomonitoring station locations (1BSMT005.71 and 1BSMT006.62) as compared to the upstream GMU sites. These data suggest that sedimentation and other habitat problems are worse in the lower reach, possibly caused by intensive agricultural activities in the lower portion of the watershed. Low pH conditions are considered to be primarily responsible for the noted benthic community impairments on Mountain Run and Fridley Run. There is a transition from limestone to shale geology in this area, which decreases the buffering capacity of the stream. Acid deposition and reduced buffering capacity are believed to be responsible for the low pH values observed in Mountain Run and Fridley Run. Nutrient levels do not appear to have caused negative impacts to DO and pH conditions; therefore, nutrient (phosphorus) reductions were not required. Sediment load reductions and the implementation of the Lacey Spring Branch TMDL should reduce nutrients, organic matter inputs, and other pollutants that may be causing water quality and biological problems. Best Management Practices (BMPs) that are typically used to control sediment also help reduce these other pollutants.

3.4. *Modeling for Bacteria Impairment*

An *E. coli* TMDL was developed using the Loading Simulation Program C++ (LSPC) model. LSPC is a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a simplified stream transport model.

Weather conditions are the driving force for watershed hydrology processes. For the Smith Creek watershed simulation model, the required parameters included hourly precipitation and hourly potential evapotranspiration. Since there were no weather monitoring stations located within the Smith Creek watershed, weather data collected at the Woodstock (449263) and Edinburg (442663) weather stations were used to setup the LSPC model. Available daily precipitation data were disaggregated to hourly measurements based on the hourly distribution of nearby weather stations.

Streamflow data were needed to calibrate the watershed hydrologic parameters in the LSPC model. Hourly streamflow data from the Smith Creek USGS gage (01632900) were used to calibrate hydrology. Representative flow data were available from 1980 through 2002. Two time periods were selected for hydrology calibration: 1990 through 1991 and 1996 through 1997. The land use coverage used in the model was developed during the mid 1990s; therefore, the selected calibration periods were consistent with this key model input. The model was then validated for long-term and seasonal representation of hydrologic trends using the current 13-year period (1990-2002). The calibration and validation periods covered a range of hydrologic conditions, including low and high flow conditions, as well as seasonal variation. The calibrated LSPC model adequately simulated the hydrology of the impaired watershed.

Following hydrology calibration, water quality was calibrated by comparing modeled versus observed in-stream fecal coliform bacteria concentrations. The water quality calibration consisted of executing the watershed model, comparing water quality time series output to available water quality observation data, and adjusting water quality parameters within a reasonable range.

The LSPC model was run for the representative hydrologic period January 1, 1990 through December 31, 2002. The modeling run represents the existing *E. coli* concentrations and loadings at the watershed outlet, using the DEQ fecal coliform bacteria/*E. coli* translator (VADEQ, 2003). These data were compared to the 126 cfu/100mL geometric mean and 235 cfu/100mL instantaneous (single sample) water quality standards for *E. coli* to assess the magnitude of in-stream concentrations. Existing *E. coli* loadings by source category for Smith Creek are presented in Section 4.5. These values represent the contribution of bacteria from all sources in the watershed.

While developing allocation scenarios for the Smith Creek bacteria TMDL, an implicit margin of safety (MOS) was used. Conservative assumptions, the use of a detailed watershed model (LSPC), and other considerations were used in developing the bacteria TMDL, such that an explicit MOS was not necessary.

3.5. *Sources of Bacteria*

Point and nonpoint sources of bacteria in the Smith Creek watershed were considered in TMDL development. Agricultural runoff and wildlife are listed as the primary sources of bacteria, according to the 2002 303(d) Fact Sheet for Smith Creek. Nonpoint sources of bacteria include failing septic systems and straight pipes, livestock (including manure application loads), wildlife, and domestic pets. Point sources, such as municipal sewage treatment plants, can contribute bacteria loads to surface waters through effluent discharges. There are currently 38 point source permits in the Smith Creek watershed, including a Municipal Separate Storm Sewer System (MS4) permit that was issued to the City of Harrisonburg to help control impacts caused by stormwater runoff from urban areas (Table 3.7). The bacteria load contributed by the MS4 permit during runoff events was calculated based on the modeling results for urban lands located within the City of Harrisonburg and the Smith Creek watershed. The bacteria load contributed by all other facilities was calculated based on the permitted flow and the applicable *E. coli* limit (126 cfu/100ml, geometric mean concentration). Note that the following permits do not discharge bacteria and were not included in the

bacteria TMDL for Smith Creek: VA0091235, VAG110131, VAR100591, VAR102386, and VAR051331.

Table 3.7. VPDES point sources and existing loads

VPDES Permit No.	Facility	Flow (MGD)	Permit Limit (E. coli cfu/100ml)	Existing Annual Load (E. coli cfu/yr)
VA0027828	Valley View Mobile Home Court	0.0200	126	3.48E+10
VA0054453	New Market Poultry Products	0.3000	126	5.22E+11
VA0071848	Endless Caverns Inc	0.0048	126	8.01E+09
VA0080636	Two Hills Inc STP	0.0054	126	9.40E+09
VA0077388	Lacey Spring Elementary School STP	0.0075	126	1.31E+10
VA0080784	Holtzman Express-Mauzy	0.0060	126	1.04E+10
VA0088994	Harrisonburg-New Market KOA	0.0100	126	1.74E+10
VA0083305	Camp Overlook	0.0300	126	5.22E+10
VAG408049	Private Residence	0.0010	126	1.74E+09
VAG401001	Private Residence	0.0010	126	1.74E+09
VAG401126	Private Residence	0.0010	126	1.74E+09
VAG401201	Private Residence	0.0010	126	1.74E+09
VAG401179	Private Residence	0.0010	126	1.74E+09
VAG401383	Private Residence	0.0010	126	1.74E+09
VAG401482	Private Residence	0.0010	126	1.74E+09
VAG401537	Private Residence	0.0010	126	1.74E+09
VAG401551	Private Residence	0.0010	126	1.74E+09
VAG401406	Private Residence	0.0010	126	1.74E+09
VAG401890	Private Residence	0.0010	126	1.74E+09
VAG401868	Private Residence	0.0010	126	1.74E+09
VAG401988	Private Residence	0.0010	126	1.74E+09
VAG401981	Private Residence	0.0010	126	1.74E+09
VAG401805	Private Residence	0.0010	126	1.74E+09
VAG401820	Private Residence	0.0010	126	1.74E+09
VAG401432	Private Residence	0.0010	126	1.74E+09
VAG401888	Private Residence	0.0010	126	1.74E+09
VAG401998	Private Residence	0.0010	126	1.74E+09
VAG408026	Private Residence	0.0010	126	1.74E+09
VAG408028	Private Residence	0.0010	126	1.74E+09
VAG408029	Private Residence	0.0010	126	1.74E+09
VAG408030	Private Residence	0.0010	126	1.74E+09
VAG408036	Private Residence	0.0010	126	1.74E+09
VA0091235	Shenandoah Fisheries, Ltd	N/A	N/A	0
VAG110131	Superior Concrete Central Plant	N/A	N/A	0
VAR100591	Rockingham Redi-Mix Inc	N/A	N/A	0
VAR102386	Holtzman Express-Mauzy	N/A	N/A	0
VAR051331	Harper's Lawn Ornaments	N/A	N/A	0
VAR040076	City of Harrisonburg - MS4 Permit	N/A	126	2.88E+12
Total	All Permits	0.4075		3.68E+12

* MGD = million gallons per day

3.6. *Modeling for Sediment Impairment*

Sediment TMDLs were developed using BasinSim 1.0 and the GWLF model (Dai et al., 2000). GWLF is a continuous-simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment, based on daily water balance totals that are summed to give monthly values.

Virginia does not currently have numeric criteria for sediment; therefore, a reference watershed approach was used to determine the sediment load that corresponds with acceptable water quality and habitat conditions necessary to support aquatic life. This approach is based on selecting a nonimpaired watershed that shares similar land use, ecoregion, and geomorphological characteristics with the impaired watershed. Stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired stream to attain its designated uses.

Sediment reductions required for the Smith Creek watershed were based on the reference sediment load that was calculated through modeling of the Hays Creek reference watershed. Daily streamflow data were needed to calibrate watershed hydrologic parameters in the GWLF model. The USGS streamflow gage (01632900), located on Smith Creek near New Market, VA, was used to calibrate hydrology for the impaired watershed (Smith Creek). USGS gage station 02022500, located on Kerrs Creek near Lexington, VA, was used to calibrate hydrology for the reference watershed (Hays Creek). The calibration periods were April 1, 1991 - September 30, 2002 for the impaired watershed and April 1, 1991 through March 31, 1997 for the reference watershed.

The calibration periods covered a range of hydrologic conditions, including low and high flow conditions, as well as seasonal variation. The calibrated GWLF model adequately simulated the hydrology of the impaired and reference watersheds.

Impaired and reference watershed models were calibrated for hydrology using different modeling periods and weather input files. Hays Creek was used as the reference watershed to determine the TMDL load for sediment. For TMDL calculation, GWLF models of the calibrated impaired and reference watersheds were run for a 12-

year period from 4/1/1990 to 3/31/2002. The total area for the reference watershed was reduced to be equal to Smith Creek watershed. This was necessary because watershed size influences sediment delivery to the stream and other model variables. The 11-year means for sediment were determined for each land use/source category in the reference and the impaired watersheds, respectively. This modeling period was used to represent a broad range of recent weather and hydrologic conditions.

While developing allocation scenarios for the sediment TMDL, an explicit margin of safety (MOS) of 10% was used. The TMDL sediment load components included the MOS and the calculated wasteload allocation (WLA), with the remainder assigned to the load allocation (LA). LA consists of loads from nonpoint and background sources. It is assumed that this MOS will account for any uncertainty in the data and in the computational methodology used for the analysis, and will provide an additional level of protection for designated uses.

3.7. *Sources of Sediment*

Sediment sources can be divided into point and nonpoint sources. Sediment loads are primarily contributed by nonpoint sources in the Smith Creek watershed. The major sources of sediment are agricultural land and urban land. Agricultural lands, such as cropland and pasture/hay areas, can contribute excessive sediment loads through erosion and build-up/washoff processes. Agricultural lands are particularly susceptible to erosion due to less vegetative coverage. There are currently 38 point source permits in the Smith Creek watershed, including a Municipal Separate Storm Sewer System (MS4) permit that was issued to the City of Harrisonburg to help control impacts caused by stormwater runoff from urban areas (see Table 3.8). All of these facilities potentially discharge sediment to streams in the Smith Creek watershed.

Table 3.8. VPDES point source facilities in the Smith Creek watershed

VPDES Permit No.	Facility Name	Receiving Stream
VA0027626	Valley View Mobile Home Court	Dry Fork X Trib
VA0054453	New Market Poultry Products	Smith Creek
VA0071846	Endless Caverns Inc	Smith Creek X Trib
VA0080535	Two Hills Inc STP	Smith Creek
VA0077399	Lacey Spring Elementary School STP	Lacey Spring, U.T.
VA0090794	Holtzman Express-Mauzy	Smith Creek
VA0091235	Shenandoah Fisheries, Ltd	Lacey Spring
VA0088994	Harrisonburg-New Market KOA	War Branch
VA0083305	Camp Overlook	Mountain Run
VAG408049	Private Residence	Smith Creek, UT
VAG401001	Private Residence	Smith Creek
VAG401128	Private Residence	Smith Creek, U.T.
VAG401201	Private Residence	Smith Creek
VAG401179	Private Residence	Smith Creek, U.T.
VAG401363	Private Residence	Smith Creek, U.T.
VAG401492	Private Residence	Smith Creek, U.T.
VAG401537	Private Residence	Smith Creek, U.T.
VAG401551	Private Residence	Smith Creek, U.T.
VAG401405	Private Residence	Smith Creek, U.T.
VAG401890	Private Residence	War Branch
VAG401956	Private Residence	Smith Creek, U.T.
VAG401966	Private Residence	Smith Creek UT
VAG401961	Private Residence	Smith Creek UT
VAG401805	Private Residence	Smith Creek, U.T.
VAG401920	Private Residence	Smith Creek, UT
VAG401432	Private Residence	Smith Creek
VAG401988	Private Residence	Smith Creek, U.T.
VAG401998	Private Residence	Smith Creek, U.T.
VAG408026	Private Residence	Dry Fork, U.T.
VAG408028	Private Residence	Smith Creek, U.T.
VAG408029	Private Residence	Smith Creek, U.T.
VAG408030	Private Residence	Smith Creek, U.T.
VAG408035	Private Residence	Smith Creek, U.T.
VAG110131	Superior Concrete Central Plant	Quarry in Smith Creek watershed
VAR100591	Rockingham Redi-Mix Inc	Dry Fork, UT
VAR102386	Holtzman Express-Mauzy	Smith Creek, UT
VAR051331	Harper's Lawn Ornaments	Dry Fork, UT
VAR040075	City of Harrisonburg MS4	N/A

3.8. *TMDL Allocations and Load Reductions*

The objective of TMDL allocations was to distribute allowable loads among different pollutant sources so that the appropriate control actions can be taken to achieve water quality standards (EPA, 1994).

3.8.1. Bacteria TMDL and Allocation Scenarios

The TMDL consists of a point source waste load allocation (WLA), a nonpoint source load allocation (LA), and an implicit margin of safety (MOS), as shown in Table 3.9. The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis.

Table 3.9. *E. coli* TMDL for Smith Creek (cfu/yr)

WLA	LA	MOS	TMDL
8.53E+11	1.24E+13	Implicit	1.33E+13

Load or waste load allocations were assigned to each source category in the watershed. Various allocation scenarios were examined for reducing *E. coli* loads to levels that would result in the attainment of water quality standards (Table 3.10). Scenario 6 presents the source reductions required to achieve the *E. Coli* instantaneous and calendar month geometric mean criteria. Scenario 3 presents the reductions required to meet the Stage I implementation goal of <10% violation of the instantaneous criteria. Reductions in load contributions from in-stream sources had the greatest impact on *E. coli* concentrations. Significant reductions from land-based loadings were also required to meet the geometric mean standard.

Table 3.10. TMDL allocation scenarios and percent violations

	Direct (Instream) Sources			Indirect (NPS) Sources				Percent Violations	
Scenario Number	Straight Pipes	Livestock	Wildlife	Cropland	Pasture	Built up	Forest	Inst. Exceeds 235 cfu/100ml	Geom. Exceeds 126 cfu/100ml
1	0	0	0	0	0	0	0	20%	42%
2	50	50	0	50	50	50	0	11%	6%
3	100	60	0	50	50	60	0	10%	4%
4	75	75	0	75	75	75	0	5%	1%
5	80	80	0	85	85	85	0	2%	0%
6	100	95	0	92	92	95	0	0%	0%

TMDL allocations for Smith Creek (under Scenario 6) are presented in Table 3.11 and Table 3.12.

Table 3.11. Existing and Allocation Loads for LAs under Allocation Scenario 6

Sources		Total Annual Loading for Existing Conditions (cfu/yr)	Total Annual Loading for Allocation Conditions (cfu/yr)	Percent Reduction
Direct	Straight Pipes	<1.00E+4	<1.00E+4	100%
	Livestock	1.68E+13	8.38E+11	95%
	Wildlife	2.64E+12	2.64E+12	0%
Indirect	Cropland*	3.45E+13	2.76E+12	92%
	Pasture**	5.93E+13	4.74E+12	92%
	Built up***	1.15E+13	5.77E+11	95%
	Forest****	8.65E+11	8.65E+11	0%
Total		1.26E+14	1.24E+13	90%

* Includes Barren
** Includes Hayland
*** Non MS4 Urban Pervious and Urban Impervious
**** Includes Wetland

Table 3.12. Existing and Allocation Loads for WLAs under Allocation Scenario 6

Sources	Total Annual Loading for Existing Conditions (E. coli cfu/yr)	Total Annual Loading for Allocation Conditions (E. coli cfu/yr)	Percent Reduction
Permits*	7.09E+11	7.09E+11	0%
MS4 - VAR040075	2.88E+12	1.44E+11	95%
Total	3.59E+12	8.53E+11	76%

* Total for all permits, excluding the Harrisonburg MS4 permit.

3.8.2. Sediment TMDL and Load Allocation Scenarios

The TMDL established for this stream consists of a point source waste load allocation (WLA), a nonpoint source load allocation (LA), and a margin of safety (MOS). The sediment TMDL was based on the total load calculated for the Hays Creek watershed (area adjusted to the appropriate watershed size).

The TMDL equation is as follows:

TMDL = WLA + LA + MOS

The WLA portion of this equation is the total loading assigned to point sources. The LA portion represents the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and the computational methodology used for the analysis. The TMDL (annual load) was calculated by adding reference watershed sediment loads together with point source sediment loads and adding in a 10% margin of safety, as shown in Table 3.13.

Table 3.13. Sediment TMDL for the Smith Creek watershed

TMDL (lbs/yr)	WLA (lbs/yr) (including MS4)	LA (lbs/yr)	MOS (lbs/yr)
27,062,901	353,867	24,002,222	2,706,812

Load or waste load allocations were assigned to each source category in the Smith Creek watershed. Several allocation scenarios were developed for the watershed to examine the outcome of various load reduction combinations. The recommended scenario for Smith Creek (Table 3.14) is based on equal percent load reductions from each source category, with the following exceptions. Sediment loads from forest lands represent the natural condition that would be expected to exist, and therefore, were not reduced. Also, sediment loads from point sources were not reduced because these facilities are currently permitted, meeting their pollutant discharge limits and other permit requirements, and expected to result in attainment of the WLAs as required by the TMDL. Note that the sediment WLA values presented in the following tables represent the sum of all point source WLAs. The estimated sediment loads contributed to the watershed by all permitted facilities are shown in Table 3.15.

Table 3.14. Recommended sediment allocations for Smith Creek

Source Category	Sediment Load Allocation (lbs/yr)	Sediment % Reduction
Forest	299,718	0.0%
Water	0	0.0%
Pasture/Hay	19,040,555	22.0%
Cropland	4,221,267	22.0%
Transitional	363,059	22.0%
Urban (pervious & impervious)	77,623	22.0%
Groundwater	0	0.0%
Point Sources	334,069	0.0%
MS4	19,798	22.0%
TMDL Load (minus MOS)	24,356,089	21.6%

Table 3.15. Sediment waste load allocation for the Smith Creek watershed

VPDES Permit No.	Facility Name	Discharge Type	Design Flow (MGD)	Permitted Concentration (mg/L) or Load (kg/day)	TSS load (lbs/yr)
VA0027626	Valley View Mobile Home Court	General	0.02	45	2,735.9
VA0054453	New Market Poultry Products	General	0.3	147	134,382.8
VA0071846	Endless Caverns Inc	General	0.0046	117	1,641.6
VA0080535	Two Hills Inc STP	General	0.0054	45	740.3
VA0077399	Lacey Spring Elementary School STP	General	0.0075	45	1,030.0
VA0090794	Holtzman Express-Mauzy	General	0.006	45	820.8
VA0091235	Shenandoah Fisheries, Ltd	General	N/A	0.46 kg/day average (final permit limit)	370.2
VA0088994	Harrisonburg-New Market KOA	General	0.01	45	1,368.0
VA0083305	Camp Overlook	General	0.03	45	4,112.0
VAG408049	Private Residence	Stormwater	N/A	30	91.4
VAG401001	Private Residence	Stormwater	N/A	30	91.4
VAG401128	Private Residence	Stormwater	N/A	30	91.4
VAG401201	Private Residence	Stormwater	N/A	30	91.4
VAG401179	Private Residence	Stormwater	N/A	30	91.4
VAG401363	Private Residence	Stormwater	N/A	30	91.4
VAG401492	Private Residence	Stormwater	N/A	30	91.4
VAG401537	Private Residence	Stormwater	N/A	30	91.4
VAG401551	Private Residence	Stormwater	N/A	30	91.4
VAG401405	Private Residence	Stormwater	N/A	30	91.4
VAG401890	Private Residence	Stormwater	N/A	30	91.4
VAG401956	Private Residence	Stormwater	N/A	30	91.4
VAG401966	Private Residence	Stormwater	N/A	30	91.4
VAG401961	Private Residence	Stormwater	N/A	30	91.4
VAG401805	Private Residence	Stormwater	N/A	30	91.4
VAG401920	Private Residence	Stormwater	N/A	30	91.4
VAG401432	Private Residence	Stormwater	N/A	30	91.4
VAG401988	Private Residence	Stormwater	N/A	30	91.4
VAG401998	Private Residence	Stormwater	N/A	30	91.4
VAG408026	Private Residence	Stormwater	N/A	30	91.4
VAG408028	Private Residence	Stormwater	N/A	30	91.4
VAG408029	Private Residence	Stormwater	N/A	30	91.4
VAG408030	Private Residence	Stormwater	N/A	30	91.4
VAG408035	Private Residence	Stormwater	N/A	30	91.4
VAG110131	Superior Concrete Central Plant	Stormwater	N/A	30	91.4
VAR100591	Rockingham Redi-Mix Inc	Stormwater	N/A	100	98,000.1
VAR102386	Holtzman Express-Mauzy	Stormwater	N/A	100	69,253.4
VAR051331	Harper's Lawn Ornaments	Stormwater	N/A	100	17,329.7
VAR040075	City of Harrisonburg MS4	Stormwater	N/A	N/A	19,797.6
				Total Load	**353,867.0**

4.0 CHANGES AND PROGRESS SINCE THE TMDL STUDY

4.1. *BMP Implementation*

Within the Smith Creek watershed, a number of best management practices (BMPs), supported by private and public funding, have been installed since completion of the TMDL study, resulting in new installations of riparian buffers and various other conservation practices, along with the establishment of several conservation easements. These BMP sites are distributed along Smith Creek from its headwaters at Fridleys Gap to its confluence with the North Fork of the Shenandoah River near Mt. Jackson, providing a geographical opportunity for extensive education and the possibility of literally "connecting the dots" with new projects. These restored and protected sites include:

- 65 acres of newly planted forest buffer on two properties restoring four miles of creek frontage near the headwaters at Fridleys Gap, resulting in restored native brook trout. This innovative work has been undertaken under the auspices of the Eastern Brook Trout Joint Venture, U.S. Forest Service, DGIF, and James Madison University students and faculty.
- 334 contiguous acres adjoining Smith Creek just downstream from the brook trout projects listed above and permanently conserved through three conservation easements held by the VOF with support from VCC. Each of the three properties is either enrolled in the Conservation Reserve Enhancement Program (CREP) or has riparian forest buffer protection within the easement.
- four farm owners have enrolled approximately 150 acres in CREP restoring the buffer and stream banks for approximately 2.5 miles. These sites have been used for the last few years by middle school and high school groups for watershed field studies and restoration projects.
- more than 80 farms, distributed throughout the watershed, are participating in various cost share programs offered by USDA/NRCS.
- 53 acres located in downstream segments in Shenandoah County have received support from several Federal and state cost share programs and from Ducks Unlimited to restore stream banks and wetlands and to create wildlife habitat. This landowner continues to welcome studies and tours for educational purposes.

The spatial distribution of BMPs installed and paid for through either the state cost-share program or through USDA's CREP program are shown in Figure 4.1, and detailed in Table 4.1 and Table 4.2 by modeled sub-watershed. Some of these BMPs

were installed prior to the TMDL, but were not accounted for in the TMDL. All of these BMPs have been accounted for in the implementation plan.

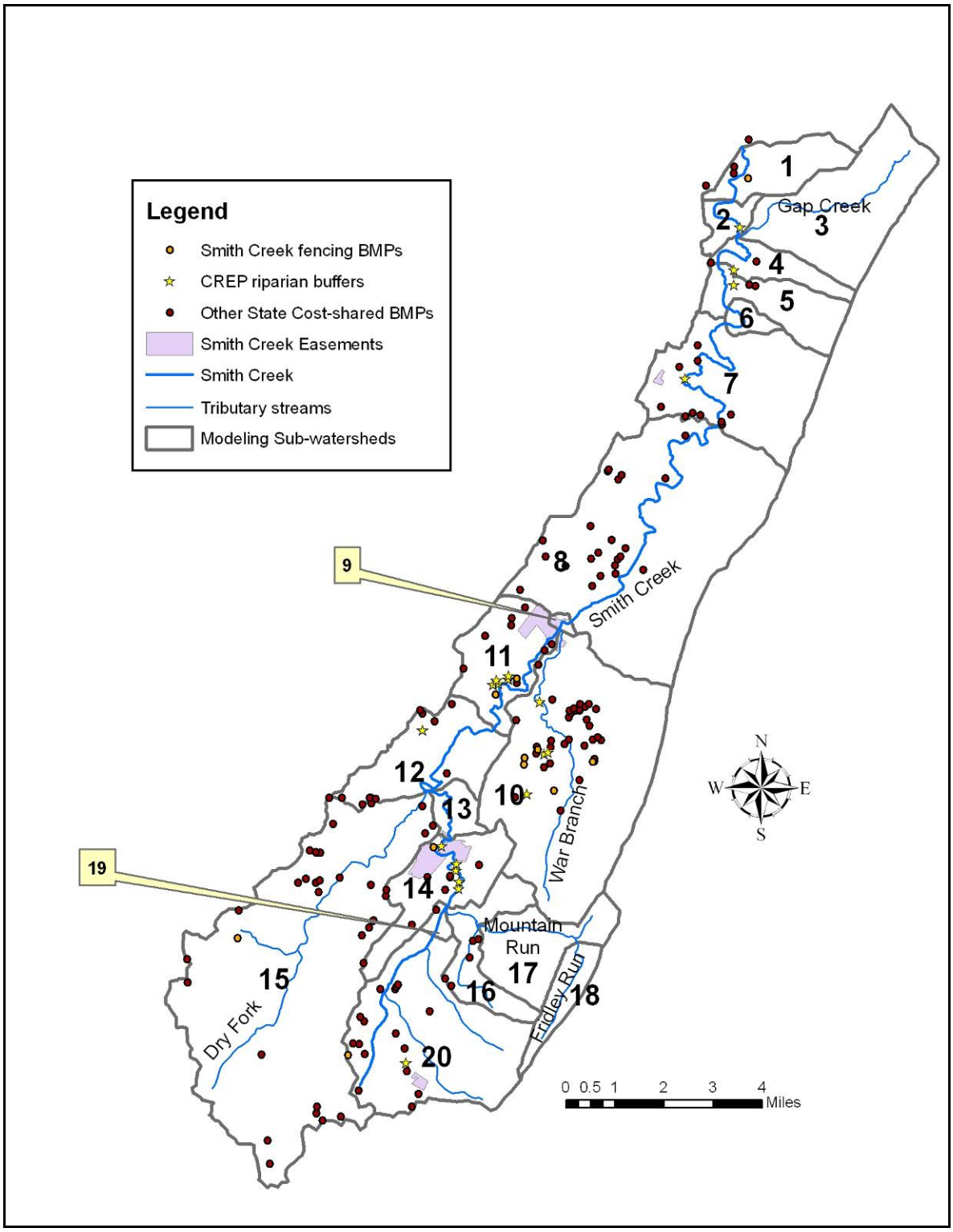

Figure 4.1. Current CREP and State Cost-shared BMPs in Smith Creek watershed

Table 4.1. Smith Creek State Cost-shared BMPs Since 1998

	Sub-watersheds												Watershed Total	Units
	1	4	5	7	8	10	11	12	14	15	16	20		
BMP Code*	**Extent Installed**													
FR-1						3.0						14.0	**17.0**	#N/A
SL-1			19.8	28.0		77.3	17.9		24.5			9.7	**177.2**	ACRES
SL-11					3.5								**3.5**	ACRES
SL-11B						0.2							**0.2**	ACRES
SL-5	1,760												**1,760.0**	LIN FT
SL-6						4,790	133.0		920.0			1,260	**7,103.0**	LIN FT
SL-8B	920		130.0	112.8	298.8	839.5	98.5	188.0	165.9	437.6	42.6	158.9	**3,392.6**	ACRES
WP-2	2,060												**2,060.0**	ACRES
WP-3					1,850								**1,850.0**	ACRES
WP-4		1			3	5	2	2		5		4	**22**	SYSTEM
WP-4B						1							**1**	SYSTEM
WP-4C				1	2	1	1	1		1		1	**8**	SYSTEM
WQ-1	15.2												**15.2**	ACRES
	Acres Benefitted													
FR-1						3.0						14.0	**17.0**	Acres
SL-1			19.8	28.0		77.3	17.9		24.5			9.7	**177.2**	
SL-11					3.4								**3.4**	
SL-11B						35.1							**35.1**	
SL-5	35.0												**35.0**	
SL-6						252.1	133.0		160.0			26.0	**571.1**	
SL-8B	920.0		130.0	164.4	298.8	839.5	98.5	188.0	165.9	437.6	42.6	158.9	**3,444.2**	
WP-2	20.0												**20.0**	
WP-3					1.3								**1.3**	
WP-4B						28.6							**28.6**	
WQ-1	15.2												**15.2**	
	Animal Waste Treated (tons/yr)													
WP-4 (BEEF)						820				145			**965**	tons/yr
WP-4 (DAIRY)						1,420	911			506		3,130	**5,967**	
WP-4 (POULTRY)		187			3,873	2,574	936	2,102		1,324			**10,996**	
WP-4 (TURKEY)												1,740	**1,740**	
WP-4C (BROILER)				510									**510**	
WP-4C (POULTRY)					19	23	23	18		8			**91**	
WP-4C (TURKEY)												23	**23**	

* BMP Code Descriptions are listed in Appendix B.

Table 4.2. Smith Creek USDA-funded CREP Installations Since 1998

	Sub-watersheds									Watershed Total	Units
	2	4	5	7	10	11	12	14	20		
BMP Code*	**Extent Installed**										
CP-21						5.5				5.5	ACRES
CP-22	6.1	1.6	2.6	32.9	31.7	39	4.5	108.3	1.2	227.9	ACRES
CP-22B								35.9		35.9	ACRES
CRFR-3	6.1	1.6	2.6	32.9	31.7	44.5	4.5	108.3	1.2	233.4	ACRES
CRLF-1						300		23232		23532	LIN FT
SL-6					6428	940		1874	1100	10342	LIN FT
WP-2					1010	925	1430			3365	LIN FT
	Acres Benefitted										
CP-21						5.5				5.5	ACRES
CP-22	6.1	1.6	2.6	32.9	31.7	39	4.5	108.3	1.2	227.9	
CP-22B								35.9		35.9	
CRFR-3	6.1	1.6	2.6	32.9	31.7	44.5	4.5	108.3	1.2	233.4	
CRLF-1						0.3		176.6		176.9	
SL-6					53.8	67.2		20.3	25	166.3	
WP-2					6.1	70.2	23.1			99.4	

* BMP Code Descriptions are listed in Appendix B.

4.2. *Monitoring*

4.2.1. Interim Monitoring Sites

Four additional monitoring sites have been sampled in the watershed since completion of the TMDL study. Two probabilistic biological stations were sampled on Smith Creek since the TMDL study, one in 2008 near the outlet at SMT001.53 and the other in 2007 near the Shenandoah / Rockingham county line – SMT009.08; a new water quality station added near the watershed outlet – SMT001.42; and an interim water quality monitoring station in 2005-2006 on War Branch – WAR003.38. These new sites together with 5 other previously active DEQ monitoring sites are shown in Figure 4.2.

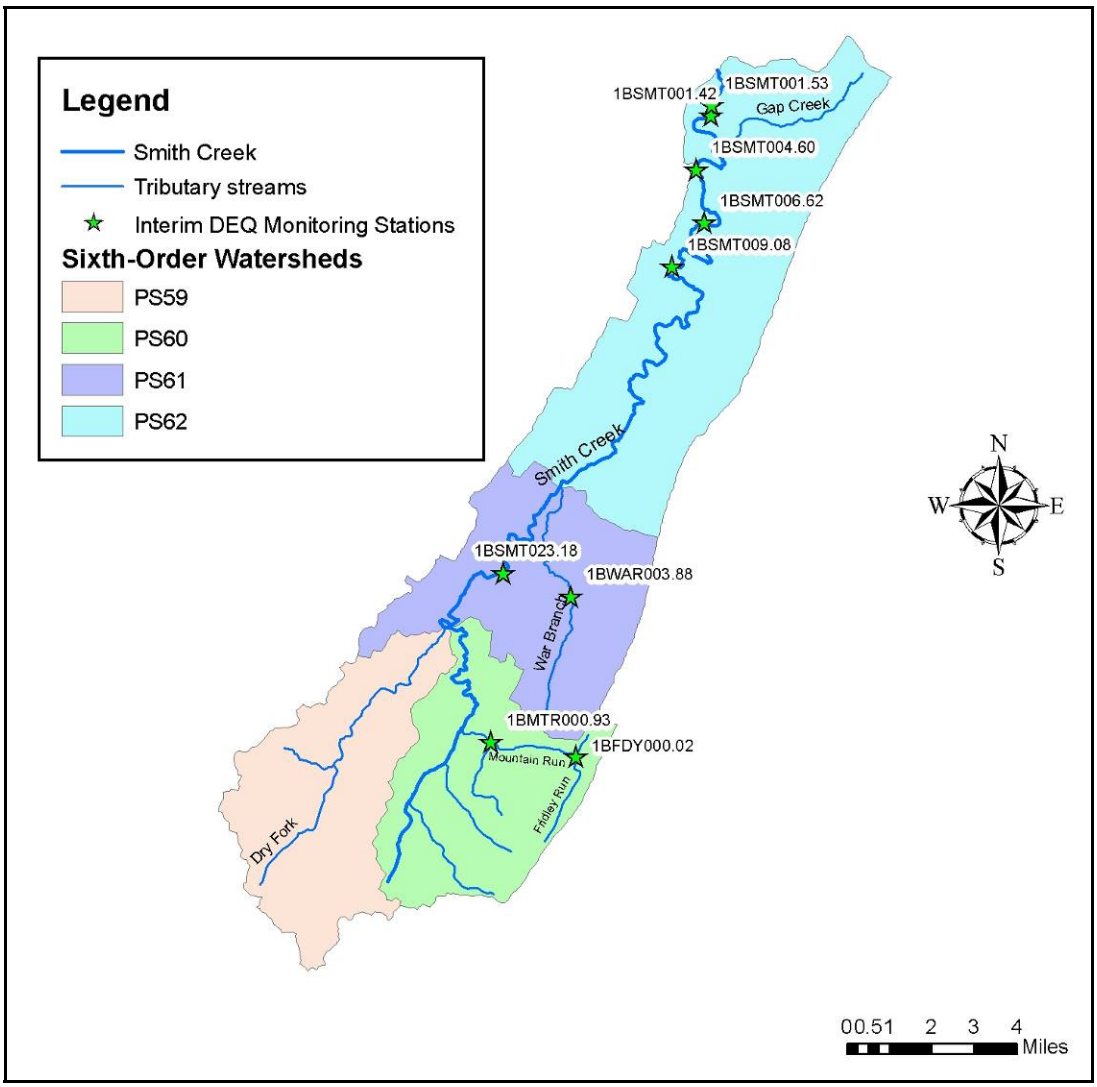

Figure 4.2. DEQ Monitoring Stations in Smith Creek used to assess progress between the TMDL and the Implementation Plan

4.2.2. Biological Monitoring

Biological monitoring in Smith Creek, which is only marginally impaired for its aquatic life use, has remained fairly steady in its periodic Virginia Stream Condition Index (VaSCI) scores compared with historical values, as shown in Figure 4.3. The two samples taken at Dry Fork were lower than all others and appear to be related to poor bank and riparian vegetation above these stations, as shown in Table 4.3. Recent samples taken near the outlet indicate that the lower portion of the main stem of Smith Creek is currently supportive of its aquatic life use.

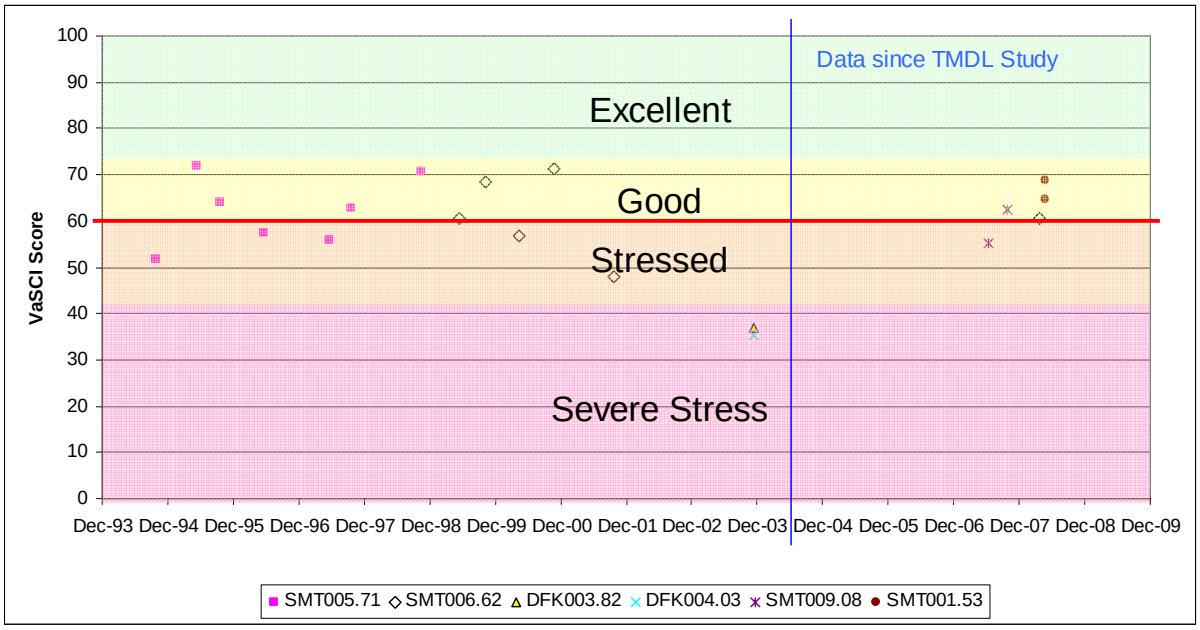

Figure 4.3. Benthic Macroinvertebrate Stream Condition Index (VaSCI)

Table 4.3. Smith Creek Habitat Metrics and Total Scores

Station ID	1BSMT005.71							1BSMT006.62						1BSMT009.08		1BSMT001.53	Average Metric Score
Collection Date	10/5/1994	5/22/1995	9/28/1995	5/23/1996	5/27/1997	9/23/1997	10/20/1998	5/18/1999	10/14/1999	4/17/2000	11/2/2000	9/27/2001	3/26/2008	6/13/2007	9/26/2007	4/30/2008	
Bank Stability	8	16	14	16	12	16	6	15	16	17	14	17	13	14	12	16	13.9
Channel Alteration	16	16	18	18	16	10	15	17	18	17	18	18	17	18	15	18	16.6
Channel Flow Status	18	20	20	20	20	20	19	20	19	18	18	16	18	14	14	19	18.3
Embeddedness	8	12	10	12	12	10	10	12	16	17	15	11	14	9	13	16	12.3
Epifaunal Substrate	8	12	10	14	14	12	16	17	18	15	17	16	17	5	16	18	14.1
Frequency of riffles	8	12	8	10	8	8	3	11	10	10	13	11	13	17	3	13	9.9
Riparian Vegetation Width	4	6	4	6	6	4	2	3	12	10	7	6	8	16	16	14	7.8
Sediment Deposition	10	12	12	12	14	10	7	12	18	14	16	8	7	7	6	18	11.4
Vegetative Protection	10	16	16	14	8	10	9	14	18	15	19	15	15	18	18	18	14.6
Velocity / Depth Regime	12	14	12	14	12	16	15	15	17	15	17	18	17	15	14	17	15.0
10-Metric Total	102	136	124	136	122	116	102	136	162	148	154	136	139	133	127	167	133.8

- Habitat metric score assessed as "marginal" or "poor".

Data since TMDL Study

4.2.3. Water Quality Monitoring

In more recent years, the fecal coliform laboratory analysis method has changed and the upper end of the detection range has decreased from 8,000 to 2,000 cfu/100 mL. Therefore, the apparent decrease in recent fecal coliform concentrations at the primary DEQ monitoring station (SMT004.60) does not necessarily reflect a decrease in the range of fecal coliform concentrations (Figure 4.4). Historically, the highest frequencies of violations were seen in Dry Fork and between Smith Creek stations SMT023.18 and SMT028.00.

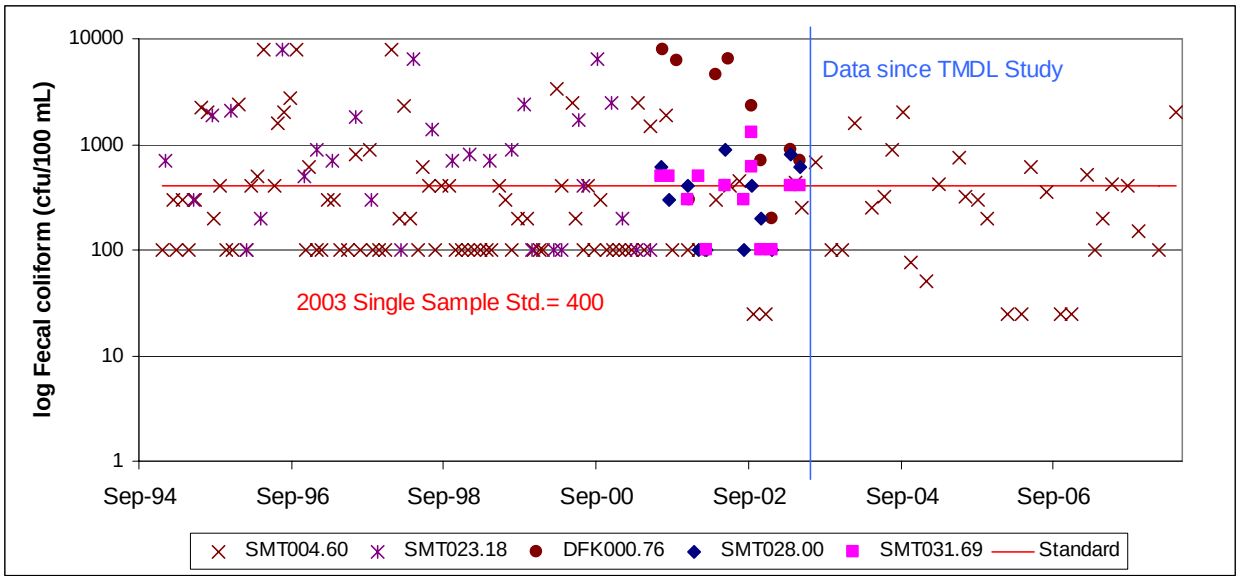

Figure 4.4. DEQ Ambient Fecal Coliform Concentrations

Most of the *E. coli* sampling has occurred since completion of the TMDL study, as shown in Figure 4.5. Violations have been reported at all monitored sites, with the highest violation rates reported at the primary DEQ monitoring site, SMT04.60, and on War Branch, as shown in Table 4.4. For the one station (SMT004.60) with available monitoring data during both the 1995-2003 and 2004-2008 periods, increasing violation rates for both fecal coliform and *E. coli* were observed during the more recent period. Station SMT023.18 showed relatively high exceedence rates for fecal coliform in 1995-2003, but relatively lower rates of *E. coli* exceedence in 2004-2008.

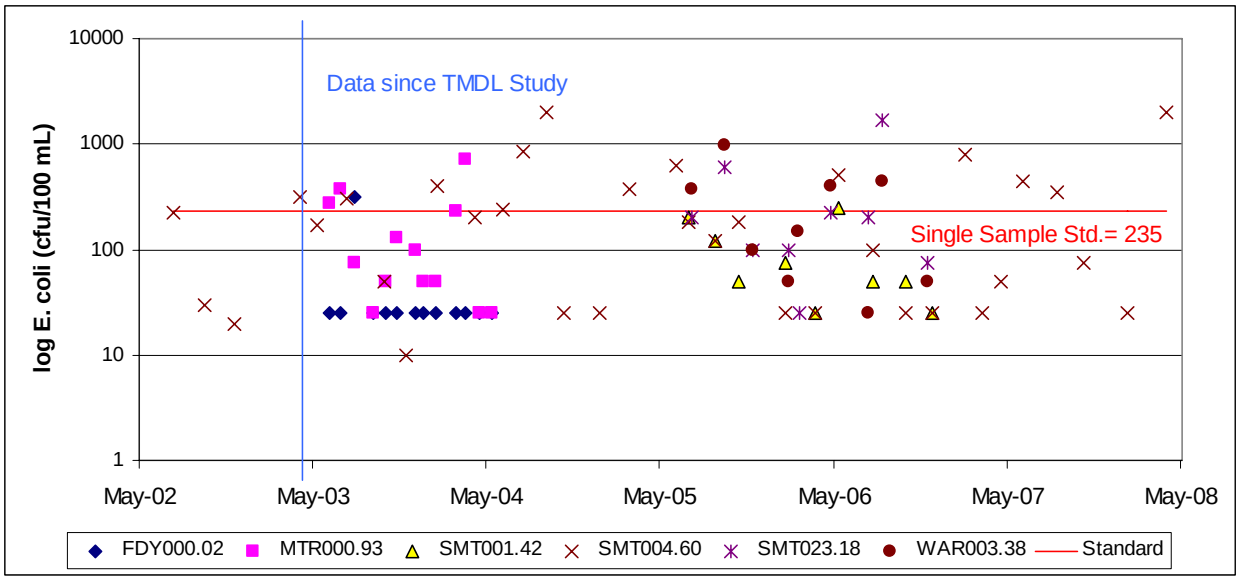

Figure 4.5. DEQ Ambient *E. coli* Concentrations

Table 4.4. DEQ Bacteria Violation Rates

	Std = 400 cfu/100 mL		Std = 235 cfu/100 mL	
	FC % Violations		E coli % Violations	
	1995-2003	2004-2008	1995-2003	2004-2008
SMT001.42	ND	ND	ND	11%
SMT004.60	25%	35%	25%	42%
SMT023.18	60%	ND	ND	22%
SMT028.00	33%	ND	ND	ND
SMT031.69	38%	ND	ND	ND
DFK000.76	73%	ND	ND	ND
WAR003.38	ND	ND	ND	44%
FDY000.02	ND	ND	ND	8%
MTR000.93	ND	ND	ND	23%

ND = no data

4.3. *TMDL Modifications*

The Cedar Lane Trailer Court (VA0092363), located in the Smith Creek watershed, recently submitted an application to DEQ for a VPDES discharge permit. This facility is currently served by on site septic systems that are failing. The failing septic systems will be replaced with a small wastewater treatment facility designed to treat 0.004 mgd. Since this is a new discharge permit, the Smith Creek bacteria and sediment TMDLs do not currently include a WLA for this facility. The TMDLs also have no built-in allocations for growth. DEQ proposes to modify the WLA tables in the TMDL as described below to accommodate this additional discharger.

The revised WLA tables would accommodate this additional discharger at a permitted design flow of 0.004 mgd and at permitted *E. coli* and total suspended solids (TSS) concentrations of 126 cfu/100ml and 30 mg/L, respectively. This equates to a bacteria WLA of 6.96 x 10^9 cfu/100ml and a TSS WLA of 365.5 lbs/yr for this facility. These loads equate to <1% of the bacteria and sediment TMDLs. DEQ proposes to accommodate this increase without increasing the overall WLA or the TMDL by reallocating the WLA assigned to another facility that is no longer discharging. The Valley View Mobile Home Court (VA0027626), which was discharging in the Smith Creek watershed at the time of TMDL development, is no longer discharging. This facility has connected to a regional sewer system that discharges out of the Smith Creek basin. The facility has successfully completed an approved closure plan, and the permit has been terminated, making the assigned waste load allocations of 3.48 x 10^{10} cfu/100ml bacteria and 2,735.9 lbs/yr TSS available for reallocation. These available allocations are more than enough to accommodate the new Cedar Lane Trailer Court discharge. In addition, the Shenandoah Fisheries, Ltd (VA0091235) permit has expired. This facility discharged into Lacey Spring Branch, a tributary of Smith Creek, and was covered by the Trout Farm TMDL completed in June of 2002. Additionally, since the TMDL, 16 new domestic sewage permits have been approved, 4 domestic sewage permits have been terminated, and 4 additional NPDES permits have been approved.

Every facility that proposes to discharge into an impaired stream goes through a Permit Review to ensure it is in compliance with all applicable water quality management plans. All new permits are evaluated to be sure that the discharge of this point source is not more than 1% of the TMDL, and is therefore an insignificant load. The new discharges are also totaled to ensure the combined load of all discharges does not approach the 1% threshold. Updating the WLA tables in the Smith Creek bacteria and sediment TMDLs in accordance with this memo will not cause a water quality violation because the overall WLA and TMDL are not being modified. This revision merely reallocates the existing WLA among dischargers and establishes an allocation for future growth.

The NPDES and single-family home (SFH) permits that have been issued or terminated since completion of the TMDL are shown in Table 4.5.

Table 4.5. New NPDES and General Permits Issued since the TMDL

Permit Number	Type	Status	Receiving Stream
VAG401412	Domestic Sewage/SFH	New	War Branch
VAG401988	Domestic Sewage/SFH	Terminated	Smith Creek, U.T.
VAG408028	Domestic Sewage/SFH	Terminated	Smith Creek, U.T.
VAG408029	Domestic Sewage/SFH	Terminated	Smith Creek, U.T.
VAG408030	Domestic Sewage/SFH	Terminated	Smith Creek, U.T.
VAG408104	Domestic Sewage/SFH	New	War Branch
VAG408129	Domestic Sewage/SFH	New	Dry Fork
VAG408168	Domestic Sewage/SFH	New	Smith Creek
VAG408180	Domestic Sewage/SFH	New	Smith Creek
VAG408192	Domestic Sewage/SFH	New	Smith Creek
VAG408212	Domestic Sewage/SFH	New	Smith Creek
VAG408215	Domestic Sewage/SFH	New	Smith Creek
VAG408224	Domestic Sewage/SFH	New	Smith Creek
VAG408234	Domestic Sewage/SFH	New	Gap Run
VAG408262	Domestic Sewage/SFH	New	Dry Fork
VAG408296	Domestic Sewage/SFH	New	Smith Creek UT
VAG408297	Domestic Sewage/SFH	New	Smith Creek UT
VAG408301	Domestic Sewage/SFH	New	War Branch
VAG408350	Domestic Sewage/SFH	New	Smith Creek UT
VAG408358	Domestic Sewage/SFH	New	Mountain Run, UT
VAR050798	French's Auto Parts, Inc.	New	Smith Creek
VAR050836	RR Donnelley & Sons	New	Dry Fork
VAR050947	Cycle Systems, Inc	New	Smith Creek
VAR051628	Green Earth LLC	New	Smith Creek

4.4. *Corrections to TMDL Land Uses and Watershed Boundary*

4.4.1. Revisions to Categorized Watershed Land Use Areas

An error in the watershed boundary was noticed during the implementation planning process that arose most likely from the use of digital elevation model (DEM) elevation data to define the drainage area during the TMDL study. Since this boundary was not consistent with the state 6-digit watershed boundaries, but only affected sub-watershed 15 and the Harrisonburg MS4 areas in Smith Creek watershed, the TMDL watershed boundary was adjusted to the 6-digit watershed boundary in that sub-watershed. Sub-watershed 15, total watershed, and MS4 acreages were revised accordingly, as shown in Figure 4.6.

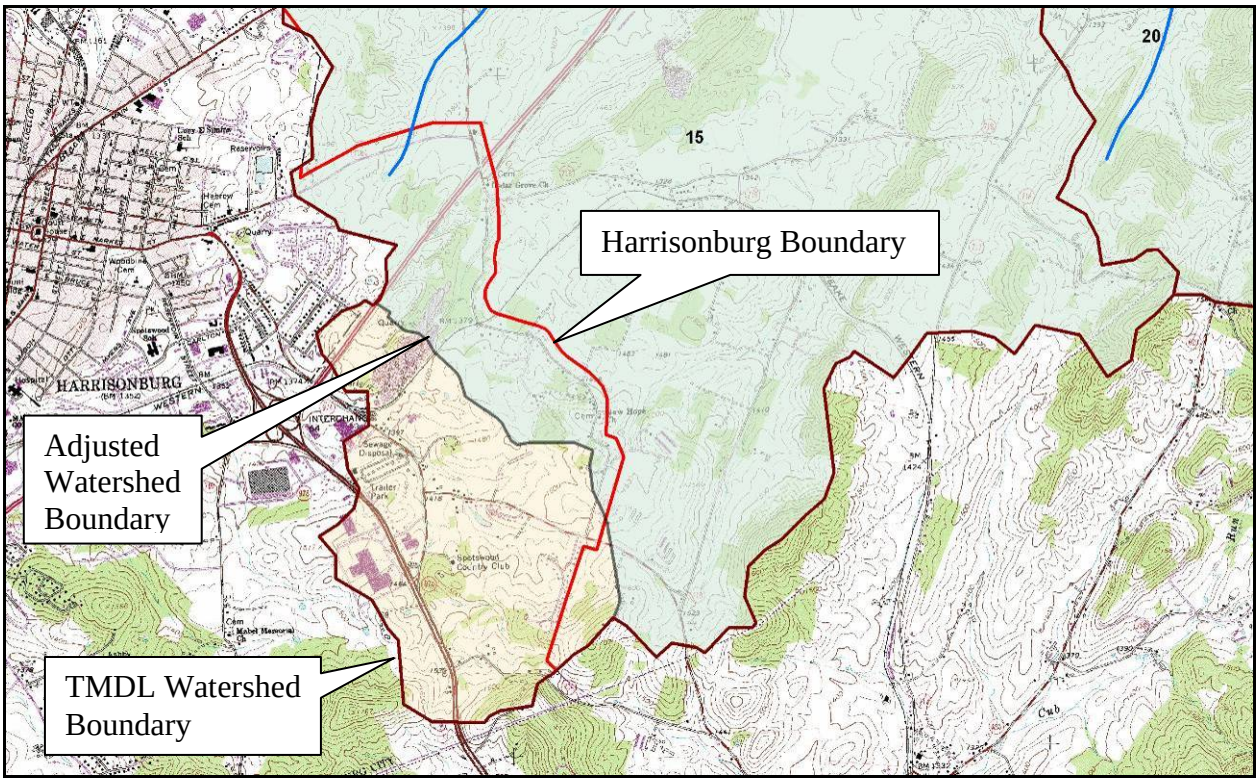

Figure 4.6. Adjustment to the Smith Creek TMDL Watershed Boundary

Also during analysis of land use data from the TMDL study, a small amount (24.83 acres) of land classified as transitional in the Gap Creek area (sub-watershed 3) was re-assessed as mixed forest areas with rock-outcrops. An additional correction was made to reassign this area to the forest land use category. A summary of the land use changes from both the re-classification and the boundary change are given in Table 4.6, as used for bacteria modeling.

Table 4.6. Summary of Corrections to the TMDL Categorized Land Uses

Land Use Category	TMDL Area (acres)	Revised Area (acres)
Barren	172.87	90.49
Cropland	2,585.62	2,551.65
Forest	33,193.96	33,075.82
Pasture	29,444.97	29,190.89
Urban Non-MS4	1,914.34	1,914.34
Urban (MS4)	477.09	101.61
Wetlands	36.25	36.25
Water	88.01	84.94
Total	**67,913.10**	**67,045.98**

Along with the boundary change, the length of roads available for street sweeping within the City of Harrisonburg in the Smith Creek watershed was reduced from 17.82 miles to 5.71 miles, and the perennial stream length in the Harrisonburg portion of Smith Creek watershed was reduced from 1.517 miles to 0.206 miles.

4.4.2. Adjustments to TMDL Target Loads

The implementation plan preserves the bacteria percent reductions by land use category called for in the TMDL study. However, since adjustments were necessary in the contributing areas of the various land uses, the unit-area loads (UALs) associated with the allocated loads and their associated percent reductions were applied to the revised categorized land use areas to define revised target loads for the implementation plan. A summary of the original and revised loads for bacteria are shown in Table 4.7.

Table 4.7. Summary of Original and Revised Bacteria Loads for Implementation Planning

Sources	Existing Load		Allocated Load		% Reductions in Allocated Loads
	Original	Revised	Original	Revised	
Direct NPS Sources					
Straight Pipes	<1.00E+14	NC	0	NC	0.00%
Livestock	1.68E+13	NC	8.38E+11	NC	0.00%
Wildlife	2.64E+12	NC	2.64E+12	NC	0.00%
Indirect NPS Sources					
Cropland**	3.45E+13	3.44E+13	2.76E+12	2.75E+12	0.35%
Pasture	5.93E+13	5.91E+13	4.74E+12	4.72E+12	0.32%
Urban Non-MS4	1.15E+13	NC	5.77E+11	NC	0.00%
Urban MS4	2.88E+12	2.51E+12	1.44E+11	1.25E+11	12.85%
Forest	8.65E+11	8.64E+11	8.65E+11	8.64E+11	0.14%

NC = no change.
** Cropland includes minor bacteria loads from transitional areas.

The implementation plan also preserves the sediment percent reductions by land use category called for in the TMDL study. Since the total watershed area used for the original sediment modeling was slightly different from that used for bacteria modeling, the areas of the original modeled sediment land use categories were used as a starting point and the decreased acreage from the boundary adjustment subtracted from the original areas. As with the bacteria load adjustments, the unit-area loads (UALs) associated with the allocated sediment loads and associated percent reductions were

applied to the revised categorized land use areas to define the revised target loads for the implementation plan. In the original TMDL study, the MS4 load was calculated as the total load from urban lands times the percentage of urban lands within the City of Harrisonburg (20%). Since the boundary change reduced the included area of the City, the percentage of the load attributable to the MS4 area was recalculated as 7.2%. A summary of the categorized areas, sediment loads, and target sediment loads used for implementation planning are shown in Table 4.8.

Table 4.8. Summary of Categorized Areas, Sediment Loads, and IP Target Loads based on the Original and Revised Watershed Boundaries

NPS Sediment Load Categories	Sediment					
	Area (acres)		Load (tons/yr)		IP Target Load (tons/yr)	
	Original	Revised	Original	Revised	Original	Revised
Forest	33,598.43	33,480.32	149.86	149.33	149.9	149.3
Water	100.82	97.67	0.00	0.00	0.0	0.0
Pasture	28,985.32	28,731.34	12,205.55	12,098.56	9,520.3	9,436.9
Cropland	2,656.08	2,622.03	2,705.87	2,671.26	2,110.6	2,083.6
Transitional	158.64	76.18	232.62	111.76	181.4	87.2
Urban Non-MS4	1,999.73	1,972.41	51.53	12.93	40.2	10.1
MS4	499.93	153.03	12.88	3.23	10.0	2.5
MS4 as %Urban	20.0%	7.2%				
NPS Totals	**67,999.0**	**67,133.0**	**15,358.3**	**15,047.1**	**12,012.5**	**11,769.6**

4.4.3. Revisions to Pet Waste Contribution

The TMDL originally estimated the pet population in the MS4 area as 20% of the total watershed pet population. The total pet population was 2,687 and the initial MS4 pet population was 537. Since the MS4 area decreased by 62.5% of its original area with the boundary correction, the pet population in both the MS4 and the watershed areas were reduced by 537 times 0.625 (336), giving new pet populations in the MS4 area of 201, and in the total watershed of 2,351. The pet population in the Non-MS4 Urban area was not changed.

4.4.4. Load Reductions due to Control Measures Implemented since TMDL

Because many BMPs have already been installed in Smith Creek since the completion of the TMDL study, as summarized in section 4.1, the associated load reductions have given the watershed a head start toward meeting the load reduction

target goals for both bacteria and sediment. An estimate of the associated bacteria load reductions due to these implemented control measures in the agricultural source categories are given in Figure 4.7.

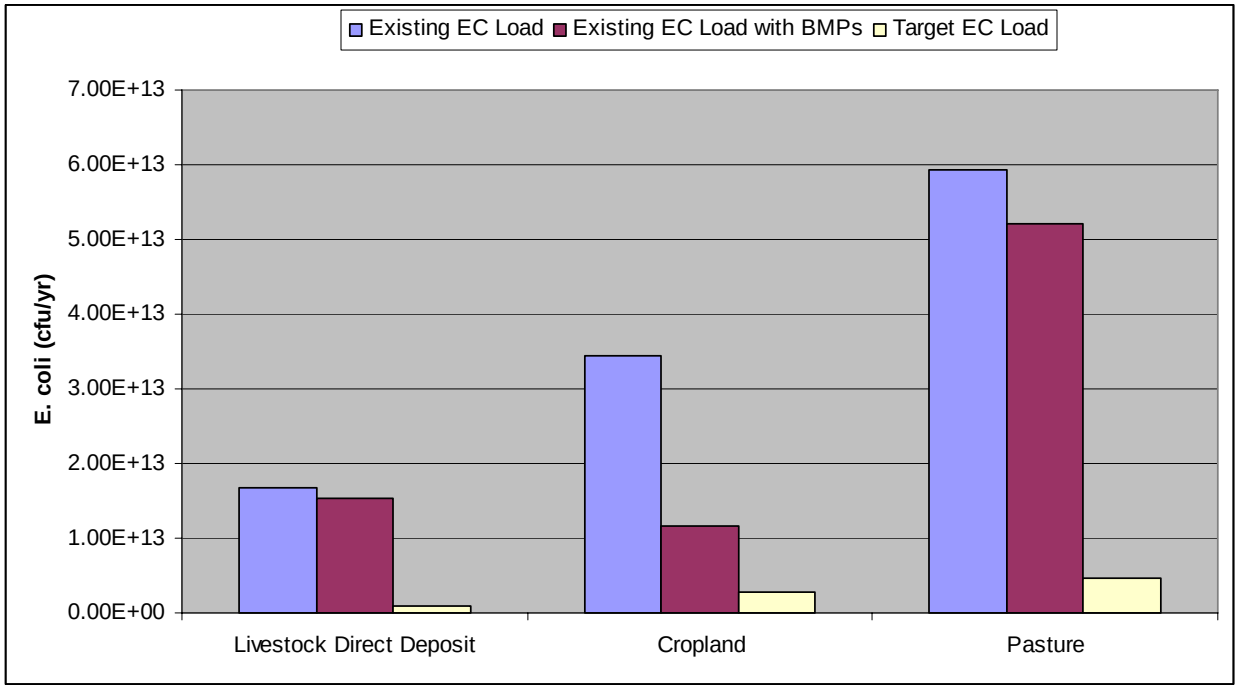

Figure 4.7. Progress in Bacteria Load Reductions in Smith Creek Watershed

5.0 PUBLIC PARTICIPATION

An essential step in developing and carrying out a TMDL IP is gathering input from a broad range of individuals, agencies, organizations and businesses with interest in and familiarity with local water quality needs and conditions. Watershed stakeholders are best suited to identify and resolve sources of water quality problems within their own communities. Public participation facilitates dialogue between local stakeholders and government agencies, encourages the commitment of resources for TMDL implementation, such as funding and technical support, and facilitates implementation of feasible solutions to water quality problems.

The Resource Team for this project included members of Virginia Tech's Biological Systems Engineering (BSE) Department, University of Virginia's Institute for Environmental Negotiation, the Healthy Waters Initiative, VADEQ, and the Virginia Department of Conservation and Recreation (VADCR).

Public participation in the development of the IP was achieved through a series of Focus Groups under the facilitation of the Resource Team.

An informational meeting was held on May 27, 2008 at the Town Hall in New Market, Virginia to discuss the development of a watershed plan (the Smith Creek TMDL Implementation Plan) to reduce identified pollutants in the Smith Creek watershed. The meeting was attended by 25 members of local, state, regional, and county agencies. The focus of this meeting was a review of details from the TMDL study, information about current activities in the watershed, information on the implementation planning process, and an invitation to the public to be involved in the IP development by participating in Focus Group discussions.

A web site forum was set up to provide stakeholders in Smith Creek access to handouts and presentations from all public and focus groups and to provide an accessible means of feedback to the Resource Team (http://www.tmdl.bse.vt.edu/forums/).

An informational booth describing the Smith Creek Watershed Partnership was set up and manned during the Tenth Legion Ruritan Lawn Parties on June 13-14 and July 25-26 by members of the Resource Team. Information was provided about clean-up efforts in the Smith Creek watershed and invitations were given to participate in the implementation planning process.

The first public meeting for developing the TMDL Implementation Plan for Smith Creek was held on Wednesday, August 6, 2008, at the New Market Town Hall at 7:00 pm.

A post card, a press release, and a public notice were distributed to advertise the meeting. During the second half of the meeting, the group divided up into three working or Focus Groups. The Focus Groups were developed to represent the major interests in the watershed, and named Agricultural, Residential/Urban and Government. Because of the perceived commonalities, the Residential/Urban and Local Government Groups were combined into the Growth & Development Focus Group. Each Focus Group was given the following tasks related to identified problems in Smith Creek relevant to their focus area:

1. Discuss the extent and probable locations of problems.
2. Discuss best management practices (BMPs) or other ways to reduce pollutant loads from the various sources.
3. Review watershed information related to simulating planned pollutant reductions.
4. Discuss constraints faced by stakeholders in implementing BMPs.
5. Discuss strategies to educate and involve stakeholders in implementing the needed changes.

A second set of Focus Group meetings was held on September 3, with the Agricultural Focus Group meeting from 1:00-3:00 pm, and the Growth & Development Focus Group meeting from 3:30-5:00 pm. Each group was presented with draft strategies comprised of proposed BMPs and extents required to meet the source-specific bacteria and sediment reductions called for in the TMDL. The discussions and feedback resulted in changes both in the proposed list of BMPs and in the relative extents of each that were expected to be achievable in the watershed.

A third set of Focus Group meetings was held on November 6, 2008, with the Agricultural Focus Group meeting from 1:00-3:00 pm, and the Growth & Development Focus Group meeting from 3:30-5:00 pm. Each group was presented with a refined set of alternative control measures and extents required to meet the source-specific bacteria and sediment reductions called for in the TMDL. A presentation was also given during the Growth & Development Focus Group about the Nonpoint Education for Municipal Officials (NEMO) program, an educational program for local land use officials that addresses the relationship of land use to natural resource protection, and how it might assist with implementation of the Smith Creek IP. The discussions and feedback helped to finalize the list of control measures and extents included in the IP.

The final public meeting for the Smith Creek TMDL Implementation Plan was held at 6:00 pm on February 22, 2009 at the Tenth Legion Ruritan Hall, in Tenth Legion, Virginia. Over 70 people attended this Celebration Event, which was advertised by letters and phone calls to landowners, watershed signs at stream crossings and email newsletters. A BBQ dinner was provided for all participants by the Highlands Action Program, a project partner. After dinner, the TMDL and IP were summarized, and a guest speaker was introduced. Corey Guilliams, District Conservationist for NRCS in Rockingham County, spoke about the relationship between herd health and water quality. After his short program, attendees were able to visit over 14 exhibits set up by project partners about how their organizations are improving water quality in Smith Creek

A Steering Committee is in the process of being formed through invitation from the Resource Team. The Committee is envisioned as a combination of governmental agency personnel, representatives from each of the Focus Groups, the Support Team, and stakeholders with existing responsibilities related to the various pollutant source reduction categories. A joint meeting of the Steering Committee and the Resource Team is planned to be held after the Final Public Meeting.

6.0 IMPLEMENTATION ACTIONS

An important element of the TMDL implementation plan is to encourage voluntary compliance with implementation of control measures by local, state, and federal government agencies, business owners, and private citizens. In order to encourage voluntary implementation, information must be obtained on the types of control measures that can achieve the pollutant reduction goals specified in the TMDL as practically and cost-effectively as possible.

6.1. *TMDL Reduction Goals*

The Smith Creek TMDL identified bacteria and sediment as the pollutants responsible for the impairment in Smith Creek. Table 6.1 summarizes the pollutant sources and reductions called for in the TMDL for both bacteria and sediment. Since many of the control measures or best management practices (BMPs) installed for bacteria reductions also reduce sediment and since the needed bacteria reductions are much greater than those needed for sediment, a separate set of Stage I sediment reduction targets were not specified in the TMDL.

Table 6.1. Summary of Smith Creek TMDL Reductions

Sources	Bacteria		Sediment
	TMDL	Stage I	
Direct Stream Sources			
Livestock - direct deposit	95%	60%	NA
Straight pipes and failing septic systems	100%	100%	NA
Indirect Land Sources			
Cropland	92%	50%	22%
Pasture	92%	50%	22%
BuiltUp Areas			
Non-MS4 Urban	95%	60%	22%
Transitional			22%
MS4 Urban	95%	60%	22%

6.2. *Selection of Appropriate Control Measures*

Potential control measures, their costs, and pollutant removal effectiveness estimates were identified through a review of the Smith Creek TMDL, through input from the Smith Creek TMDL IP focus groups, from a literature review, and from modeling.

Because Smith Creek contains a combination of agricultural, rural, suburban, and urban land uses, implementation actions to address the required pollutant reductions will consist of a variety of control measures to address each pollutant source. Control measure selection was based on their ability to control specific pollutant sources, the required pollutant load reductions, the potential for cost-sharing of the control measure, the likelihood of implementation by landowners, and the input of Smith Creek watershed stakeholders. Pollutant sources fall into two basic categories: those contributing directly to the stream and those contributing indirectly to the stream from land sources. Control measures required to reduce these pollutant sources are described below.

6.2.1. Control Measures for Direct Stream Sources

Control measures were needed to reduce pollutant sources that contribute directly to the stream, the "Direct Stream Sources". The Direct Stream Sources that need to be controlled in Smith Creek include livestock defecating directly in streams (direct deposit) and residential wastewater discharges (straight pipes and failing septic systems). In order to meet the 95% reduction in direct deposits from livestock, some form of stream exclusion is necessary. The 100% reduction in bacteria loads from the residential wastewater discharges is a pre-existing legal requirement, further reinforced by this TMDL. Control measures used to address these sources include new or repaired septic systems, alternative onsite sewage treatment systems, or connection to an available sewer system.

6.2.2. Control Measures for Indirect Land Sources

Control measures were also needed to reduce pollutant sources that are distributed across the land surface, whose loads are then transported to streams during surface runoff, the "Indirect Land Sources". Control measures may reduce bacteria loads to the land surface, or may reduce sediment and bacteria transport by surface runoff through infiltration, filtration, or reductions in flow velocity. The Indirect Land Sources that need to be controlled in Smith Creek include runoff from cropland, pasture, and urban areas. The final set of control measures and their related efficiencies used in this study to estimate pollutant load reductions are listed in Table 6.2. The control measures are arranged by general land use/source categories.

Table 6.2. Potential control measure efficiencies for bacteria and sediment

Control Measures	Associated Cost-shared BMPs	% Effectiveness		Effectiveness Source	
		Bacteria	Sediment	Bacteria	Sediment
Agricultural Control Measures					
Grass riparian buffers[b]	CP-21, WQ-1	40%	40%	2	1
Forested riparian buffers[b]	CRFR-3	40%	40%	2	1
Reforestation of erodible pasture	FR-1	simulated	simulated	3	3
Critical area stabilization	SL-11	simulated	simulated	3	3
Contour stripcropping	SL-3, SL-3B	1 - P factor	1 - P factor	2	19
Cover crops	SL-8B, SL-8H, WQ-4	20%	20%	2	4
Manure injection		90%	-- NA --	5	-- NA --
Manure storage facility - beef	WP-4	75%	-- NA --	10	-- NA --
- dairy	WP-4	75%	-- NA --	10	-- NA --
- poultry	WP-4	99%	-- NA --	8	-- NA --
- turkey	WP-4	75%	-- NA --	10	-- NA --
Livestock exclusion fencing	SL-6, WP-2T, CREP, CRP	100%	-- NA --	6	-- NA --
Livestock exclusion buffers[b]	SL-6, WP-2T, CREP, CRP	40%	40%	2	1
Adaptive fencing		100%	-- NA --	6	-- NA --
Hardened crossings[c]	WP-2T				
Alternative water systems[c]	SL-6, SL-6B, CREP, CRP				
Improved pasture management		92%	92%	2	7
Winter feeding facility	WP-4B, WP-8	75%	-- NA --	11	-- NA --
Agricultural sinkhole protection	WQ-11				
Suburban/Urban Control Measures					
Pet waste program		75%	-- NA --	8	-- NA --
Street sweeping		22%	22%	2	9
Rain gardens[b]		85%	85%	2	6
Bioretention filters[b]		85%	85%	2	6
Enhanced E&S Management		-- NA --	40%	-- NA --	1
Residential Wastewater Control Measures					
System Pumpouts	RB-1		-- NA --		-- NA --
New Sewer Hookups	RB-2	100%	-- NA --	6	-- NA --
System Repairs	RB-3	100%	-- NA --	6	-- NA --
New Septic Systems	RB-4	100%	-- NA --	6	-- NA --
New Septic Systems w/ pumps	RB-4P	100%	-- NA --	6	-- NA --
Alternative Septic Systems	RB-5	100%	-- NA --	6	-- NA --

[b] Filtering includes additional reductions from upstream runoff loads: buffers - 4x buffer area; rain gardens - 6x; bioretention filters - 20x.
[c] Included as part of livestock exclusion fencing systems.
1 - EPA-CBP, 2008.
2 - Bacteria efficiency assumed equal to sediment efficiency.
3 - Based on differential loading rates to different land uses.
4 - EPA-CBP, 2006.
5 - Alberta Government, Agriculture and Rural Development, 2005.
6 - By definition.
7 - Based on simulated unit area sediment load difference between "fair" and "good" pasture.
8 - MapTech, Inc. 2006.
9 - Curtis, M.C., 2002.
10 - EPA-CBP, 2003.
11 - Scraped manure transferred to manure storage, so bacteria reduction estimated same as WP-4.
19 - Contour strip-cropping has a variable effectiveness based on its slope range, Wischmeier and Smith, 1978.

6.3. *Quantification of Control Measures by Pollutant Source*

The extent of existing control measures previously implemented in the Smith Creek watershed were quantified using the Virginia DCR and USDA Conservation Reserve Enhancement Program (CREP) databases and from local Soil and Water Conservation District (SWCD) estimates of voluntary installations (Chapter 4). The beginning list of control measures considered for inclusion in the implementation plan consisted of those practices already installed in the Smith Creek watershed, given that there is already some degree of acceptability for these types of control measures. An analysis was then performed to identify the maximum extent of each measure needed to meet reduction goals. The initial list of control measures was supplemented with additional measures through discussions with stakeholders at the public and focus group meetings. Additional measures needed to meet the bacteria and sediment reduction targets (Table 6.1) were identified through discussions with focus group participants and quantified using a combination of GIS analysis and modeling, followed by spreadsheet analyses to calculate load reductions from each control measure as applied to each pollutant type and source category. This section provides a summary of the final set of control measures and extents needed to achieve the pollutant load reductions specified in the TMDL.

Load reductions were based on source loads simulated for the TMDL study, changes in land use, filtering effects of applicable control measures, and the application of effectiveness estimates. Additional details on load reduction calculations are provided in Appendix C.

6.3.1. Livestock Direct Deposit

Eliminating unrestricted livestock access to streams (100% livestock exclusion) is assumed to provide 100% reduction in livestock direct deposits. A GIS analysis was performed to delineate stream lengths adjacent to, or included in, pasture areas in the Smith Creek watershed, using both the National Land Classification Dataset (NLCD) and more recent Mid-Atlantic RESAC land use data layers. Although a comparison of the NLCD-classified pasture areas with aerial imagery indicated poor alignment of pasture areas, the total NLCD pasture acreage was determined (through consultation

with the regional USDA-NRCS GIS analyst) to be more reflective of conditions in the watershed and could be used to provide a reasonable estimate of riparian streams. Since NLCD data was also used for the determination of land use areas for the TMDL modeling, these data were used for IP development to assess the relative position of pasture areas and streams. The National Hydrography Dataset (NHD) streams layer was used to represent streams and to classify them as either perennial or intermittent. In discussions with local SWCD and UDSA-NRCS personnel, it was estimated that in addition to the perennial streams in pasture areas, 30% of intermittent streams could benefit from livestock exclusion control measures.

"Livestock exclusion fencing" is defined as fencing that meets DCR cost-share requirements with a minimum 35 ft. buffer, while "adaptive fencing" is defined as poly-wire fencing with a narrower buffer width, estimated as 10 ft. for planning purposes. The option of "adaptive fencing" was included to accommodate the flexibility desired by some farmers in the type of fencing and the amount of buffer width they are willing to exclude from their pasture areas. While buffer widths were not necessary to define the extent of livestock exclusion fencing needed, they provide complimentary filtering of pollutants from upland pasture sources. Table 6.3 summarizes the control measures and extents estimated to achieve the 95% reduction in bacteria loads from livestock direct deposits, specified in the TMDL. Based on the distribution of stream locations, 68.1% of the required control measures are needed in Rockingham County and 31.9% in Shenandoah County.

Table 6.3. The Extent of Livestock Exclusion Control Measures and Reductions

Livestock Exclusion Measures	Units	Extent installed since TMDL	Add'l. Extent Required	In-stream Bacteria Load Reduction (cfu/yr)	% Reduction
Livestock exclusion fencing[a]	lin.ft.	52,458	671,748	1.19E+ 13	71.3%
Adaptive fencing[a]	lin.ft.		241,402	3.98E+ 12	23.8%
Hardened crossings[c]	no.		36		
Alternative water systems[c]	no.		150		
			IP EC Reductions =	1.59E+ 13	95.0%
			TMDL EC Reduction Goals =	**1.59E+ 13**	**95%**
			IP EC Load =	8.38E+ 11	

[a] Fencing unit cost includes charger and an allowance for cross-fencing.
[c] Components of fencing systems.

Conversations with DCR and local SWCD personnel were used to determine characteristics of typical livestock exclusion systems in order to quantify the number of expected cost-shared BMPs. The typical cost-shared BMPs for livestock exclusion are the SL-6 and WP-2T systems of practices. The SL-6 practice (Grazing Land Protection Systems) includes streamside fencing, cross fencing, alternative watering system(s), and a 35-ft buffer from the stream. According to the VADCR Agricultural BMP Database, ten of these systems have been installed with an average streamside fencing length of 710 feet and an average cost of $20,300. However discussions with local SWCD personnel reported that the cost of just installing an alternative watering system in the area would run $20,000 and average system streamside fencing lengths are typically longer. Based on these discussions, an SL-6 system was defined as fencing along both sides of 2,000 feet of stream, an additional 50% of length allowed for cross-fencing, an alternative watering system, and a 35-ft stream buffer, at an average system cost of $36,456. Since some operations requiring fencing already have alternative watering systems in place, the WP-2T practice (Stream Protection Systems) will be more appropriate. The WP-2T system in Smith Creek was defined as fencing along both sides of 1,200 feet of stream, a hardened stream crossing, and a 35-ft stream buffer, at an average system cost of $11,864. Each WP-2T system was defined for a shorter length of stream, as crossings were more likely to be needed along perennial streams, whereas SL-6 installations were considered to include a combination of perennial and intermittent streams.

During the Agricultural Focus Group discussions, it was concluded that some farmers would be unwilling to install fencing with a 35-ft setback. The pilot fencing program that is currently being implemented by the Shenandoah RC&D was used as a model to demonstrate how we might be able to work with other landowners in the watershed to exclude livestock from streams with adaptive fencing, a practice that is not currently eligible for cost-sharing through DCR. Approximately 10% of the extent of required stream fencing was estimated as being installed through the WP-2T practice, 25% as adaptive fencing, and the remaining amount through the SL-6 practice. In the Smith Creek watershed, this amounts to 150 SL-6 systems, 36 WP-2T systems, and 45.7 miles of adaptive fencing. This IP focuses on fencing along both perennial and

intermittent streams because the TMDL requires stringent reductions of fecal bacteria from direct livestock and agricultural nonpoint sources.

6.3.2. Straight Pipes and Failing Septic Systems

The percentages of the non-sewered population with failing septic systems and straight pipes in Smith Creek watershed were estimated as 4% and 0.5%, respectively, in each sub-watershed, according to the TMDL report. During a follow-up analysis of sewered areas in the watershed, a portion of the sewered population surrounding the town of New Market was identified that had not been included in the TMDL analysis. Therefore, the non-sewered population and associated numbers of failing septic systems and straight pipes were reduced in two of the affected sub-watersheds. The number of systems was then calculated as the non-sewered population in each sub-watershed divided by the area-weighted "average population/household" obtained from census data. Since this source of bacteria loading is not permitted, 100% reduction of this source is required in the TMDL. Table 6.4 gives a summary of control measures estimated to remediate this source of bacteria, together with control measures installed since completion of the TMDL. "System pump outs" may not necessarily solve existing problems, but are control measures needed for routine maintenance. These pump outs will likely prevent future problems and will also provide a means to begin a dialogue with homeowners whose systems may need one of the other control measures. Some alternative septic systems are needed because of soil and bedrock limitations in the watershed. In addition to these control measures, an educational effort will be important for successful implementation. Based on the distribution of population, 72.2% of the needed control measures are in Rockingham County and 27.8% are in Shenandoah County.

Table 6.4. The Extent of Residential Wastewater Control Measures

Control Measures	BMP Code	No. Needed	Extent Installed since TMDL~	Addt'l Extent Required
System Pumpouts	RB-1	1,169	61	1,108
New Sewer Hookups	RB-2	7	0	7
System Repairs	RB-3	17	9	8
New Septic Systems	RB-4	13	0	13
New Septic Systems w/ pumps	RB-4P	6	0	6
Alternative Septic Systems	RB-5	72	2	70

RB-1 estimated as 60% of total number minus other repairs.
RB-2 estimated from existing homes near sewered area boundaries.
RB-3 estimated as 20% of failing septic systems.
RB-4 estimated as systems needed to replace straight pipes.
RB-4P estimated as ≈1/2 of RB-4 systems.
RB-5 estimated as 80% of failing septic systems.
~ Control measures installed by FNFSR in 2003-2004.

6.3.3. Cropland

Runoff from cropland is a source of both bacteria and sediment loads. Bacteria loads to the land come from the spreading of stored manure and from wildlife, while sediment loads result from combinations of slope, soil conditions, vegetative cover, and rainfall intensity. Bacteria from manure can be reduced either by source reduction or filtering measures (buffers), while sediment can be reduced by measures that increase vegetative cover, reduce effective slope lengths, or provide filtering. Control measures that have been installed since the TMDL or that had been installed prior to the TMDL but were not credited in the TMDL were identified and their load reductions quantified. Additional measures were then identified and pollutant load reductions quantified so that the required cropland TMDL load reductions were met (Table 6.5).

Since proximity to streams is a factor in pollutant delivery to streams, a GIS analysis was performed to identify cropland that was adjacent to, or included, perennial stream segments. Grass buffers were included to reduce the pollutant loads associated with cropland adjacent to streams. Two of the Smith Creek sub-watersheds have slopes that are significantly steeper than the rest of the watershed. Pollutant loads from the very small amounts of cropland in these sub-watersheds may best be reduced by converting it to some type of permanent cover, forest, or pasture. While the “manure

injection" control measure currently appears to be too expensive for widespread application, this control measure is specified on a small fraction of the cropland acreage (0.8%) to acknowledge an existing demonstration effort and to encourage future consideration of this measure in the watershed. A large number of animal waste facilities have been installed in the watershed, so the capacity for a large amount of bacteria source reduction is already in place. Together with the other measures, only a few additional beef and poultry waste storage facilities will be needed to achieve the 92% bacteria load reduction required from cropland. Because many of the bacteria control measures also reduce sediment, and because the 22% required sediment load reduction from cropland was much smaller than that specified for bacteria, no further control measures are needed to explicitly control sediment losses from cropland. Based on the distribution of cropland in Smith Creek, 66.7% of the needed control measures are needed in Rockingham County and 33.3% in Shenandoah County.

6.3.4. Pasture

Runoff from pasture is also a source of both bacteria and sediment loads. Bacteria loads to pasture areas come from grazing livestock, the spreading of stored manure, and wildlife. The control measures needed to meet TMDL load reductions for both bacteria and sediment are shown in Table 6.6. After accounting for load reductions from currently installed control measures, load reductions resulting from filtering effects of buffers associated with livestock exclusion fencing were quantified. Load reductions realized by reforestation of 5% of the pastures in the 2 steepest sub-watersheds were also quantified. Bacteria load reductions to the pasture surface due to the application of stored manure were also credited. Stored manure contains fewer bacteria because bacteria die-off occurs while the manure is in storage. It was estimated that 25% of the manure stored in the Smith Creek watershed is applied to pasture. Upon the recommendation of local SWCD personnel, winter feeding facilities were added as a control measure option. Finally, improved pasture management was included on 71% of the pasture acreage as a companion to livestock exclusion control measures. This collective set of control measures provided the needed 92% bacteria load reductions. As with cropland, because many of the bacteria control measures also reduce sediment, and because the 22% required sediment load reduction from pasture was much smaller

than that needed for bacteria, no further control measures are needed explicitly for sediment control from pasture. Throughout the Smith Creek watershed, 207 sinkholes have been identified on pasture areas through a GIS overlay of county soil surveys and the NLCD land use layers. The agricultural sinkhole protection control measure is new and its pollutant reduction effects have not been specifically quantified and were not included in any of the modeling. Nevertheless, this practice was identified as a needed control measure and included to address approximately 20% of the identified sinkholes, based on discussions with local and state agency personnel. Based on the distribution of pasture, 77.4% of the needed control measures are needed in Rockingham County and 22.6% in Shenandoah County.

Table 6.5. The Extent of Cropland Control Measures and Reductions

Cropland Control Measures	Units	Extent installed since TMDL	Add'l. Extent Required	Land-Applied Bacteria Load Reduction (cfu/yr)	% Reduction	Sediment Load Reduction (tons/yr)	% Reduction
Grass riparian buffers[b]	acres	24.12	3.5	8.01E+ 13	0.29%	58.7	2.2%
Forested riparian buffers[b]	acres	323.4	0	8.90E+ 14	3.3%	692.1	25.9%
Critical area stabilization	acres	177.2	3.22	2.46E+ 14	0.9%	192.3	7.2%
Contour stripcropping	acres		53.1	2.45E+ 14	0.9%	33.8	1.3%
Cover crops	acres	3,433.1	0			735.4	27.5%
Manure injection	acres		20.0	1.86E+ 14	0.7%	-- NA --	
Manure storage facility - beef	no.	3	4	5.68E+ 15	20.7%	-- NA --	
- dairy	no.	5	1	6.74E+ 15	24.6%	-- NA --	
- poultry	no.	12	3	1.08E+ 16	39.6%	-- NA --	
- turkey	no.	2	0	2.58E+ 14	0.9%	-- NA --	
			IP FC Reductions =	2.52E+ 16	92.0%	1,712.3	64.1%
			TMDL FC Reduction Goals =	**2.52E+ 16**	**92%**	**587.7**	**22%**
			IP EC Load =	2.76E+ 12			

[b] Filtering includes additional reductions from upstream runoff loads: buffers - 4x buffer area.

Table 6.6. The Extent of Pasture Control Measures and Reductions

Pasture Control Measures	Units	Extent installed since TMDL	Add'l. Extent Required	Land-Applied Bacteria Load Reduction (cfu/yr)	% Reduction	Sediment Load Reduction (tons/yr)	% Reduction
Livestock exclusion buffers[b]	acres	42.1	436	1.50E+ 15	2.6%	237.9	2.0%
Reforestation of erodible pasture	acres	23	21.0	8.45E+ 13	0.1%	37.0	0.3%
Improved pasture management	acres	677.7	20,235	3.89E+ 16	67.4%	4,534.4	37.5%
Winter feeding facility	no.		15	4.80E+ 15	8.3%	-- NA --	
Agricultural sinkhole protection	no.		40				
Manure storage facility - beef	no.	3	4	1.89E+ 15	3.3%	-- NA --	
- dairy	no.	5	1	2.25E+ 15	3.9%	-- NA --	
- poultry	no.	12	3	3.61E+ 15	6.3%	-- NA --	
- turkey	no.	2		8.61E+ 13	0.1%	-- NA --	
			IP FC Reductions =	5.31E+ 16	92.0%	4,809.4	39.8%
			TMDL FC Reduction Goals =	**5.31E+ 16**	**92%**	**2,661.7**	**22%**
			IP EC Load =	4.71E+ 12			

6.3.5. Built-Up Areas

Pet waste is the dominant source of bacteria loading on Built-Up areas in the Smith Creek watershed, while land disturbing activities on transitional areas are the largest source of sediment. Built-Up areas include urban/residential areas and transitional areas. Some urban areas are subject to stormwater regulations under the Municipal Separate Storm Sewer System (MS4) program. Therefore, urban areas located in a permitted urban stormwater area are designated as MS4, while others are designated as Non-MS4 areas. The portion of the City of Harrisonburg in Smith Creek watershed is an MS4 area. Several control measures used to reduce pollutant loads in Built-Up areas were determined only to be practical in areas of concentrated populations, such as cities and towns. These concentrated population centers in the Smith Creek watershed include the portion of the City of Harrisonburg (the MS4 area) and the town of New Market in the Non-MS4 area. The control measures applicable to these population centers include forested riparian buffers, pet waste programs, and street sweeping.

The extent of control measures needing to be installed to meet TMDL load reduction requirements for Urban Non-MS4 areas are shown in Table 6.7. In the urban/residential areas in the Smith Creek watershed outside of the City of Harrisonburg city limits (the Non-MS4 area), forested riparian buffers are proposed for the streams in and around the town of New Market, consistent with a future stream corridor greenway included in the town's comprehensive plan. Stream lengths were delineated using GIS, with 35 ft. buffers used for extent quantification. Load reductions from a Pet Waste Program in the town of New Market were based on the associated pet population and bacteria production rates given in the TMDL. Street sweeping is already practiced in the New Market area and is performed 6 times a year. New Market streets were delineated and the area swept was quantified assuming 20 ft. wide streets. The other two specified control measures (rain gardens and bioretention filters) are suitable for diffuse land uses such as rural residential areas, as well as for individual residences. Since many of these bacteria control measures also reduce sediment, and because the 22% required sediment load reduction from urban/residential areas was much smaller than for bacteria, no further control measures are needed explicitly for sediment control from

these areas. Based on the distribution of urban and residential areas, 77.9% of the needed Urban Non-MS4 control measures are needed in Rockingham County and 22.1% in Shenandoah County.

Control measures needed to meet the required TMDL pollutant load reductions in the TMDL Urban MS4 areas are shown in Table 6.8. In the urban/residential areas in the Smith Creek watershed within the City of Harrisonburg city limits (the MS4 area), forested riparian buffers are proposed for all included streams and waterbodies. Stream lengths were delineated in GIS using 35 ft. buffers to quantify their extent. Load reductions from a Pet Waste Program in the city were based on the associated pet population and bacteria production rates given in the TMDL, and have been implemented in conjunction with the Blacks Run/Cooks Creek TMDL. Street sweeping is already practiced in the city of Harrisonburg and is performed 4 times a year. This implementation plan calls for an additional 50% increase in loads removed through street sweeping, which can be met either by increasing the area swept, by increasing the efficiency of the sweepers, or by increasing the sweeping frequency. Harrisonburg streets were extracted from TIGER spatial data and the area swept was quantified assuming 20 ft. wide streets. Rain gardens are suited for individual residences, while bioretention filters are more suited for more public spaces such as road drainageways. The extents of these practices were increased until the TMDL requirements for a 95% reduction in bacteria loads were met. Since many of these bacteria control measures also reduce sediment, and because the 22% required sediment load reduction from urban/residential areas was much smaller than for bacteria, no further control measures are needed explicitly for sediment control from these areas. All of the Urban MS4 control measures will be applied in that portion of Smith Creek within the City of Harrisonburg.

Table 6.7. The Extent of Urban Non-MS4 Control Measures and Reductions

Urban Non-MS4 Control Measures	Units	Extent installed since TMDL	Addt'l Extent Required	Land-Applied Bacteria Load Reduction (cfu/yr)	% Reduction	Sediment Load Reduction (tons/yr)	% Reduction
Forested riparian buffers[b]	acres		42.4	8.63E+ 13	5.1%	1.5	11.8%
Pet waste program	no.		1	2.91E+ 14	17.3%	-- NA --	
Street sweeping	acres	22.76	0	7.64E+ 12	0.5%	0.1	1.1%
Rain gardens[b]	acres		100.7	5.22E+ 14	31.0%	13.8	106.7%
Bioretention filters[b]	acres		40	6.92E+ 14	41.1%	18.3	141.3%
			IP FC Reductions =	1.60E+ 15	95.0%	33.7	260.9%
			TMDL FC Reduction Goals =	**1.60E+ 15**	**95%**	**2.8**	**22%**
			IP EC Load =	5.77E+ 11			

[b] Filtering includes additional reductions from upstream runoff loads: buffers - 4x buffer area; rain gardens - 6x; bioretention filters - 20x.

Table 6.8. The Extent of Urban MS4 Control Measures and Reductions

Urban MS4 Control Measures	Units	Extent installed since TMDL	Addt'l Extent Required	Land-Applied Bacteria Load Reduction (cfu/yr)	% Reduction	Sediment Load Reduction (tons/yr)	% Reduction
Forested riparian buffers[b]	acres		1.7	3.56E+ 12	1.0%	0.1	2.4%
Pet waste program	no.	1		2.10E+ 14	57.3%	-- NA --	
Street sweeping	acres	13.84	6.92	4.64E+ 12	1.3%	0.1	2.7%
Rain gardens[b]	acres		8.45	4.38E+ 13	11.9%	1.2	35.8%
Bioretention filters[b]	acres		5.0	8.64E+ 13	23.6%	2.3	70.6%
			IP FC Reductions =	3.48E+ 14	95.0%	3.6	111.5%
			TMDL FC Reduction Goals =	**3.48E+ 14**	**95%**	**0.7**	**22%**
			IP EC Load =	1.25E+ 11			

[b] Filtering includes additional reductions from upstream runoff loads: buffers - 4x buffer area; rain gardens - 6x; bioretention filters - 20x.

Sediment loads from transitional areas in the Smith Creek watershed arise primarily from stormwater runoff over areas where land has been disturbed and vegetative cover removed. Some of these areas may have had transient erosion and sediment (E&S) permits, may have been disturbed prior to the issuance of a permit, or may represent smaller areas of disturbance that do not require a permit. The small reductions called for to meet the required 22% sediment load reductions are expected to be met through an increased efficiency with existing resources within individual local E&S programs and educational programs targeted at developers and contractors (Table 6.9). The enhanced E&S practices that will result in increased efficiency may include additional VSMP permit requirements, such as increased setback distances, faster establishment of vegetation in setback areas, or for increased plantings in setback areas.

Table 6.9. Transitional Area Control Measures Needed

Control Measures	Units	Addt'l Extent Required*	Sediment Load Reduction (tons/yr)	% Reduction
Enhanced E&S Mgmt. (Rockingham)	acres	5.1	3.0	2.7%
Enhanced E&S Mgmt. (Shenandoah)	acres	28.9	17.0	15.2%
Enhanced E&S Mgmt. (Harrisonburg)	acres	7.9	4.6	4.2%
		IP Reductions =	24.6	22.1%
		TMDL Reduction Goals =	**24.6**	**22%**

* - Increased efficiency with existing resources.

6.4. *Education and Technical Assistance*

Educational Programs

Through discussions with stakeholder focus groups, the following educational tasks were identified for the Smith Creek watershed. Most of the educational opportunities rely on the many and varied available watershed partners and existing organizations or agencies for their accomplishment.

1. Residential Programs
   - Promote benefits of properly installed and maintained septic systems.

- Conduct a sanitary septic system survey to better target residential wastewater treatment control measures.
- Support Shenandoah County efforts to adopt an ordinance requiring mandatory septic system pump outs for real estate transfers. Wastewater treatment capacity is increasing to handle pump outs.
- Utilize the Virginia Cooperative Extension (VCE) Household Water Quality Program (www.wellwater.bse.vt.edu) to educate homeowners about well and septic system management.
- Educate urban residents about the needs and benefits of pet waste control.
- Use the new New Market library which is currently applying for LEED certification as a demonstration site for field trips, tours, and programs.
- Utilize the VCE Master Naturalist Program (www.virginiamasternaturalist.org/) to assist with appropriate, related educational efforts.
- Utilize materials and existing ideas from Harrisonburg's existing MS4 program.
- Coordinate with Friends of the North Fork Shenandoah River, Valley Conservation Council, Pure Water Forum, and other watershed groups when conducting outreach programs with stakeholders.

2. Schools/Youth Program
    - Provide materials for conservation and natural resources management to local area schools.
    - Identify opportunities in Smith Creek watershed for field trips, guest speakers, and community projects related to the implementation plan.
    - Provide implementation effort materials to local VCE 4-H and agricultural extension agents, e.g. Tom Stanley, Eric Bendfeldt, for use in their presentations.
    - Encourage participation in local Envirothon teams.
    - Contact County School Superintendents, and identify ways to include natural resource conservation and appreciation in Standards of Learning (SOLs).

3. Developer, Engineer, and Contractor Programs
    - Make a presentation at a quarterly meeting, possibly using the VDGIF workshop materials on Conservation Landscaping (Contact: Carol Heiser). Potential partner: Shenandoah Valley Builders Association.
    - Develop a contractor guidance and expectations handout to prevent some sediment control problems that arisen in each jurisdiction and require the responsible land disturber (RLD) during development to be the contractor, not the engineer.
    - Prepare presentation for single-family home developers to encourage use of runoff control measures.
    - Prepare and distribute periodic Stakeholder E&S reports. Potential partner: Jeff Kelble, Shenandoah Riverkeeper.

- Distribute "Citizen's Guide to E&S Control".
- Conduct an LID workshop at a location that uses LID, such as the New Market Library, James Madison University, Eastern Mennonite University, or the US Forest Service building in Edinburg.
- Utilize existing components of Harrisonburg MS4 (Contact: Thanh Dang) and County Comprehensive Plans
- Conduct additional workshops or presentations on the following topics: Sustainable or Low Impact Development, LEED Construction, and no-runoff development.

4. Municipal Officials Program
    - Include state NEMO (Nonpoint Education for Municipal Officials) representatives in developing local land use plans sensitive to natural resource protection. Contact/Potential partner: Todd Janeski, DCR.
    - Stormwater specialists: Mark Chambers (DCR), David Sample (Biological Systems Engineering, VCE and Virginia Tech's Occoquan Lab).
    - Support development of local stormwater ordinances – applicable to disturbed areas greater than one acre. Localities will have the option of taking over the ordinance, but staffing will be an issue. Potential partners: Rockingham County and Shenandoah County, DCR.

Technical Assistance

Technical assistance is required to assist with stakeholder recruitment, to coordinate with control measure contractors, to provide public education about the implementation plan, and to track installation of implementation control measures and corresponding water quality improvements. The amount of, and costs for, technical assistance were estimated in consultation with personnel from the Shenandoah Valley and Lord Fairfax SWCDs and the Public Works Planner from the City of Harrisonburg.

6.5. *Costs of Implementation*

6.5.1. Agricultural Control Measures

The extent of the agricultural control measures quantified earlier in this chapter for meeting TMDL pollutant reductions are summarized in Table 6.10, together with their unit costs and implementation costs. Unit costs were estimated from the DCR state agricultural cost-share database for Rockingham and Shenandoah counties, from the 2008 USDA-NRCS cost list for Virginia, from literature values, and from discussions with

focus group members. The total estimated cost for full implementation of agricultural control measures in the Smith Creek watershed is $9.21 M.

Table 6.10. Agricultural Control Measures Costs

Livestock Exclusion Measures	Units	Cost / Unit	Cost Source	Extent installed since TMDL	Add'l. Extent Required	IP Cost ($)
SL-6 Systems	no.	$36,456	16	10	150	$5,468,438
WP-2T Systems	no.	$11,864	16	1	36	$427,104
Adaptive fencing[a]	lin.ft.	$1.50	16		241,402	$362,103
					Livestock Exclusion Total Cost =	**$6,257,645**
Cropland Control Measures	**Units**	**Cost / Unit**	**Cost Source**	**Extent installed since TMDL**	**Add'l. Extent Required**	**IP Cost ($)**
Grass riparian buffers[b]	acres	$237	12	24.12	3.5	$831
Forested riparian buffers[b]	acres	$1,284	15	323.4	0	$0
Critical area stabilization	acres	$1,355	12	177.2	3.22	$4,363
Contour stripcropping	acres	$175	12		53.1	$9,290
Manure injection	acres	$146	16		20.0	$2,920
Manure storage facility - beef	no.	$27,139	17	3	4	$108,555
- dairy	no.	$88,736	17	5	1	$88,736
- poultry	no.	$25,833	17	12	3	$77,498
					Cropland Total Cost =	**$292,191**
Pasture Control Measures	**Units**	**Cost / Unit**	**Cost Source**	**Extent installed since TMDL**	**Add'l. Extent Required**	**IP Cost ($)**
Livestock exclusion buffers[b]	acres			42.1	436	
Reforestation of erodible pasture	acres	$1,355	12	23	21.0	$28,432
Improved pasture management	acres	$107	8	677.7	20,235	$2,165,156
Winter feeding facility	no.	$24,192	14, 16		15	$362,880
Agricultural sinkhole protection	no.	$2,500			40	$100,000
					Pasture Total Cost =	**$2,656,468**

[a] Fencing unit cost includes an allowance for cross-fencing.
[b] Filtering provides additional reductions from upstream runoff loads: buffers - 4x buffer area.
8 - MapTech, Inc., 2006.
12 - USDA-NRCS, 2007.
14 - Southwestern Illinois RC&D, Inc., 2004.
16 - SWCD estimate includes BMP-defined components and component costs.
17 - DCR agricultural cost-share database.

6.5.2. Urban MS4 and Non-MS4 Control Measures

The extent of Urban MS4 and Urban Non-MS4 control measures quantified earlier in this chapter are summarized in Table 6.11, together with unit costs, and total

implementation costs. Unit costs were estimated using the Blacks Run Implementation Plan and the 2005 Shenandoah River Tributary Strategy. The total estimated cost for full implementation of the Urban Non-MS4 measures is $0.96M, and the cost for the Urban MS4 measures is approximately $0.09M.

Table 6.11. Urban Control Measures Costs

Urban Non-MS4 Control Measures	Units	Cost / Unit	Cost Source	Extent installed since TMDL	Addt'l Extent Required	IP Cost ($)
Forested riparian buffers[b]	acres	$1,284	15		42.4	$54,473
Pet waste program	no.	$3,750	8		1	$3,750
Street sweeping	acres	-- NA --		22.76	0	
Rain gardens[b]	acres	$5,000	8		100.7	$503,600
Bioretention filters[b]	acres	$10,000	8		40	$400,000
					Urban Non-MS4 Total Costs =	**$961,823**
Urban MS4 Control Measures	**Units**	**Cost / Unit**	**Cost Source**	**Extent installed since TMDL**	**Addt'l Extent Required**	**IP Cost ($)**
Forested riparian buffers[b]	acres	$1,284	15		1.7	$2,245
Pet waste program	no.	$3,750	8	1		
Street sweeping	acres	-- NA --		13.84	6.92	
Rain gardens[b]	acres	$5,000	8		8.45	$42,250
Bioretention filters[b]	acres	$10,000	8		5.0	$50,000
					Urban MS4 Total Costs =	**$94,495**

8 - MapTech, Inc. 2006.
15 – Commonwealth of Virginia, 2005 Shenandoah River Tributary Strategy.

6.5.3. Residential Wastewater Control Measures

The extents of residential wastewater control measures quantified earlier in this chapter are summarized in Table 6.12, together with unit costs and implementation costs. Unit costs for these practices were obtained from the Blacks Run TMDL Implementation Plan. The one exception was the estimate for system pump outs, which was based on focus group discussions with local SWCD and VDH personnel. The estimated implementation cost for residential wastewater control measures in the Smith Creek watershed is $1.91M.

Table 6.12. Residential Wastewater Control Measure Costs

Control Measures	BMP Code	Units	Cost / Unit*	No. Needed	Extent Installed since TMDL~	Add'l. Extent Required	IP Cost ($)
System Pumpouts	RB-1	no.	$275	1,169	61	1,108	$304,679
New Sewer Hookups	RB-2	no.	$5,600	7	0	7	$39,200
System Repairs	RB-3	no.	$3,000	17	9	8	$24,000
New Septic Systems	RB-4	systems	$7,000	13	0	13	$91,000
New Septic Systems w/ pumps	RB-4P	systems	$9,000	6	0	6	$54,000
Alternative Septic Systems	RB-5	systems	$20,000	72	2	70	$1,400,000
						Residential Wastewater Total Costs =	**$1,912,879**

The total estimated cost for the needed control measures in the Smith Creek watershed is $12.18M, with approximately $8.73M needed in Rockingham County, $3.35M in Shenandoah County, and $0.09M in the City of Harrisonburg.

Technical assistance needs were calculated based on the personnel required for installation of the agricultural control measures in each SWCD, the residential wastewater and Urban Non-MS4 control measures, and the Urban MS4 control measures. For planning purposes, one full-time employee (FTE) was budgeted as $50,000/yr, including benefits, training, and related costs. Agricultural technical assistance was estimated as 1.0 FTE for the Shenandoah Valley SWCD and 0.5 FTE for the Lord Fairfax SWCD over the 10 years of implementation, amounting to $75,000 per year. The residential wastewater and Urban Non-MS4 technical assistance was estimated to require 0.75 FTE for the first 5 years of implementation, and 0.375 FTE during the second 5 years, amounting to $37,500 per year in Stage I, and $18,750 per year in Stage II. Urban MS4 technical assistance was estimated as 0.05 FTE ($2,500/yr) for the first five years, and increased to twice that amount in Stage II. Although most of the implementation requirements in the MS4 area would not be required until Stage II, the City may find it beneficial to consolidate its improvements in Stage I.

Therefore, the total costs for technical assistance amount to $115,000 per year for Stage I, $98,750 per year for Stage II, or a total Technical Assistance cost of $1,068,750. The full cost for implementation of this plan in the Smith Creek watershed, including technical assistance will be $13.24M.

The number of pollutants reduced with each control measure may vary from a single pollutant to a wide range of pollutants. The cost effectiveness analysis shown in Table 6.13 does not attempt to perform a complete benefit analysis, but is confined to costs/unit pollutant for the two pollutants identified in the Smith Creek TMDL – bacteria and sediment. These cost effectiveness factors for the various control measures do not factor the cost savings for a second control measure, when a control measure reduces more than one pollutant.

Table 6.13. Cost effectiveness of control measures for bacteria and sediment removal

Control Measures	$ / trillion cfu	$ / ton sediment
Agricultural		
Livestock exclusion fencing	$2.20	-
Adaptive fencing	$2.70	-
Grass riparian buffers on cropland	$65.03	$111
Critical area stabilization	$791.48	$1,271
Contour stripcropping	$30.16	$275
Manure injection	$12.52	-
Manure storage facility		
beef	$19.98	-
dairy	$47.13	-
poultry	$21.33	-
Reforestation of erodible pasture	$428.30	$1,610
Improved pasture management	$34.94	$493
Winter feeding facility	$45.88	-
Urban		
Forested riparian buffers	$92.09	$35,880
Pet waste program	$1.88	-
Rain gardens	$140.63	$36,513
Bioretention filters	$84.38	$21,908
Residential Wastewater		
New Sewer Hookups	$21.85	-
System Repairs	$11.71	-
New Septic Systems	$27.31	-
New Septic Systems w/ pumps	$35.12	-
Alternative Septic Systems	$78.04	-

6.6. *Benefits of Implementation*

The primary benefit of implementation is cleaner waters in Virginia. Specifically, fecal contamination in Smith Creek will be reduced to meet water quality standards, and the aquatic communities in these streams will be restored. 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 falsely 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. In addition to allowing the aquatic communities to thrive, the sediment control measures will also reduce delivery of other pollutants to the stream from upland locations. Many of the BMPs intended to reduce soil losses also increase infiltration, which will decrease peak flows downstream.

During implementation planning, it is important to recognize that healthy waters improve economic opportunities for Virginians and a healthy economic base provides the resources and funding necessary to pursue restoration and enhancement activities. The agricultural, residential, and urban practices recommended in this document will provide economic benefits to the community, as well as the expected environmental benefits.

Specifically, alternative (clean) water sources, exclusion of cattle from streams, improved pasture management, and private sewage system maintenance will each provide economic benefits to land owners. Additionally, money spent by landowners and state agencies in the process of implementing this plan will stimulate the local economy.

A clean water source has been shown to improve weight gain and milk production in cattle. Fresh clean water is an essential requirement for healthy livestock, with healthy cattle consuming, on a daily basis, 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. For instance, coccidia can be delivered through feed, water and haircoat contamination with manure (VCE, 2000). In addition, horses drinking from marshy areas or areas where wildlife or cattle carrying Leptospirosis have access tend to have an increased incidence of moonblindness associated with Leptospirosis infections (VCE, 1998b). Some farmers have also noticed decreased leg

injuries in livestock from crossing steep or muddy stream banks (Zeckoski et al., 2007). 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 as are often found next to streams where cattle have regular access. Keeping cattle in clean, dry areas has been shown to reduce the occurrence of mastitis and foot rot. The VCE (1998a) reports that mastitis costs producers $100 per cow in reduced quantity and quality of milk produced. On a larger scale, mastitis costs the U.S. dairy industry about $1.7-2 billion annually or 11% of total U.S. milk production. While the spread of mastitis through a dairy herd can be reduced through proper sanitation of milking equipment, mastitis-causing bacteria can be harbored and spread in the environment where cattle have access to wet and dirty areas. Installation of streamside fencing and well managed loafing areas will reduce the amount of time that cattle have access to these areas.

Taking the opportunity to instigate 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 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 (VCE, 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. Distributed off-stream waterers and cross-fencing can also improve forage utilization and manure nutrient distribution throughout a pasture (Zeckoski et al., 2007). 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 in closer proximity to each other, allowing for quicker examination and handling. In general, many

of the agricultural BMPs recommended in this document will provide both environmental benefits and economic benefits to the farmer.

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 on-site sewage treatment systems (OSTS), 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 to 25 years, if properly maintained. Proper maintenance includes: knowing the location of the system components and protecting them (e.g., not driving or parking on top of them), not planting trees in locations where roots could damage the system, keeping hazardous chemicals out of the system, and pumping out the septic tank every 3 to 5 years. The cost of proper maintenance, as outlined here, is relatively inexpensive in comparison to repairing or replacing an entire system. Additionally, the repair/replacement and pump-out programs will benefit owners of private sewage (e.g., septic) systems, particularly low-income homeowners, by sharing the cost of required maintenance.

In addition to the benefits to 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 other BMP components can expect to see an increase in business during implementation. Additionally, income from maintenance of these systems should continue long after implementation is complete. A portion of the funding for implementation can be expected to come from state and federal sources. This portion of funding represents money that is new to the area and will stimulate the local economy. In general, implementation will provide not only environmental benefits to the community, but economic benefits as well, which, in turn, will allow for individual landowners to participate in implementation.

7.0 MEASURABLE GOALS AND MILESTONES

7.1. *Implementation Goals*

The goals of TMDL implementation are to restore the water quality in the impaired stream segments in Smith Creek watershed so that it complies with water quality standards and to de-list these segments from the Commonwealth of Virginia's 303(d) List of Impaired Waters. Progress towards these goals can be assessed during the implementation process by tracking the number/type of control measures that are installed and programs or policies developed and executed (implementation actions) and continued water quality monitoring. Improvements in water quality will be measured through monitoring of bacteria concentrations and biological metrics that are used to calculate the Virginia Stream Condition Index (VaSCI).

7.2. *Implementation and Water Quality Milestones*

Implementation milestones establish the fraction of implementation actions to be taken within certain timeframes. Water quality milestones establish the corresponding improvements in water quality that can be expected as the implementation milestones are achieved.

Many implementation activities are already underway in the watershed. The Smith Creek Resource Team strongly supports these activities and recommends that the Smith Creek TMDL IP Steering Committee continue those efforts that are complementary to this plan. Implementation of bacteria control measures that also reduce sediment and nutrient loads are encouraged, as this reduces the need for additional sediment and nutrient control measures that may be called for under the Shenandoah River Tributary Strategy.

The implementation of control measures will be accomplished in stages. In general, the Commonwealth intends that the needed control measures be implemented in a progressive process that first addresses the pollutant sources with the largest

impact on water quality. This staged approach is based on meeting water quality goals over a fifteen-year period. The TMDL lists an interim set of Stage I goals for bacteria load reductions and will serve as the first implementation milestone at the 5-year mark. These goals specify the following pollutant source load reductions: livestock direct deposit – 60%; straight pipes and failing septic systems – 100%; crop and pasture – 50%; and Built-Up areas – 60%. Implementation of Stage I control measures is expected to reduce the bacteria loadings from controllable sources so that violations of the single sample maximum *E. coli* criterion (235 cfu/100mL) are less than 10%.The remaining control measures will be installed during the next 5-year period (Stage II). After installation of all control measures during the first two stages, full maturation of the control measures, full attainment of water quality goals (zero violations of the *E. coli* single sample maximum criterion) and de-listing from the Section 303(d) list will occur by the end of the last 5-year period (Stage III). The list and extent of control measures that are currently in place, and those scheduled to be implemented in Stage I and Stage II are shown in Table 7.1.

Monitoring will continue throughout the process to document progress towards goals and to provide a mechanism for evaluating the effectiveness of the implementation actions 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 implementation plan; 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 adequacy of the TMDL in achieving the water quality standard.

Table 7.1. Staged Implementation Goals for Smith Creek

Type of Control Measure	Units	Since TMDL	Stage I	Stage II
Livestock Exclusion Measures				
SL-6 Systems	no.	10	90	60
WP-2T Systems	no.	1	21	15
Adaptive fencing	lin.ft.	0	144,079	97,323
Cropland Control Measures				
Grass riparian buffers	acres	24.1	0.0	3.5
Critical area stabilization	acres	177.2	0.0	3.2
Contour stripcropping	acres	0.0	21.2	31.8
Manure injection	acres	0.0	0.0	20.0
Manure storage facility - beef	no.	3	0	4
- dairy	no.	5	0	1
- poultry	no.	12	0	3
- turkey	no.	2	0	0
Pasture Control Measures				
Reforestation of erodible pasture	acres	23.0	10.5	10.5
Improved pasture management	acres	677.7	10,117.6	10,117.6
Winter feeding facility	no.	0	8	7
Agricultural sinkhole protection	no.	0	20	20
Urban Non-MS4 Control Measures				
Forested riparian buffers	acres	0.0	18.7	23.8
Pet waste program	no.	0	1	0
Street sweeping	acres	22.8	0.0	0.0
Rain gardensb	acres	0.0	44.3	56.4
Bioretention filtersb	acres	0.0	17.6	22.4
Urban MS4 Control Measures				
Forested riparian buffers	acres	0.0	0.0	1.7
Pet waste program	no.	1	0	0
Street sweeping	acres	13.8	0.0	6.9
Rain gardensb	acres	0.0	0.0	8.5
Bioretention filtersb	acres	0.0	0.0	5.0
Residential Wastewater Control Measures				
System Pumpouts	no.	61	277	831
New Sewer Hookups	no.	0	7	0
System Repairs	no.	9	8	0
New Septic Systems	systems	0	13	0
New Septic Systems w/ pumps	systems	0	6	0
Alternative Septic Systems	systems	2	70	0

The costs associated with Stage I and Stage II implementation efforts are summarized in Table 7.2. Since Smith Creek lies partially within three different administrative entities – two SWCDs and the City of Harrisonburg, the costs are broken down to better reflect the relative effort needed in the various parts of the watershed.

Rockingham County lies within the Shenandoah Valley SWCD, while Shenandoah County is part of the Lord Fairfax SWCD.

Table 7.2. Staged Implementation Costs for Smith Creek

Type of Control Measure	TMDL Stage I Reductions	Stage I Implementation Costs			
		Rockingham County	Shenandoah County	Harrisonburg	IP Cost ($)
Livestock Exclusion Measures	60%	$2,550,564	$1,193,970	$0	$3,744,534
Cropland Control Measures	50%	$3,650	$65	$0	$3,716
Pasture Control Measures	50%	$1,072,082	$268,248	$0	$1,340,330
Urban Non-MS4 Control Measures	60%	$327,165	$98,137	$0	$425,302
Urban MS4 Control Measures	60%	$0	$0	$0	$0
Residential Wastewater Control Measures	100%	$1,216,736	$467,634	$0	$1,684,370
Technical Assistance					
agricultural BMPs		$250,000	$125,000		$375,000
urban and residential BMPs		$125,000	$62,500	$12,500	$200,000
Total Stage I Costs		**$5,545,196**	**$2,215,555**	**$12,500**	**$7,773,251**
		Stage II Implementation Costs			
Type of Control Measure		**Rockingham County**	**Shenandoah County**	**Harrisonburg**	**IP Cost ($)**
Livestock Exclusion Measures		$1,711,788	$801,323	$0	$2,513,111
Cropland Control Measures		$207,219	$81,256	$0	$288,475
Pasture Control Measures		$1,047,890	$268,248	$0	$1,316,138
Urban Non-MS4 Control Measures		$416,391	$120,130	$0	$536,521
Urban MS4 Control Measures		$0	$0	$94,495	$94,495
Residential Wastewater Control Measures		$160,469	$68,041	$0	$228,510
Technical Assistance					
agricultural BMPs		$250,000	$125,000		$375,000
urban and residential BMPs		$62,500	$31,250	$25,000	$118,750
Total Stage II Costs		**$3,856,258**	**$1,495,247**	**$119,495**	**$5,470,999**
Total Implementation Costs		**$9,401,454**	**$3,710,802**	**$131,995**	**$13,244,251**

7.3. *Implementation Tracking and Monitoring*

7.3.1. Implementation Tracking

Agricultural control measures will be tracked through the Virginia Agricultural Cost-Share Program. Residential Wastewater control measures will be tracked cooperatively through individual SWCDs. Urban Non-MS4 control measures will be tracked through individual SWCDs and in cooperation with the town of New Market. Urban MS4 control measures will be tracked through the City of Harrisonburg's MS4 program, while the enhanced E&S management for Transitional areas will be tracked through the Rockingham County and Shenandoah County E&S Programs.

7.3.2. Water Quality Monitoring

The monitoring program to assess implementation progress will be based on state DEQ bacteria and biological monitoring at the existing 2009 monitoring sites listed in Table 7.3 and shown in Figure 7.1. The Friends of the North Fork Shenandoah River have indicated their willingness to assist with volunteer monitoring in additional locations, if needed.

Table 7.3. Existing 2009 DEQ Water Quality Monitoring Stations

Station ID	Stream Name	Location	Monitoring Type
1BDFK000.76	Dry Fork	Rt. 806 Bridge	bacteria
1BMTR000.93	Mountain Run	Rt. 620 Bridge	bacteria
1BSMT001.42	Smith Creek	Rt. 730 Bridge	bacteria
1BSMT004.60	Smith Creek	Rt. 620 Bridge	bacteria
1BSMT006.62	Smith Creek	Rt. 620 Bridge	biological
1BSMT019.26	Smith Creek	Rt. 796 Bridge	bacteria
1BSMT026.41	Smith Creek	Rt. 717 Bridge	bacteria

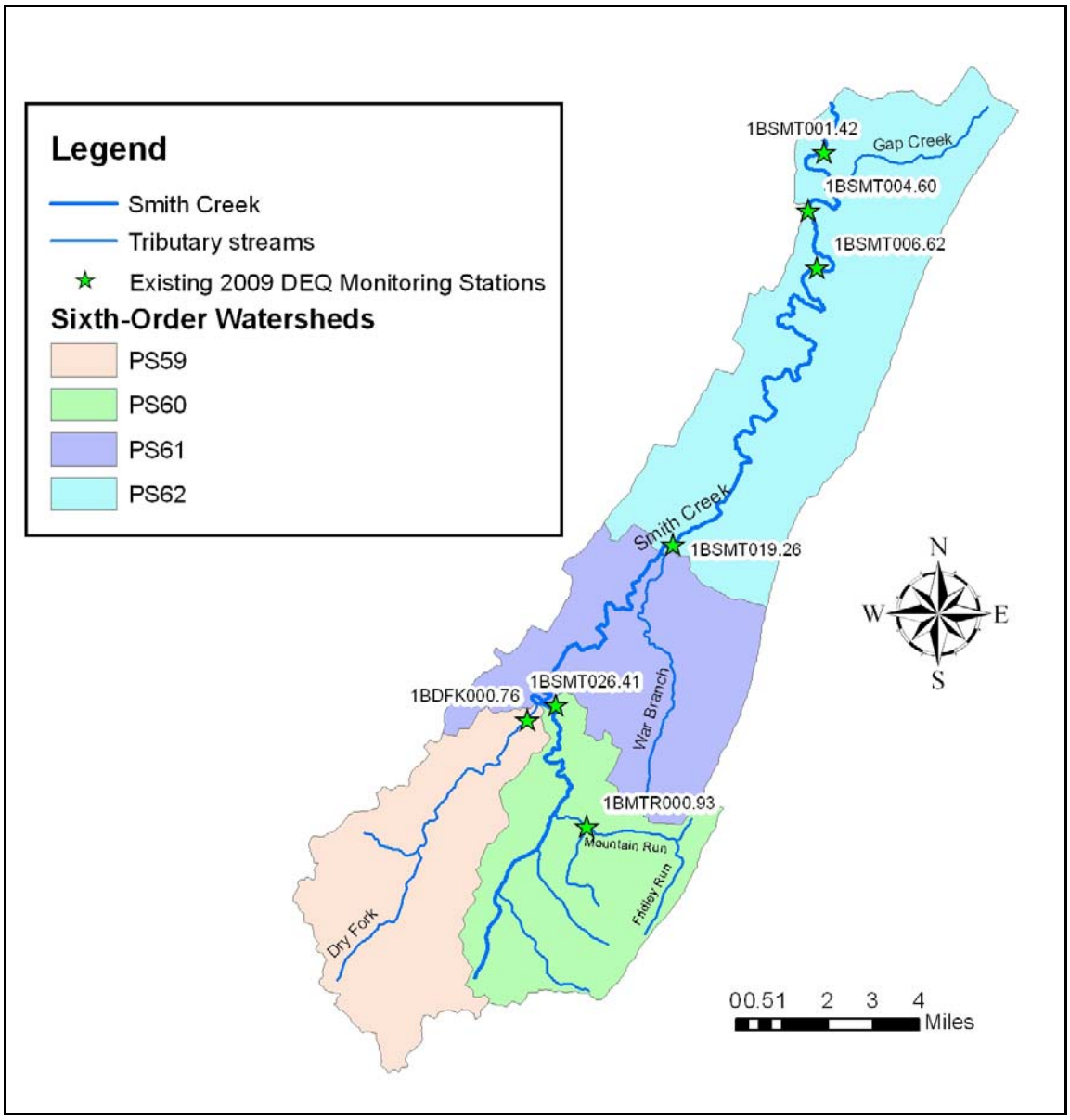

Figure 7.1. Existing 2009 DEQ Monitoring Station Locations

DEQ will conduct monthly or bi-monthly ambient and bacteria sampling for *E. coli* at each of the existing bacteria monitoring sites in Smith Creek. Sampling at the one DEQ biological station will be performed at least every other year spring and fall. Metrics will be calculated for these samples for evaluation of the VaSCI and RBP II indices. Since many habitat metrics are particularly relevant to the impact of sediment, DEQ will be requested to perform the habitat evaluation every spring and fall at the biological site, regardless of whether biological samples are taken.

7.4. *The Staged Implementation Approach and Targeting*

During each annual evaluation of implementation progress on Smith Creek, a reassessment of implementation priorities will be made by the Steering Committee to readjust and fine-tune the targeting approach in concert with the staged implementation approach. Periodic re-evaluation is especially critical during these times of economic uncertainty, where increasing energy prices and fluctuating market prices are bound to affect stakeholders in the agricultural sector and their willingness to commit resources for conservation, especially if they are struggling to maintain their viability as a farming enterprise.

If reasonable progress toward implementing the management practices is not demonstrated, the Steering Committee will consider additional implementation actions. If it is demonstrated that reasonable and feasible management measures have been implemented for a sufficient period of time and TMDL targets are still not being met, the TMDL will be reevaluated and revised accordingly. If after five years the Steering Committee determines that load reductions are being achieved as management measures are implemented, then the recommended appropriate course of action would be to continue management measure implementation and compliance oversight. If it is determined that all proposed control measures have been implemented, yet the TMDL is not achieved, further investigations will be made to determine whether: 1) the control measures are not effective; 2) sediment loads are due to sources not previously addressed; or 3) the TMDL is unattainable.

7.5. *Reasonable Assurance*

Public participation is an integral part of the IP development and is critical in gaining support for both the voluntary and MS4 compliant implementation activities that are being planned. During the public participation process, the major stakeholders in the watershed and a wide variety of local conservation agency personnel were involved in Focus Groups and public meetings, and provided additional information through email and phone conversations. This participation by the major watershed stakeholders provides a reasonable assurance that the public was contributing to the TMDL process

and had input into the selection of management and implementation practices recommended by this IP.

A Smith Creek TMDL IP Steering Committee will be formed following development of the implementation plan with guidance provided by agency members of the Resource Team, ensuring continuity of leadership and vision. Smith Creek is already receiving funding through the EPA's Healthy Waters Initiative, and the Smith Creek Partnership has submitted proposals for additional grant funding, ensuring their continuing interest, participation, and support. Smith Creek is also on the schedule for EPA §319 funding through DCR to assist with implementation costs.

This integration with existing planning entities, further discussed in Chapter 9, provides additional assurance that the implementation envisioned in this plan will be carried out.

Implementation to address the bacteria and sediment-related biological impairments on Smith Creek will be carried out primarily through the use of voluntary and MS4 compliant best management practices and education. While available cost-share programs will be utilized to the extent possible to provide incentives (typically at 75% of installation costs) to targeted watershed stakeholders, it is recognized that it may be necessary in some instances to raise the level of incentives to 100% to ensure participation by some stakeholders. Grant funding will be sought to provide this additional incentive, which we expect will increase participation from specific targeted stakeholders that would otherwise be reticent to participate.

Taken together, all of these planning components comprise a reasonable assurance that implementation will progress as planned and will lead to restoration of water quality in Smith Creek.

8.0 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 chapter is to identify and define the roles of the stakeholders who will work together to develop the IP. The roles and responsibilities of some of the major stakeholders are described below.

8.1. *Federal Government*

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 also rely on the expertise on NRCS staff. 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/.

8.2. *State Government*

In the Commonwealth of Virginia, water quality problems are dealt with through legislation, incentive programs, education, and legal actions. Currently, there are five state agencies responsible for regulating and/or overseeing statewide activities that impact water quality in Smith Creek watershed. These agencies are:

Virginia Department of Environmental Quality (VADEQ): The State Water Control Law authorizes the State Water Control Board to control and plan for the reduction of pollutants impacting the chemical and biological quality of the State's waters resulting in the degradation of the swimming, fishing, shell fishing, aquatic life, and drinking water uses. For many years the focus of VADEQ's pollution reduction efforts was the treated effluent discharged into Virginia's waters via the VPDES permit process. The TMDL process has expanded the focus of VADEQ's pollution reduction efforts from the effluent of wastewater treatment plants to the nonpoint source pollutants causing impairments of the streams, lakes, and estuaries. The reduction tools are being expanded beyond the permit process to include a variety of voluntary strategies and BMPs.

VADEQ is the lead agency in the TMDL process and is funneling the funding for the development of this IP from the EPA's Healthy Waters Initiative (more information in Chapter 10). 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 EPA 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): 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. EPA 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. 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. VADCR is also the lead agency for administering the Virginia Stormwater Management Program (VSMP) and Virginia's Erosion and Sediment Control Program (ESC), and as such is responsible for tracking and implementing Waste Load Allocations for permit holders under these programs. 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. DCR is also the home of Virginia's NEMO program. NEMO stands for Network Education for Municipal Officials and is a clearinghouse of information for groups looking to education themselves, their organizations and their localities about how land use relates to water. Check out their website for more details: www.chesapeakenemo.net.

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.

Virginia Department of Health (VDH): The VDH is responsible for maintaining safe drinking water measured by standards set by the EPA. Their duties also include septic system regulation and regulation of biosolids land application. Like VDACS, VDH is complaint driven. Complaints can range from a vent pipe odor that is not an actual sewage violation and takes very little time to investigate, to a large discharge violation that may take many weeks or longer to effect compliance. For TMDLs, VDH has the responsibility of enforcing actions to correct failed septic systems and/or eliminate straight pipes (Sewage Handling and Disposal Regulations, 12 VAC 5-610-10 et seq.).

Virginia Department of Forestry (DOF): The 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 (www.dof.state.va.us/wq/wq-bmp-guide.htm). Forestry BMPs are directed primarily to

control erosion. For example, streamside forest buffers provide nutrient uptake and soil stabilization, which can benefit water quality by reducing the amount of nutrients and sediments that enter local streams. DOF's BMP program is voluntary.

Another state entity with responsibilities for activities that impact water quality in Smith Creek watershed is:

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 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 published several publications that deal specifically with TMDLs and partners with DCR on the NEMO program. For more information on these publications and to find the location of county extension offices, visit www.ext.vt.edu.

8.3. *Regional and Local Government*

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. Some local government groups and their roles in the TMDL process are listed below.

Lord Fairfax (Shenandoah County) and Shenandoah Valley (Rockingham County) SWCDs: 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.

Central Shenandoah PDC and Northern Shenandoah Valley Regional Commission: Planning District Commissions (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.

City of Harrisonburg and Town of New Market: Local government staff members may work closely with PDCs and state agencies to develop and implement TMDLs in concert with their comprehensive plans. They may also help to promote education and outreach to citizens, businesses and developers to introduce the importance of the TMDL process.

Rockingham and Shenandoah Counties: County government staff members work closely with PDCs and state agencies to develop and implement TMDLs in concert with their comprehensive plans. They may also help to promote education and outreach to citizens, businesses and developers to introduce the importance of the TMDL process.

8.4. *Businesses, Community Groups, and Citizens*

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.

Valley Conservation Council (VCC): Valley Conservation Council promotes land use that sustains the farms, forests, open spaces, and cultural heritage of the Shenandoah Valley region of Virginia. Founded in 1990, Valley Conservation Council is a member-supported, private, non-profit land trust and citizens organization. VCC now shares stewardship responsibility for over 14,000 acres of privately owned conservation land in 11 counties.

Community Watershed Groups: (Friends of the North Fork of the Shenandoah River [FNFSR], Save Our Streams, etc.) Local watershed groups offer a meeting place for river groups to share ideas and coordinate preservation efforts and are also a showcase site for citizen action. Watershed groups also have a valuable knowledge of the local watershed and river habitat that is important to the implementation process.

Shenandoah Pure Water Forum: A 501c (3) non-profit organization working to achieve clean water by involving citizens in planning, education, coordination, attracting funding and serving as advocates for water resources.

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 5.1), assisting with public outreach, providing input about the local watershed history, and/or implementing best management practices 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 the Ruritan, Farm Clubs, Homeowner Associations and youth organizations such as 4-H and Future Farmers of America. These groups offer a resource to assist in the public participation process, educational outreach, and assisting with 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 land owners, not only in rural areas, but in urban areas as well, where pet waste has been identified as a source of bacteria in water bodies. Virginia's approach to correcting non-point source pollution problems continues to be encouragement of participation through education and financial incentives; that is, outside of the regulatory framework. If, however, voluntary approaches prove to be ineffective, it is likely that implementation will become less voluntary and more regulatory.

Secondary Schools: Long-term solutions to our water quality problems must include education of future generations regarding the need to make changes in our personal and social habits and traditions, in order to preserve and maintain our land and water resources. Towards this end, environmental education, especially that which includes hands-on interaction with natural resources through field trips and class projects, is highly recommended. Activities, such as those included in the Future Farmers of America and Envirothon programs, help our youth understand how they can maintain and enhance these precious resources.

9.0 INTEGRATION WITH OTHER WATERSHED PLANS

Each watershed within the state is under the jurisdiction of a multitude of individual yet related water quality programs and activities, many of which have specific geographical boundaries and goals. These include, but are not limited to, Total Maximum Daily Loads, water quality management plans (WQMPs), sediment and erosion control regulations, stormwater management (SWM), Source Water Assessment Program (SWAP), and local comprehensive plans. The local comprehensive plans will be discussed in more detail in the following chapter. In some cases, an IP may even address multiple TMDLs (e.g., bacteria and benthic) for the same impaired water body.

9.1. *Ongoing Partnerships*

Since completion of the Smith Creek TMDL study, several groups have stepped forward to pursue conservation efforts in the watershed, which have pro-actively contributed towards the implementation of conservation measures needed in the watershed.

The Shenandoah Valley has widely benefited from the work of several land trusts including the Valley Conservation Council (VCC), a private regional land trust, and the Virginia Outdoors Foundation (VOF), the state's primary conservation easement holder. For 18 years VCC has provided ongoing outreach efforts to connect landowners with the easement services of VOF and has targeted the Smith Creek watershed as a priority focus area in its strategic plan. VCC also holds a number of riparian easements with Valley Soil and Water Conservation Districts.

The Eastern Brook Trout Joint Venture (EBTJV) is a unique partnership between state and federal agencies, regional and local governments, and conservation organizations to restore historic habitat for eastern brook trout. EBTJV assessed Smith Creek as a priority watershed for restoration and protection and has already directed Federal funds for this purpose.

Trout Unlimited, through its partnership with the U.S. Fish and Wildlife Service and U. S. Forest Service, is keenly interested in supporting the restoration of Smith Creek as part of its newly launched Interstate-81 Coldwaters Area Restoration Effort (I-81 CARE). I-81 CARE is a long-term large-scale campaign to reduce pollution and conserve, protect, and restore spring creeks and mountain head headwaters streams in the region served by I-81 in Virginia.

Mark Hudy, a National Aquatic Ecologist for the USDA Forest Service, is an adjunct professor at James Madison University (JMU) in Harrisonburg. He has worked closely with other faculty to sponsor undergraduate and graduate research opportunities on Smith Creek. Research projects cover a variety of topics, including: biofilm, biomass and nutrient uptake in Smith Creek; nutrient hotspots in the Smith Creek Watershed; validation of a temperature model for brook trout restoration in Smith Creek; and sapling growth and viability in the Smith Creek watershed.

There is an existing but inactive Citizens Advisory Committee that was involved with several National Fish and Wildlife Foundation and Virginia Water Quality Improvement Act – funded projects. This committee is presently being re-energized to address conservation and restoration opportunities. This group consists mainly of landowners and represents a key source of interested volunteers that should be involved in TMDL implementation planning.

9.2. *New Partnerships*

The Smith Creek TMDL study supports the need for land use changes in the watershed that will benefit, not only the condition of Smith Creek and its tributaries, but also downstream waters that eventually flow to the Chesapeake Bay. The Virginia Department of Conservation and Recreation (DCR) regional TMDL planning team has given Smith Creek a high priority rank for developing a TMDL implementation plan.

As part of a four-state (VA, PA, MD, WV) regional effort to bring focused support and collaborative partnerships to resource restoration and conservation in the Mid-Atlantic Appalachian region, the Highlands Action Program (HAP) has identified the Smith Creek watershed as a unique project opportunity. During the beginning of 2008, Faye Cooper, the VA HAP Liaison in DCR, hosted three information sharing meetings

with Smith Creek watershed landowners and government agency staff to discuss opportunities to build on the momentum already evident in the watershed. The level of participation and input observed at all of these meetings have indicated a strong community "will" to improve the water quality of Smith Creek and to sustain the agrarian culture of the area. At the last of the three meetings, which was held at the Mountain Valley Ruritan Hall, 21 of the 30 participants were Smith Creek landowners, many of whom expressed interest in a continued collaborative effort on behalf of their watershed and community.

As a result of these preliminary local discussions the HAP Liaison worked with EPA, the Virginia Department of Environmental Quality (DEQ), and DCR to request EPA Region III "Healthy Waters Initiative" funds to the Smith Creek watershed planning process. As a result, support was received from the EPA Region III Healthy Waters Initiative (HWI) in Spring 2008. The purpose of the HWI is to address the need for improved and coordinated actions that will augment the pace of water body restoration and protection. HWI implementation funding has been allocated to Pennsylvania and Virginia, and a portion of Virginia's allocation has been directed towards the development of an implementation plan for the Smith Creek watershed. The goal of the DEQ and DCR, the HWI managing agencies, is to use an expanded approach to plan development that will include citizen, community, and local government support.

9.3. *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 NPSs. 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 (Board) the duty and authority to conduct the CPP in Virginia. Under the authority of Virginia Code Section 10.1-1183, VADEQ serves as the administration arm of the Board. 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 18 WQMPs developed under Sections 208 and 303(e). Many of these plans are outdated, and efforts are underway to update them. The updated plans will serve as repositories for all TMDLs approved by EPA and adopted by the Board, as well as IPs approved by the Board.

9.4. *Watershed and Water Quality Management Planning Programs in Virginia*

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

WQMPs – Water Quality Management Plans (WQMPs) are produced and updated by VADEQ in accordance with Sections 208 and 303(e) of the CWA as outlined in the CPP section above. These plans will be the repository for TMDLs and TMDL IPs.

Sediment and Erosion Control Regulations – VADCR implements the state Erosion and Sediment Control (ESC) Program according to the Virginia Erosion and Sediment Control Law, Regulations, and Certification Regulations (VESCL&R). The ESC Program goal is to control soil erosion, sedimentation, and nonagricultural runoff from regulated "land-disturbing activities" to prevent degradation of property and natural resources. The regulations specify "Minimum Standards," which include criteria, techniques and policies that must be followed on all regulated activities. These statutes delineate the rights and responsibilities of governments that administer a local ESC

program and those of property owners who must comply. For more information, visit http://www.VADCR.state.va.us/sw/e&s.htm.

VSMP – Virginia Stormwater Management Programs are implemented according to the Stormwater Management Law and Virginia Stormwater Management Regulations (VSWML&R). These statutes are specifically set forth regarding land development activities to prevent water pollution, stream channel erosion, depletion of ground water resources, and more frequent localized flooding to protect property values and natural resources. SWM 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. VADCR oversees regulated activities undertaken on state and federal property, while localities have the option to establish a local program to regulate these same activities on private property in their jurisdiction. For more information, visit http://www.VADCR.state.va.us/sw/stormwat.htm.

Municipal Separate Storm Sewer Systems (MS4) Permits, Phase II – (City of Harrisonburg) – The Storm Water Phase II Regulations requires all operators of urban municipal separate storm sewer systems (MS4s) to: 1) obtain a NPDES permit and 2) develop a storm water management program designed to prevent harmful pollutants from being washed by storm water into the storm sewer, then discharged from the storm sewer into local water bodies. The program must contain elements for each of the following six minimum control measures:

- public education and outreach,
- public involvement and participation,
- illicit discharge and detection elimination,
- construction site stormwater runoff control,
- post-construction stormwater management in new development and redevelopment, and
- pollution prevention/good housekeeping for municipal operations.

SWAP – Section 1453 of the 1986 Amendments of the Safe Drinking Water Act (SDWA) requires each state to develop a Surface Water Assessment Plan (SWAP) that will delineate the boundaries of the assessment areas from which public water systems

receive drinking water using hydrogeologic information, water flow, recharge, and discharge and other reliable information. The VDH is the primary agency for drinking water and is therefore responsible for SWAP. In Virginia, all 187 surface water intakes serving 151 public waterworks have completed surface water assessments. All 4,584 ground water source assessments, serving nearly 4,000 public waterworks, were completed by the end of 2003.

Local Comprehensive Plans – (Rockingham County, Shenandoah County, Town of New Market, City of Harrisonburg) – Virginia state law requires all local governments have an adopted comprehensive plan. Typical topics addressed in a comprehensive plan include the analysis of population change, land use and 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 TMDL implementation, especially the latter for urbanized watersheds. These are discussed in more detail in the next chapter.

Chesapeake Bay Tributary Strategies – The Chesapeake Bay Nutrient and Sediment Reduction Tributary Strategy for the Shenandoah and Potomac River Basins reflects a continuation of Virginia's commitment to improving local water quality and the water quality and living resources of the Chesapeake Bay. The nonpoint source approach, under the coordination of the Virginia Department of Conservation and Recreation, is to refocus available tools, to steer new resources to Virginia's strongest nonpoint source control programs, and to push them to maximize reductions of nutrients and sediment across the landscape. These efforts focus on seven programmatic areas:

1. Agricultural Best Management Practices (BMP) acceleration
2. Expansion of nutrient management planning and implementation efforts
3. The consolidation and strengthening of the Virginia Stormwater Management Program
4. Enhancing implementation of the Virginia Erosion and Sediment Control Program
5. Strengthen implementation of the Chesapeake Bay Preservation Act
6. Enhancement of the NPS Implementation Database Tracking Systems
7. Enhancing outreach, media and education efforts to reduce pollution producing behaviors

10.0 LOCAL GOVERNMENT PLANNING

Representatives from the each of the four municipalities located within the watershed have participated in the Smith Creek IP development. IP Planning team members also met individually with planning department staff in order to get the most up to date information about land planning goals and local government water quality initiatives and to discuss future collaborative efforts among the jurisdictions pertaining to Smith Creek water quality improvements. The Smith Creek watershed includes part of four local jurisdictions – Rockingham and Shenandoah Counties, the City of Harrisonburg, and the Town of New Market. Each of the four local government comprehensive plans contain strong goals and objectives that give priority to water quality improvements and land conservation in areas that overlap with the Smith Creek watershed.

10.1. *Rockingham County*

The major portion of the Smith Creek watershed within Rockingham County is planned as an "agriculture reserve" land use, according to its "Comprehensive Plan for 2020 and Beyond". According to county planning staff, this designation is not likely to change in the near future due to services (water and sewer) limitations and the extensive karst geology present in the area. An area containing approximately 2,754 acres located along U.S. Route 11 north of Harrisonburg is designated for mixed use and is serviced by county water and sewer (see Figure 10.1).

The plan also contains strong goals and strategies for protecting and improving water quality as shown in the following Plan excerpts of policies and implementation actions.

Strategy 1.1: Protect water quality.

1.1.1. Consider requiring nutrient management plans for all intensive agricultural enterprises (which are now required only for poultry).

1.1.2. Continue to participate in TMDL (total maximum daily [pollutant] load) water quality studies for impaired streams.

1.1.3. Seek continued and expanded funding for agricultural BMPs.

1.1.4. Continue to follow and update the current Board of Supervisors' position in the Interim Nutrient Cap Strategy for the Shenandoah and Potomac River Basins.

1.1.5. Request extensive public participation in all water quality programs sponsored by Department of Environmental Quality (DEQ) and other governmental agencies.

1.1.6. Take a comprehensive approach to stormwater management.

1.1.7. Limit impervious surfaces through lot coverage ratios; amend the Zoning and Subdivision Ordinances to accomplish this.

1.1.9. Promote the setting aside of floodplain lands as open space during the development process to form the backbone of a countywide greenway system for flood protection, water quality protection, wildlife habitat preservation, and passive recreation.

Strategy 1.2: Protect community water supply sources.

1.2.2. Explore the feasibility of the County performing its own source water assessments for the public water systems of its Towns and sanitary systems that use wells, with priority in karst areas; include the delineation of well recharge areas and an inventory of potential contaminant sources within these areas.

1.2.3. Continue to use the Shenandoah Summit water supply planning project as a forum for regional efforts regarding water supply, quality and quantity.

1.2.4. Expand cooperation with other water providers to address regional needs.

1.2.5. Expand public education programs about water resources.

1.2.6 Discourage high density or high intensity development in areas that are likely to have high groundwater recharge potential.

1.2.7 Encourage, through the development approval process, the establishment of buffers 100 feet in width along major stream corridors and tributaries, defined as those watersheds which drain an area of one square mile or greater. Such buffers should be maintained in a natural condition with little or no clearing, grading or other land disturbing activity, except for that necessary to locate any essential utility lines or similar public facilities. Provide for such buffers to be created through the clustering of development density so as to maintain a reasonable overall development potential for tracts affected by the stream buffer policy.

The Rockingham County Storm Water Management Ordinance (Sections 5.6 and 5.7) requires a 35-foot riparian buffer for new development located along state waters "for the purposes of retarding runoff, preventing erosion." The ordinance defines riparian buffer as follows:

> "an area of trees, shrubs, grasses, or a combination thereof, that is (i) at least thirty-five feet in width, (ii) adjacent to state waters, and (iii) managed to maintain the integrity of stream channels and shorelines and (iv) reduces the effect of upland sources of pollution through the infiltration of runoff and filtering of pollutants. A managed lawn adjacent to state waters does not constitute a riparian buffer. The riparian buffer is measured landward (horizontal distance) from the stream bank on both sides of the stream."

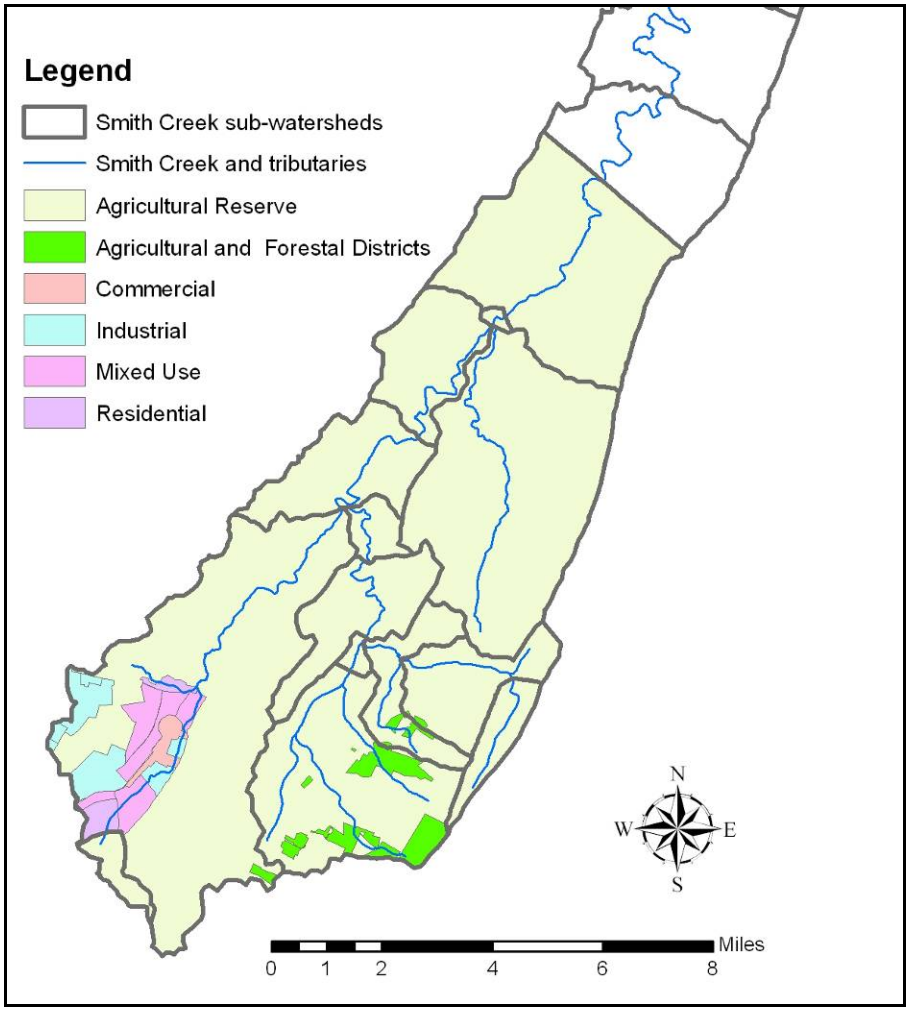

Figure 10.1. Rockingham County Future Land Use in Smith Creek Watershed

10.2. *Shenandoah County*

Other than a small growth area to the east of New Market, Shenandoah County's portion of the watershed is designated for agricultural uses (see Figure 10.2). The Shenandoah County Comprehensive Plan 2025 acknowledges that segments of Smith Creek have been identified as "impaired" by the Virginia Department of Environmental Quality and sets forth extensive goals for the protection of the county's water resources as shown in the following Plan excerpt.

Protection of Water Resources (Plan, page 2-22)

1. Address nonpoint source pollution by promotion of agricultural, urban, forestry, and other BMPs; cooperation with the Natural Resources Conservation Service and Cooperative Extension Service to implement BMPs; promotion of techniques to reduce agricultural and household chemical use; and appropriate enforcement of the Erosion and Sediment Control Law.
2. Adopt, as appropriate, the recommendations of the SWAP project pertaining to the five major public water systems that depend on groundwater supplies.
3. Additions to the Code of Virginia in 1998 and 1990 gave local governments the authority to "protect surface and groundwater." The County Code should be amended to specifically provide for this protection in all planning and zoning land use actions.
4. Use available local tools to protect groundwater from contamination by underground storage tanks, animal wastes, biosolids, excessive fertilizer and pesticide use (both agricultural and residential), or other threats as identified.
5. Institute a program for periodic inspections of septic systems and, if warranted, pump-outs. Encourage citizens to have their septic tanks pumped out every five years.
6. Locate sinkholes and sinkhole dumps, and implement sinkhole protection with a sinkhole ordinance
7. Continue improvement to municipal sewer facilities, particularly with respect to stormwater infiltration. Encourage cooperation among towns and other water and sewer service providers and outlying areas to provide services as needed.
8. Monitor all discharge from alternative systems.

9. Support the efforts of the U.S. Forest Service and the Virginia Department of Game and Inland Fisheries to mitigate the acidification of coldwater streams.
10. Support implementation of the Minimum Instream Flow Study for the North Fork recommendations.
11. Encourage riparian landowners to maintain streambank vegetation and minimize disturbances in riparian areas in order to protect stream habitat and water quality. Encourage landowners to apply to have riparian land placed in the Conservation Reserve Program or conservation easements.
12. Develop site plan review criteria for the definition and protection of wetlands.
13. Stress the role that individual landowners must play in the protection of groundwater by proper on-site wastewater system maintenance (items 5 and 8 above), limited use of fertilizers and pesticides, control of animal wastes, wellhead maintenance, proper use and disposal of household chemicals and waste oil, and the like.
14. In coordination with the towns, develop a county-wide stormwater management plan (Virginia Stormwater Management Program, 1990)

The Shenandoah County Zoning Ordinance includes a 100-foot stream buffer requirement for new development on perennial streams "in order to reduce nonpoint source pollution of County streams, promote stream bank stability and preserve riparian wildlife habitat…" (Article XIA Section 165-85.1). There are provisions for reductions in the buffer under specific circumstances but buffers cannot be less than 50 feet (see Section 165-85.1e(1)(c)).

The New Market Agricultural/Forestal District, which was established in 1985 and includes 4,727 acres, partially falls within the watershed and is established for a 10-year term (renewable in 2009). The terms of the District agreement with the County include the commitment of the participating landowners to keep their properties in agricultural and forestry uses for the duration of the District.

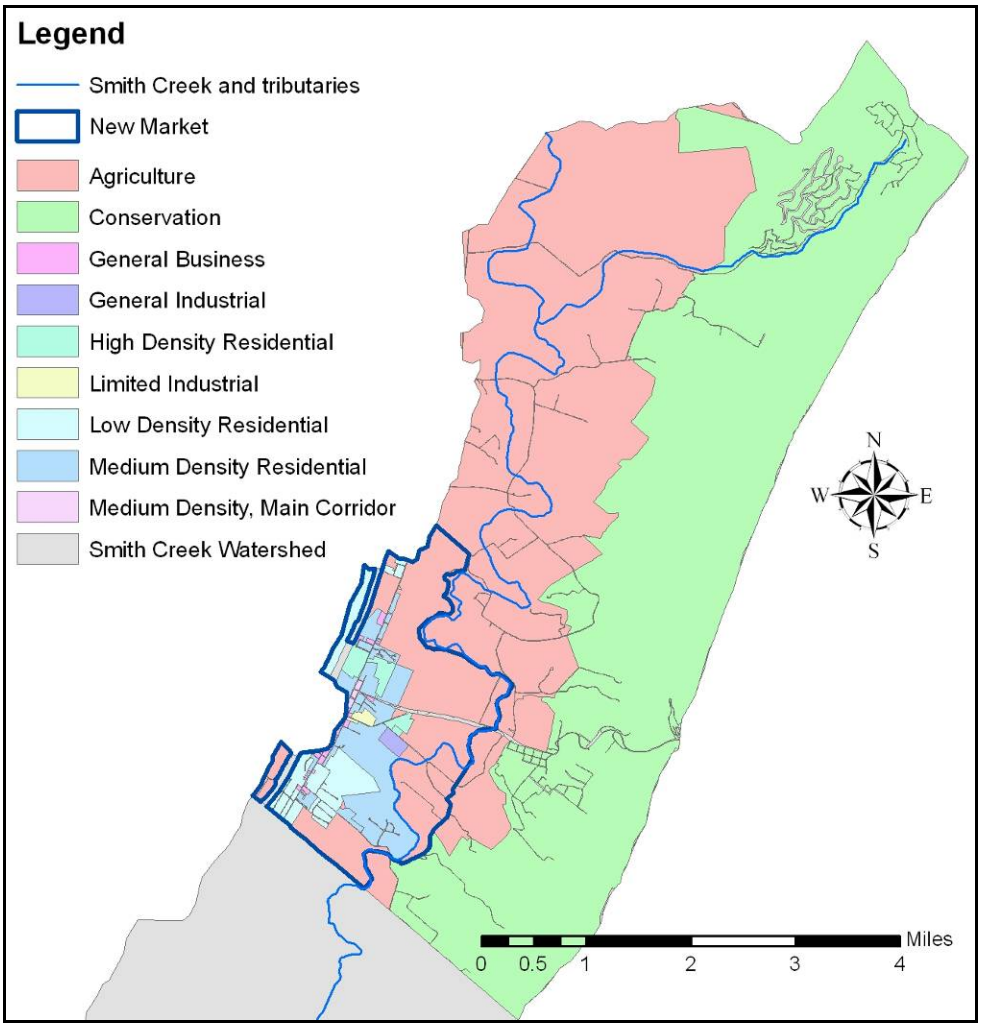

Figure 10.2. Shenandoah County Future Land Use in Smith Creek Watershed

10.3. *City of Harrisonburg MS4 Programs*

The remaining small southernmost portion of the watershed lies within the city limits of Harrisonburg (approximately 493 acres and containing 0.206 stream miles of Dry Run, a Smith Creek headwaters tributary). The majority of this area is either already developed or slated for residential development, as shown in Figure 10.3.

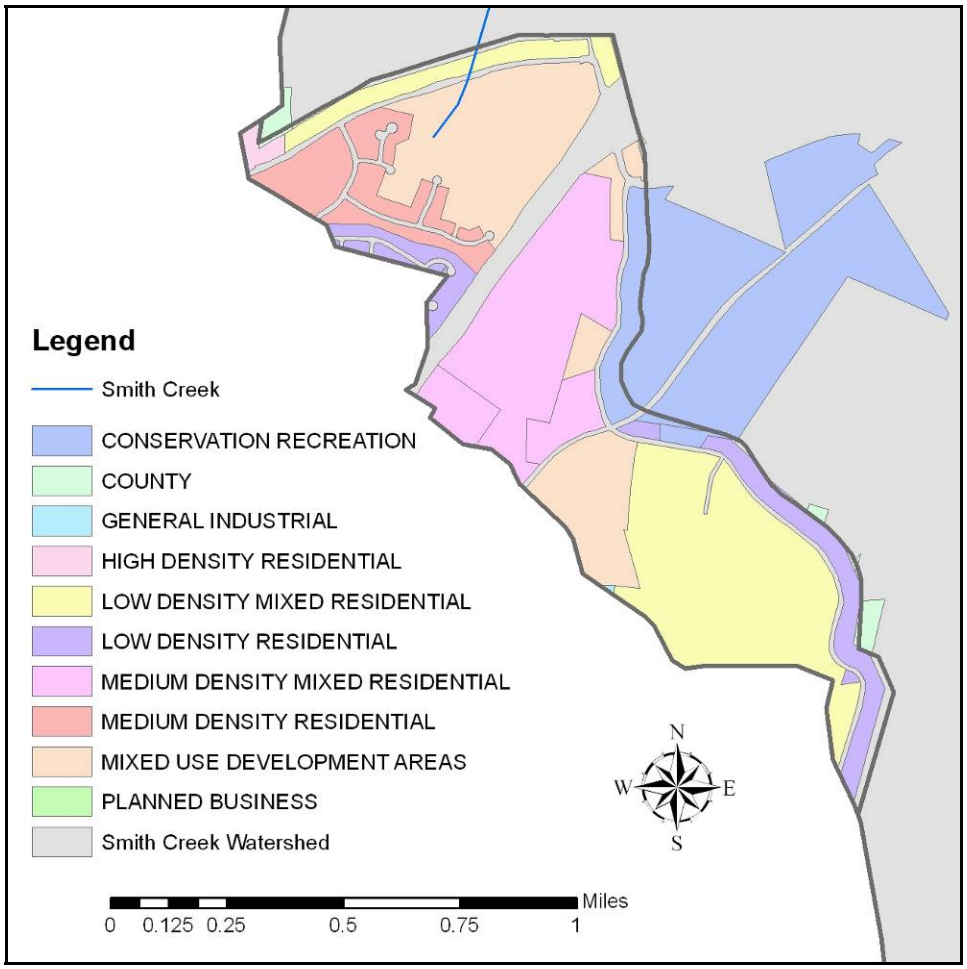

Figure 10.3. City of Harrisonburg's Future Land Use in Smith Creek Watershed

The City has created several programs to address pollutant sources arising from stormwater runoff through its Municipal Separate Storm Sewer System (MS4) permit. For instance, the City developed a web site (www.CleanStream.org) that supports a collaborative effort between the City of Harrisonburg and its community. The mission of CleanStream.org is to educate the public about the sources of water pollution, and its impact on water supply, recreational opportunities, aquatic ecosystems and quality of life. CleanStream.org encourages the protection of water resources by informing residents and businesses about how to reduce the impacts of those activities that lead to pollution. The City has also developed informative and educational brochures on topics such as lawn care and managing pet waste. Much of the City's current effort appears to be directed to the Blacks Run drainage, due to the fact that Blacks Run is the

largest watershed in the City. The Smith Creek urban focus group encouraged city planners to expand current efforts to the Smith Creek drainage as well.

10.4. *Town of New Market*

New Market, a small historic community with a population of approximately 1,800, is located in the heart of the Smith Creek watershed. It represents traditional village style development revolving around a core downtown business district that is surrounded by relatively dense residential development. The town has experienced new commercial and residential development in recent years, particularly to the south along the Rt. 11/I-81 corridor. The New Market Comprehensive Plan 2004 (pages 32-33) addresses water quality in several of its environmental goals and policies:

- Goal: To preserve and protect the Shenandoah River by keeping it fishable and swimmable in accordance with the Federal Clean Water Act, keeping flow levels at reasonable heights, and protecting "scenic and recreational" values.
    - Policy: A formalized environmental impact statement will be required for all proposed sizable industries, and commercial enterprises and subdivisions.
- Goal: To protect New Market's water resources.
    - Policy: New Market will approve an erosion and sedimentation control ordinance to apply to all development that occurs within the corporate limits.
    - Policy: The Town will promote the proper use and disposal of household chemicals and waste oil.
    - Policy: The Town will encourage riparian landowners to maintain stream bank vegetation and minimize disturbances to riparian areas, in order to protect stream habitat and water quality.
- Goal: New Market's wastewater treatment facilities will discharge a final effluent that is safe for the environment and meets state regulations.

- Policy: New Market will use the latest technology in its new treatment facility and will take measures to maintain and repair existing sewer lines.

Additionally, the Town in 2007 adopted a Growth and Annexation Concept Plan that provides for the expansion through annexation of the town's eastern boundary to Smith Creek and includes plans for a riparian greenway along the creek as shown in Figure 10.4.

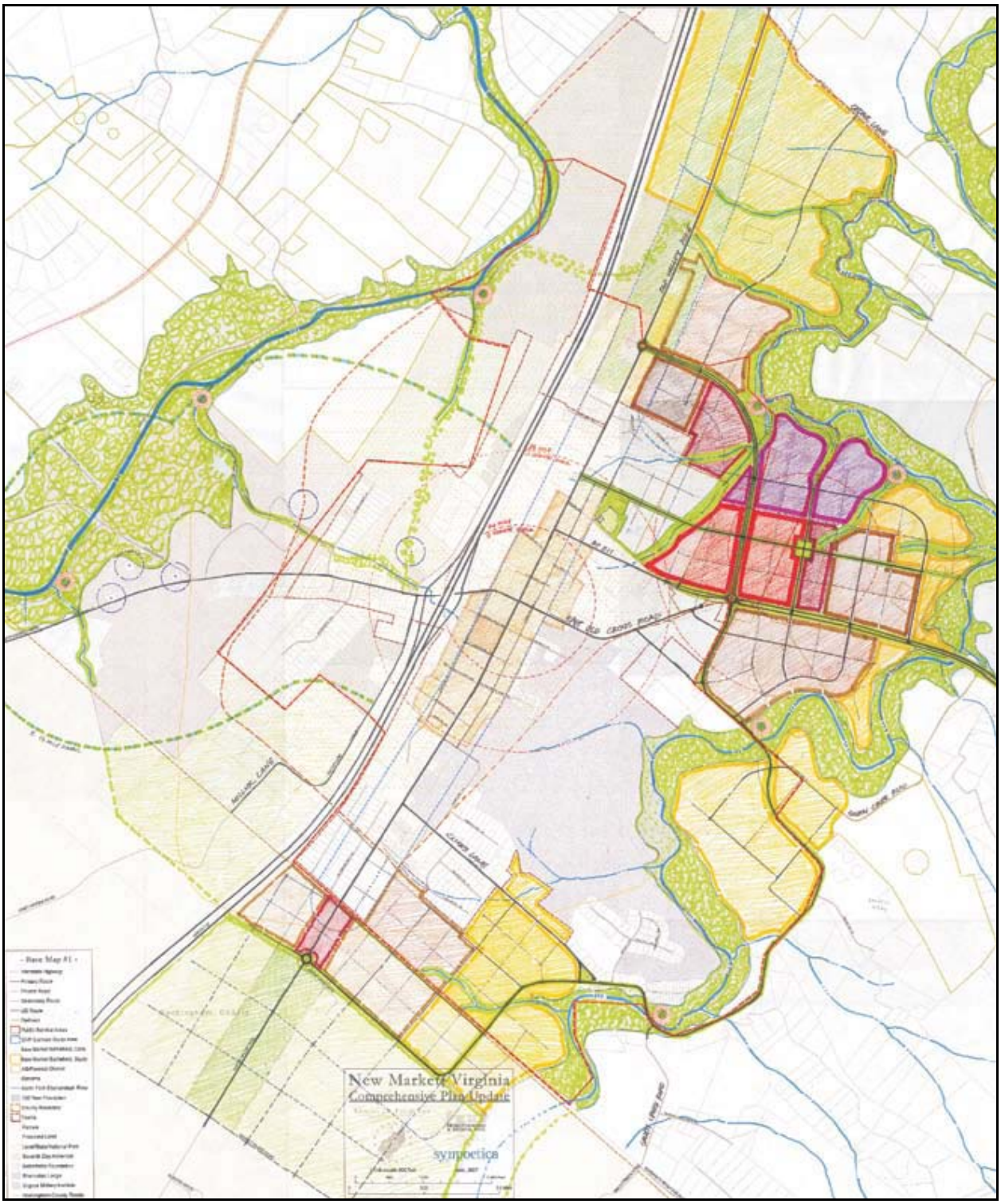

Figure 10.4. Town of New Market Future Land Use in Smith Creek Watershed

11.0 POTENTIAL FUNDING SOURCES

Canaan Valley Institute Small Grants Program – Canaan Valley Institute seeks to support local stakeholder organizations committed to restoring and protecting the natural resources of their watersheds. Therefore applications must address water quality or quantity issues or aquatic habitat. CVI encourages groups to submit projects that can show quantifiable/measurable outcomes. Priority will be given to projects that address wastewater, source water, flooding, stream restoration, or conservation planning that addresses water resources. Groups seeking organizational development funding such as watershed awareness can apply for up to $2,000; specific projects such as watershed assessments, restoration planning, project designs or implementation can apply for up to $5,000. Projects must be completed within two years.

Clean Water State Revolving Fund – EPA awards grants to states to capitalize their Clean Water State Revolving Funds (CWSRFs). The states, through the CWSRF, 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 projects include point source, nonpoint source and estuary protection projects. Point source projects typically include building wastewater treatment facilities; combined sewer overflow and sanitary sewer overflow correction; urban stormwater control; and water quality aspects of landfill projects. Nonpoint source projects include agricultural, silviculture, rural, and some urban runoff control; on-site wastewater disposal systems (septic tanks); land conservation and riparian buffers; leaking underground storage tank remediation, etc. Estuary protection projects include all of the above point and nonpoint source projects, as well as habitat restoration and other unique estuary projects.

Conservation Reserve Enhancement Program (CREP) – The Conservation Reserve Enhancement Program (CREP) is a voluntary land retirement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. CREP is an offshoot of the country's largest private-lands environmental improvement program -- the Conservation Reserve Program (CRP). Like CRP, CREP is administered by USDA's Farm Service Agency (FSA). CREP addresses high-priority conservation issues of both local and national significance, such as impacts to water supplies, loss of critical habitat for

threatened and endangered wildlife species, soil erosion, and reduced habitat for fish populations such as salmon. CREP is a community-based, results-oriented effort centered around local participation and leadership. Like CRP, CREP contracts require a 10- to 15-year commitment to keep lands out of agricultural production. A federal annual rental rate, including an FSA state committee-determined maintenance incentive payment, is offered, plus cost-share of up to 50 percent of the eligible costs to install the practice.

Conservation Reserve Program (CRP) – Offers are accepted and processed during fixed signup periods that are announced by FSA. All eligible (cropland) offers are ranked using a national ranking process. If accepted, contracts are developed for a minimum of 10 and not more than 15 years. Payments are based on a per-acre soil rental rate. Cost-share assistance is available to establish the conservation cover of tree or herbaceous vegetation. The per-acre rental rate may not exceed the Commodity Credit Corporation's maximum payment amount, but producers may elect to receive an amount less than the maximum payment rate, which can increase the ranking score. To be eligible for consideration, the following criteria must be met: 1) cropland was planted or considered planted in an agricultural commodity for two of the five most recent crop years, and 2) cropland is classified as "highly erodible" by NRCS. Eligible practices include planting these areas to trees and/or herbaceous vegetation. Application evaluation points can be increased if certain tree species, spacing, and seeding mixtures that maximize wildlife habitats are selected. Land must have been owned or operated by the applicant for at least 12 months prior to the close of the signup period. The payment to the participant is up to 50% of the cost for establishing ground cover. Incentive payments for wetlands hydrology restoration equal 25% of the cost of restoration.

Environmental Quality Incentives Program – The USDA Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP) was established to provide a voluntary conservation program for farmers and ranchers to address significant natural resource needs and objectives. Nationally, it provides technical, financial, and educational assistance, with sixty percent targeted to livestock-related natural resource concerns and the rest to more general conservation priorities. EQIP is available primarily in nationwide where there are significant natural resource concerns and objectives.

Five-Star Restoration Program – The EPA supports the Five-Star Restoration Program by providing funds to the National Fish and Wildlife Foundation and its partners, the

National Association of Counties, NOAA's Community-based Restoration Program and the Wildlife Habitat Council. These groups then make subgrants to support community-based wetland and riparian restoration projects. Competitive projects will have a strong on-the-ground habitat restoration component that provides long-term ecological, educational, and/or socioeconomic benefits to the people and their community. Preference will be given to projects that are part of a larger watershed or community stewardship effort and include a description of long-term management activities. Projects must involve contributions from multiple and diverse partners, including citizen volunteer organizations, corporations, private landowners, local conservation organizations, youth groups, charitable foundations, and other federal, state, and tribal agencies and local governments. Each project would ideally involve at least five partners who are expected to contribute funding, land, technical assistance, workforce support, or other in-kind services that are equivalent to the federal contribution.

Landowner Incentive Program (Non-Tribal) – The U.S. Fish and Wildlife Service's Landowner Incentive Program (LIP) grant program provides competitive matching grants to states, territories, and the District of Columbia to establish or supplement landowner incentive programs. These programs provide technical and financial assistance to private landowners for projects that protect and restore habitats of listed species or species determined to be at-risk. LIP projects will likely involve activities such as the restoration of marginal farmlands to wetlands, the removal of exotic plants to restore natural prairies, a change in grazing practices and fencing to enhance important riparian habitats, instream structural improvements to benefit aquatic species, road closures to protect habitats and reduce harassment of wildlife, and acquisition of conservation easements. Although not directly eligible for these grants, third parties such as nonprofit organizations may benefit from these funds by working directly with their states to see if either grants or partnering opportunities are available.

NFWF Innovative Nutrient and Sediment Reductions Program – The National Fish and Wildlife Foundation, in partnership with EPA and the Chesapeake Bay Program, awards grants on a competitive basis of between $200,000 and $1 million each to support the demonstration of innovative approaches to expand the collective knowledge about the most cost effective and sustainable approaches to dramatically reduce or eliminate nutrient and sediment pollution to the Chesapeake Bay and its tributaries. A total of up to $12.9 million will be awarded through this solicitation.

Nonpoint Source Implementation Grants (319 Program) – Through its 319 program, EPA provides formula grants to the states and tribes to implement nonpoint source projects and programs in accordance with section 319 of the Clean Water Act (CWA). Nonpoint source pollution reduction projects can be used to protect source water areas and the general quality of water resources in a watershed. Examples of previously funded projects include installation of best management practices (BMPs) for animal waste; design and implementation of BMP systems for stream, lake, and estuary watersheds; Basinwide landowner education programs; and lake projects previously funded under the CWA section 314 Clean Lakes Program.

Open Space Lands Preservation Trust Fund – Farmland, forest land and open spaced land are important to our heritage in Virginia. These lands are under increasing pressure from urban development in parts of the Commonwealth. The 1997 Virginia General Assembly created a new fund (Va. Code Sections 10.1801-2) to assist landowners with the costs of conveying conservation easements and the purchase of all or part of the value of the easements. The fund is operated by the Virginia Outdoors Foundation. Conservation easements preserve farmland, forestland, and natural and recreational areas by restricting intensive uses, such as development and mining, which would alter the conservation values of the land. An easement is a voluntary legal agreement between a landowner and a public body or conservation group in which the parties agree to protect the open-space and natural resource values of the land. Each easement is tailored to reflect the conservation values of the property and is recorded in the local courthouse as a permanent part of the property records. Easements do not grant public access to a landowner's property. Costs that the fund may reimburse include: legal costs, appraisal and other costs, and all or part of the easement's value. To be eligible, the easement must be perpetual in duration. Additional information is available at: http://www.virginiaoutdoorsfoundation.org/ptf.html .

Southeast Rural Community Assistance Project (SE/R-CAP) – The mission of this project is to promote, cultivate, and encourage the development of water and wastewater facilities to serve low-income residents at affordable costs and to support other development activities that will improve the quality of life in rural areas. Staff members of other community organizations complement the SE/R-CAP central office staff across the region. They can provide (at no cost to a community): on-site technical assistance and consultation, operation and maintenance/management assistance, training, education,

facilitation, volunteers, and financial assistance. Financial assistance includes $1,500 toward repair/replacement/installation of a septic system and $2,000 toward repair/replacement/installation of an alternative waste treatment system. Funding is only available for families making less than 125% of the federal poverty level. The federal poverty threshold for a family of four is $18,850.

Transportation Equity Act for the 21st Century Funding Programs – The Transportation Equity Act for the 21st Century (TEA-21) funds numerous transportation programs (Surface Transportation Program (STP), National Highway System, etc.) to improve the nation's transportation infrastructure, enhance economic growth, and protect the environment. States may spend up to 20 percent of the STP dollars used on certain projects to rehabilitate existing transportation facilities for environmental restoration and pollution abatement projects, including the construction of stormwater treatment systems. Additionally, each state sets aside 10 percent of STP funds for transportation enhancement projects, which can include acquisition of conservation and scenic easements and the mitigation of highway stormwater runoff water quality, as well as scenic beautification, pedestrian and bicycle trails, archaeological planning, and historic preservation. These varied project types can be used to protect source water areas during construction of transportation corridors.

Urban and Community Forestry Challenge Cost-Share Grants – The U.S. Forest Service's Urban and Community Forestry Challenge Cost-Share Grant Program seeks to establish sustainable urban and community forests by encouraging communities to manage and protect their natural resources. The program works to achieve a number of goals, including (1) effectively communicating information about the social, economic, and ecological values of urban and community forests; (2) involving diverse resource professionals in urban and community forestry issues; and (3) supporting a holistic view of urban and community forestry. In particular, the program supports an ecosystem approach to managing urban forests for their benefits to air quality, stormwater runoff, wildlife and fish habitat, and other related ecosystem concerns. The Forest Service awards these grants based on recommendations made by The National Urban and Community Forestry Advisory Council, a 15-member advisory council created by the 1990 Farm Bill to provide advice to the Secretary of Agriculture on urban and community forestry.

Virginia Ag BMP Cost-Share Program – The Virginia Agricultural Best Management Practices (BMPs) Cost-Share Program provides funds to help install conservation practices that protect water and make farms more productive. Funding availability varies by district. The state provides districts funds to target areas with known water quality needs. Areas with the greatest need receive the greatest funding. The cost-share program supports using various practices in conservation planning to treat animal waste, cropland, pastureland and forested land. Some are paid for at a straight per-acre rate. Others are cost-shared on a percentage basis up to 75 percent. In some cases, USDA also pays a percentage. In fact, the cost-share program's practices can often be funded by a combination of state and federal funds, reducing the landowner s expense to less than 30 percent of the total cost. Cost-share funds are also available for approved innovative BMP demonstration projects intended to improve water quality.

Virginia Agricultural Best Management Practices Tax Credit Program - For all taxable years, any individual or corporation, who is engaged in agricultural production for market and who has in place a soil conservation plan approved by the local SWCD, is allowed a credit against the tax imposed by Section 58.1-320 of an amount equaling 25% of the first $70,000 expended for agricultural best management practices by the individual. 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. This program can be used independently or in conjunction with other cost-share programs on the stakeholder's portion of BMP costs. It is also approved for use in supplementing the cost of repairs to streamside fencing.

Virginia Aquatic Resource Trust Fund (VARTF) – The Virginia Wetlands Restoration Trust Fund was established as a cooperative partnership between The Nature Conservancy and the Corps-Norfolk District in a Memorandum of Understanding (August, 1995). The fund is utilized when other on-site or off-site compensation alternatives are determined to be impracticable. VADEQ approved the use of the fund on December 19, 2001 as an acceptable form of compensatory mitigation for impacts to state waters, including wetlands, permitted under Virginia Water Protection individual and general permits. An amendment to the 1995 Memorandum of Understanding was made in December 2003. Among other things, the amendment changed the name of the fund to the Virginia Aquatic Resources Trust Fund and allowed for stream restoration contributions to be made.

Virginia Environmental Endowment – The Virginia Mini-Grant Program supports community-based efforts to strengthen environmental education and to promote stewardship of Virginia's waterways. Preference is given to modest local projects. Public and private schools (K-12) and nongovernmental, nonprofit community organizations in Virginia are eligible to apply for one-year Mini-Grant awards up to $5,000. Local, state, and federal government agencies and programs are not eligible.

Water Quality Cooperative Agreements – These EPA grants are provided to help states, Indian tribes, interstate agencies, and other public or nonprofit organizations develop, implement, and demonstrate innovative approaches relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution. This includes watershed approaches for combined sewer overflow, sanitary sewer overflows, and storm water discharge problems, pretreatment and sludge (biosolids) program activities, decentralized systems, and alternative ways to measure the effectiveness of point source programs. The estimate of funds available for fiscal year 2003 includes $20 million that has been requested for a new Watershed Initiative (WSI) program. Details for that program are currently being developed. If funds are appropriated for this program separate guidelines will be developed for the submittal, review, and approval of WSI projects.

Water Quality Improvement Fund – The purpose of the Virginia Water Quality Improvement Act of 1997 (WQIA) is to restore and improve the quality of state waters and to protect them from impairment and destruction for the benefit of current and future citizens of the Commonwealth of Virginia (Section 10.1-2118 of the Code of Virginia). The purpose of the fund is to provide water quality improvement grants to local governments, soil and water conservation districts and individuals for point and nonpoint source pollution prevention, reduction and control programs (Section 10.1-2128.B. of the Code of Virginia). Nonpoint source pollution is a significant cause of degradation of state waters. The Virginia Department of Environmental Quality (VADEQ) is responsible for administering point source grants, and the Virginia Department of Conservation and Recreation (VADCR) administers nonpoint source grants. WQIF funds are provided, in accordance with the guidelines, to help stimulate nonpoint source pollution reduction through the Virginia Agricultural Best Management Practices Cost-share Program and water quality improvement projects. VADCR staff provides technical assistance, as well as financial assistance.

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Appendix A. Glossary of BMP and other Control Measure Definitions

Adaptive fencing: This term refers to livestock exclusion fencing that is typically installed on a voluntary basis using less expensive poly-wire fencing, and is typically installed with a smaller buffer width, resulting in more available grazing acreage.

Agricultural sinkhole protection: A protection method to improve groundwater quality from surface contamination, by removing sources of pollution from sinkholes and providing an adequate buffer to trap and filter sediments and nutrients from surface flows that enter the groundwater through sinkholes. Cost-sharing may include measures to remove and properly dispose of all foreign materials and debris dumped in and around sinkholes, associated structural and agronomic measures to provide adequate vegetation for filtering and sediment trapping of surface run off, and for fencing in order to provide livestock exclusion and personal safety in these areas.

Alternative water system: A structural practice that will provide an alternative water source for livestock to discourage animal access to streams. Cost-sharing and/or tax credits may apply to construction or deepening of wells; development of springs or seeps, including fencing of the area where needed, to protect the development from pollution by livestock; construction or repair of dugouts, dams, pits, or ponds; and the installation of pipelines, storage facilities, cisterns, troughs and artificial watersheds.

Bioretention filter: A depressed landscaping area that is allowed to collect runoff so it percolates through the soil below the area into an underdrain, thereby promoting pollutant removal.

Critical area stabilization: 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.

Contour strip-cropping: This practice consists of growing crops in a systematic arrangement of strips or bands across the general land slope to reduce water erosion and nutrient loss. Cost-sharing and/or tax credits may cover a portion of the installation costs, including obstruction removal such as fences, stonewalls, hedgerows, or gullies; installation of sub-surface drains; and establishment of a winter cover crop.

Cover crops: A fall-seeded grass or legume crop planted after the harvest of corn or soybeans to maintain a vegetative cover over the winter.

Enhanced E&S Management: This practice consists of improvements in site monitoring and/or in additional VSMP permit requirements, such as increased setback distances, faster establishment of vegetation in setback areas, or increased plantings in the setback areas.

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.

Hardened crossing: A controlled stream crossing for livestock and/or farm machinery in order to prevent streambed erosion and reduce sediment.

Improved pasture management: This practice consists of a series of measures to improve vegetative cover on, and reduce bacteria loading from, pasture areas and may include soil testing, application of lime and fertilizer based on soil testing results, maintenance of a 3-inch minimum grass height through the growing season except for droughts, mowing to control woody vegetation, and chain-harrowing to break-up manure piles after livestock are moved from field.

Livestock exclusion: Excluding livestock from areas where grazing or trampling will cause erosion of stream banks and lowering of water quality by livestock activity in or adjacent to the water. Limitation 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.

Livestock exclusion fencing: This practice consists of installing fencing, both temporary and stream exclusion (permanent), for grazing distribution and to restrict stream access in connection with newly developed watering facilities. State cost-sharing requires that the stream exclusion fence be placed a minimum of 35 feet away from the stream, except as designed in areas immediately adjacent to livestock crossings and controlled hardened accesses.

Livestock exclusion buffers: In the implementation plan, this term is used to differentiate the filtering benefits of the buffer, as opposed to the removal of livestock and their directly deposited bacteria loads from the stream. Removal of the livestock has an immediate effect in removing bacteria loads, while the buffer mitigates loading from surface runoff during storm events.

Manure injection: This practice consists of adapting liquid manure spreaders to allow the liquid manure to be injected directly into the soil, thereby minimizing surface runoff of nutrients and bacteria contained in the manure.

Manure storage facility: This practice consists of a planned system designed to manage liquid and solid waste from areas where livestock and poultry are concentrated. The storage allows for the farm operator to apply the manure on fields during optimum times of the year, and increases the die-off of bacteria in the animal waste.

Pet waste program: This is an educational program conducted typically in urban and sub-urban areas to demonstrate how homeowners can responsibly manage fecal wastes from their pets, both at their own homes, and when taking their pets for walks in public areas. The program also usually includes signage describing water quality concerns related to pet waste and pet waste collection bag dispensers and receptacles in high pet traffic areas, such as in parks and along greenways.

Rain garden: Rain gardens are landscaped gardens of trees, shrubs, and plants located in commercial or residential areas in order 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.

Reforestation of erodible pastureland: This practice consists of planting trees (hardwoods and/or conifers) on land currently used as cropland or pastureland in order to make a permanent land use conversion to forest, so as to more effectively control the soil and nutrient loss from surface runoff, thus improving water quality. As part of the practice, a permanent vegetative cover is to

be established on gullied or eroded areas and shall be maintained until trees provide a protective canopy.

Riparian forest buffer: A protection method used along streams to reduce erosion, sedimentation, and the pollution of water from agricultural nonpoint sources. An area of trees and shrubs 35 – 300 feet wide located up gradient, adjacent, and parallel to the edge of a water feature.

Riparian grass buffer: Grass filter strips are vegetative buffers that are located along the banks of water courses to filter runoff, anchor soil particles, and protect banks against scour and erosion. The strips also improve water quality by filtering out fertilizers, pesticides, and microorganisms that otherwise might reach waterways. In addition, grass filter strips along streams serve as environmental corridors.

Septic system pump out: This preventative control measure consists of periodic maintenance of septic tank systems by having the tank pumped to remove solids and to inspect the septic tank. This practice also allows for the identification of systems which are not functioning properly. The practice also may include inspection of the distribution box to determine if the effluent is being properly distributed to the drainfields and the system is functioning in accordance to design.

Septic system repair: This measure consists of the correction of a malfunctioning on-site sewage disposal system to remove the presence of raw or partially treated sewage on the ground's surface, or in adjacent ditches or waterways, or in ground water.

Septic system, alternative: An alternative on-site waste treatment system is needed to correct a malfunctioning on-site sewage disposal system or to replace an identified straight pipe in situations where the installation/replacement of a septic tank system cannot be permitted. Alternative systems may include the following: aerobic treatment units, low pressure distribution systems, drip distribution systems, sand filters, elevated sand mounds, constructed wetlands, peat filters, vault privies, incinerator toilets, and composting toilets.

Septic system, new: This control measure consists of the installation of a septic tank system to replace an identified straight pipe which delivers sewage directly to a stream, pond, lake, or river or an installation to correct a malfunctioning on-site sewage disposal system. Cost-sharing may include the pump out and removal of solids from the malfunctioning septic tank, the installation of a septic tank and subsurface drainfield components, and the re-stabilization of disturbed areas by planting seed.

Septic system, new with pump: Same as for a new septic system, with the inclusion of a pump as a primary component to move waste to a higher elevation.

Sewer hookup, new: This practice consists of connecting a malfunctioning on-site sewage disposal system to public sewer, or replacing an identified straight pipe by a connection to public sewer. Cost-sharing may be authorized for the connection fee, which is the fee allowing the dwelling to be connected to the public sewer system, for the construction cost associated with connecting the dwelling to a sewer line, for re-stabilization of disturbed areas, and for the pump-out and removal of solids from the septic tank.

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.

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.

Winter feeding facility: Winter feeding facilities are specially designed to allow for the feeding of livestock in combination with the safe storage of manure, and to prevent contamination of nearby water corridors and streams. Winter feeding facilities are typically sized for individual farms, based on number of head of livestock fed through the winter; are designed to hold 5-7 days of feed; and to store waste for at least 120 days. This practice may also include the following components: gutters & downspouts redirect runoff, livestock watering facilities, heavy use area protection around the facility, and all-weather access roads to the structure.

Appendix B. BMP Codes and Practice Names

CP-21: CREP filter strip (rental only)
CREP: Conservation Reserve Enhancement Program
CRFR-3: Riparian forest buffer
CRP: Conservation Reserve Program
FR-1: Reforestation of erodible cropland or pastureland
RB-1: Septic tank pump out
RB-2: Connection of malfunctioning On-site Sewage Disposal System or straight pipe to public sewer
RB-3: Septic tank system repair
RB-4: Septic tank system installation/replacement
RB-4P: Septic tank system installation/replacement with pump
RB-5: Alternative on-site waste treatment system
SL-3: Stripcropping systems
SL-3B: Buffer stripcropping systems
SL-6: Grazing land protection systems
SL-6B: Alternative water system
SL-8B: Small grain cover crop for nutrient management
SL-8H: Harvestable cover crop
SL-11: Permanent vegetative cover on critical areas
WP-4: Animal waste control facility
WP-4B: Loafing lot management system
WP-8: Relocation of confined feeding operations from environmentally sensitive areas
WP-2T: Stream protection systems
WQ-1: Grass filter strips
WQ-4: Legume cover crop
WQ-11: Agricultural sinkhole protection

Appendix C. Documentation for Smith Creek BMP Modeling

Basis for BMP Extents

- Livestock exclusion: stream lengths in or adjacent to NLCD pasture areas were delineated using GIS and separated into perennial and intermittent categories (lin. ft.). After consultation with local SWCD and NRCS personnel, 30% of intermittent streams in addition to all perennial streams were considered the length requiring fencing. Adaptive fencing was estimated as the appropriate means for livestock exclusion for 25% of the total length. Associated buffer zones were calculated as 35 feet for typical cost-shared stream fencing, and as 10 feet for adaptive fencing (acres).
- Hardened crossings: estimated as 1 per 4,800 linear feet of perennial streams, as used in the Blacks Run/Cooks Creek IP (27).
- Alternative water systems: estimated as 1 per 1,200 linear feet of perennial streams by local SWCD personnel (113).
- Grass riparian buffers on cropland: estimated as a 35 foot width analyzed with GIS along the few stream lengths in Smith Creek that were adjacent to, or running through, cropland acres (3.5 acres).
- Critical area stabilization: estimated from GIS analysis as the minimal cropland acreage within two sub-watersheds with average slopes greater than 12% (3.22 acres).
- Contour stripcropping: estimated as one of the last resort control measures to achieve the final cropland bacteria target reductions, after the more acceptable control measures had been applied (64.7 acres).
- Manure injection: estimated as a minimal acreage (20 acres) to support an ongoing demonstration of this potentially useful control measure in this watershed, though currently not cost-effective.
- Manure storage facilities: in addition to the large number already installed, the number of remaining structures needed were estimated by animal type in conjunction with local SWCD personnel (4 – beef; 1 – dairy; 3 – poultry).
- Reforestation of erodible pastureland: estimated as 50% of the pasture area in the two sub-watersheds with average slopes greater than 12% (209.8 acres).
- Improved pasture management: was estimated as being needed on 70.6% of the available pasture acreage, in order to meet the pasture bacteria target reductions (19,897 acres).
- Winter feeding facilities: the number of structures was estimated basaed on conversations with DCR and local SWCD personnel (15).
- Agricultural sinkhole protection: sinkholes on pasture areas in Smith Creek were identified using digital soil survey point features. Although not considered in the TMDL and not included in the estimate of load reductions, this new cost-shared control measure was considered to be part of the solution to pollutant loading reduction for the implementation plan. Approximately 20% (40) of the 207 sinkholes will be used as the target number of sinkholes to address.
- Septic system pump outs: estimated as being needed on 60% of the houses using septic systems by VDH personnel (1,169).
- Septic system repairs: estimated as 20% of all failing septic systems by VDH personnel. Failing septic systems were enumerated in the TMDL study as 4% of the population using septic systems (17).
- Alternative septic systems: estimated as 80% of all failing septic systems by VDH personnel (70).
- New septic systems: estimated for all households currently with straight pipes. The number of straight pipes in the watershed was estimated in the TMDL study as 0.5% of the non-sewered population (13 plus 6 more with pumps).

- New sewer hookups: estimated from a visual assessment of homes in areas close to the existing sewer distribution system in the watershed, using digital raster graphic (DRG images (7).
- Forested riparian buffers: delineated using GIS and calculated as 35 foot wide buffers along stream reaches in and adjacent to New Market in the Non-MS4 urban area (42.4 acres) and in Harrisonburg in the MS4 urban area (1.7 acres).
- Pet waste program: estimated as being practical only in areas of concentrated populations around the New Market and Harrisonburg areas. The reductions due to a pet waste program in each area were estimated based on the number of pets associated with each area (650 in New Market; 201 in Harrisonburg).
- Street sweeping: estimated for the New Market and Harrisonburg portions of the watershed using GIS analyses of road lengths within each jurisdictional area and assuming a collection area based on 20 foot road widths (22.8 acres in New Market; 13.84 acres in Harrisonburg).
- Rain gardens and bioretention filters: used as control measures of last resort. Estimates of their extents were based on areas needed to achieve urban bacteria load target reductions in the urban Non-MS4 and MS4 areas, respectively. A greater emphasis was placed on rain gardens which would be installed on individual homeowner lots, versus bioretention filters more commonly placed in public right-of-ways.
- Increased E&S management: estimated as a percentage of the area of the transitional land use category needing increased efficiency to meet target sediment load reductions in the urban Non-MS4 and MS4 (acres).

Basis for Acres Benefitted (AB)

- Grass and forested riparian buffers: estimated as benefitting an upstream area equal to 4 times the buffer area based on conversations with DCR.
- Rain gardens: estimated as benefitting an upstream area equal to 6 times the area of each rain garden. This estimate was based on design guidelines, wher the sizing factor for an 8” deep loamy soil is 0.16, implying the ability to treat 6.25 times the area of the rain garden (www.aces.edu/waterquality/nemo/Fact Sheets/rain garden, mg, final.pdf).
- Bioretention filters: are generally deeper and include more storage capacity than rain gardens and may include underdrains. They generally treat an area 20 times its design area, as indicated by LID design spreadsheets found at www.lid-stormwater.net/bio-sizing.htm, where default device areas of 5% of the deign areas are commonly used. Anoth source backing this estimate was a North Carolina extension publication that cites rain gardens varying in size from 3-8% of the contributing area, depending on the amount of impervious area (www.bae.ncsu.edu/stormwater/PublicationFiles/DesigningRainGardens2001.pdf).

All control measures that reduce available bacteria loads on the surface of the land – manure storage facilities, winter feeding facilities, manure injection – were simulated first to adjust and reduce the unit-area bacteria load (UAL) that could then be reduced by other field-based control measures.

Basis for Bacteria Load Reduction Calculations

Bacteria load reductions were generally calculated either as a reduction in the overall unit-area load (UAL) of bacteria applied to an individual land use, or as an area of a given BMP, with an associated effectiveness estimate for an individual control measure. Reductions from land use changes were simulated as the difference in the UALs between the two land uses, and practices associated with additional filtering benefits were simulated as affecting some multiple of the buffer area.

- Livestock exclusion fencing:
  % of total stream length * direct deposit load

- Adaptive fencing: % of total stream length * direct deposit load

- Grass riparian buffers on cropland:
  $[(UAL_{cropland} – UAL_{forest}) + 4 * UAL_{cropland}] * BMP\ area * BMP\ efficiency$

- Forest riparian buffers on cropland:
  $[(UAL_{cropland} – UAL_{forest}) + 4 * UAL_{cropland}] * BMP\ area * BMP\ efficiency$

- Critical area stabilization:
  $(UAL_{cropland} – UAL_{forest}) * BMP\ area * BMP\ efficiency$

- Contour strip-cropping:
  $UAL_{cropland} * BMP\ area * (1 – Pfactor)$

- Manure injection: $UAL_{cropland} * BMP\ area * BMP\ efficiency$

- Manure storage facility:
  cfu/system-yr * no. of systems * BMP efficiency * 75% (manure applied to cropland)
  or
  cfu/system-yr * no. of systems * BMP efficiency * 25% (manure applied to pasture)

- Livestock exclusion buffers:
  $[(UAL_{pasture} – UAL_{forest}) + 4 * UAL_{pasture}] * BMP\ area * BMP\ efficiency$

- Reforestation of pasture areas:
  $(UAL_{pasture} – UAL_{forest}) * BMP\ area$

- Improved pasture management:
  $UAL_{pasture} * BMP\ area * BMP\ efficiency$

- Winter feeding facility: cfu/system-yr * no. of systems * BMP efficiency

- Urban forest riparian buffers:
  $5 * UAL_{urban} * BMP\ area * BMP\ efficiency$

- Pet waste program:
  % of watershed pets * urban bacteria load * % of urban load due to pets * BMP efficiency

- Street sweeping program: UAL_{urban} * BMP area * BMP efficiency
- Rain gardens: 6 * UAL_{urban} * BMP area * BMP efficiency
- Bioretention filters: 20 * UAL_{urban} * BMP area * BMP efficiency

Basis for Sediment Load Reduction Calculations

Sediment load reductions were generally calculated from unit-area loads (UALs) associated with individual land use categories from the TMDL modeling, the area of the BMP, and the estimated effectiveness of the individual control measures. Reductions from land use changes were simulated as the difference in the UALs between the two land uses, and practices associated with additional filtering benefits were simulated as affecting some multiple of the buffer area.

- Grass riparian buffers on cropland:
  $[(UAL_{cropland} – UAL_{buffer\ grass}) + 4 * UAL_{cropland}]$ * BMP area * BMP efficiency
- Forest riparian buffers on cropland:
  $[(UAL_{cropland} – UAL_{forest}) + 4 * UAL_{cropland}]$ * BMP area * BMP efficiency
- Critical area stabilization: $(UAL_{cropland} – UAL_{forest})$ * BMP area
- Contour stripcropping:
  $[0.5 * (UAL_{cropland} – UAL_{buffer\ grass}) * 0.5 * UAL_{cropland} * (1 - P\text{-factor})]$ * BMP area
- Cover crops: $UAL_{cropland}$ * BMP area * BMP efficiency
- Riparian buffers on pasture:
  $[(UAL_{pasture} – UAL_{buffer\ grass}) + 4 * UAL_{pasture}]$ * BMP area * BMP efficiency
- Reforestation of pasture areas:
  $(UAL_{pasture} – UAL_{forest})$ * BMP area
- Improved pasture management:
  $(UAL_{good\ pasture} – UAL_{fair\ pasture})$ * BMP area * BMP efficiency
- Urban forest riparian buffers:
  $[(UAL_{urban} – UAL_{forest}) + 4 * UAL_{urban}]$ * BMP area * BMP efficiency
- Street sweeping: UAL_{urban} * BMP area * BMP efficiency
- Rain gardens: 6 * UAL_{urban} * BMP area * BMP efficiency
- Bioretention filters: 20 * UAL_{urban} * BMP area * BMP efficiency
- Enhanced E&S Management: $UAL_{transitional}$ * BMP area * BMP efficiency