Bacterial TMDL Development for the Banister River (BAN06A08) and Winn Creek (WNN01A06) Watersheds

Submitted by

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May 2013

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Executive Summary

This report addresses the impaired segments of Banister River and Winn Creek listed on the 2010 Impaired Waters - 303(d) List for recreation use due to exceedances of the criteria for E. coli bacteria.

Description of the Study Area

The bacteria impaired segments are located within the borders of Halifax County and flow into the Dan River. The major roadways that run through the watershed are Route 360, which runs from North to South in the eastern portion of the watershed, and Route 501, which runs from North to South in the western portion of the watershed.

Impairment Description

Banister River (VAC-L71R_BAN06A08) was first identified as impaired on VA DEQ's 2008 303 (d) Total Maximum Daily Load Priority List due to exceedances for the state's water quality criteria for E. coli bacteria. The segment extends for 2.39 miles, beginning at the confluence with Wolf Trap Creek and continuing downstream to its mouth on the Dan River.

Winn Creek (VAC-L71R_WNN01A06) was first identified as impaired on VA DEQ's 2008 303 (d) Total Maximum Daily Load Priority List due to exceedances for the state's water quality criteria for E. coli bacteria. The segment extends for 6.94 miles, beginning at its headwaters and continuing downstream to its mouth on the Banister River.

Applicable Water Quality Standards

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."

VA DEQ specifies the following criteria for recreational uses (VA DEQ, 2011) of waterbodies located in freshwater:

- E. coli bacteria shall not exceed a monthly geometric mean of 126 colony forming units (CFU) per 100mL of freshwater or if there are insufficient data to calculate monthly geometric means in freshwater, no more than 10% of the total samples in the assessment period shall exceed 235 E. coli CFU/100 ml.

Watershed Characterization

The TMDL watershed has a drainage area of 32,060 acres.. The land use characterization for the Banister River and Winn Creek watersheds was based on the latest available land cover data from the National Land Cover Database, also known as the NLCD 2006. Dominant land uses in the watershed are forest (58%) and agriculture (18%).

Potential sources of bacteria include run-off from grazing livestock, agricultural practices, wildlife, human waste, and pet waste. Some of these sources are driven by dry weather and others are driven by wet weather. The potential bacteria sources in the watershed were identified and characterized and were found to include permitted facilities, runoff from livestock waste, direct livestock deposition, wildlife, residential waste and pets.

Based on data obtained from VA DEQ, there are four permitted facilities holding VPDES permits and seven residences holding domestic permits for discharging into the watershed. An inventory of agricultural practices (livestock populations), wildlife and pets was collected from data provided by the Census of Agriculture (2007), the Virginia Department of Game and Inland Fisheries (VDGIF), the American Veterinary Medical Association (AVMA), and from other sources.

TMDL Technical Approach

The Hydrologic Simulation Program-Fortran (HSPF) model was selected and used as a tool to predict the instream water quality conditions of the delineated watershed under varying scenarios of rainfall and fecal coliform loading. HSPF is a hydrologic, watershed-based water quality model. The results from the model were used to develop the TMDL allocations based on the existing fecal coliform load. This means that HSPF can explicitly

account for the specific watershed conditions, the seasonal variations in rainfall and climate conditions, and activities and uses related to fecal coliform loading.

The modeling process in HSPF starts with the following steps:

- delineating the watershed into smaller subwatersheds
- entering the physical data that describe each subwatershed and stream segment
- entering values for the rates and constants that describe the sources and the activities related to the fecal coliform loading in the watershed

The Banister River and Winn Creek watersheds were delineated into 29 smaller subwatersheds to represent the watershed characteristics and to improve the accuracy of the HSPF model. This delineation was based on a Digital Elevation Model (DEM), stream reaches obtained from the National Hydrography Dataset (NHD), and stream flow and instream water quality data. Stream flow data were available from the U.S. Geological Survey (USGS). Weather data were obtained from the National Climatic Data Center (NCDC).

The period of 2003 to 2008 was used for HSPF hydraulic calibration and 2008 to 2011 was used to validate the HSPF model. The hydrologic calibration parameters were adjusted until there was a good agreement between the observed and simulated stream flow, thereby indicating that the model parameterization is representative of the hydrologic characteristics of the watershed. The model results closely matched the observed flows during low flow conditions, base flow recession and storm peaks.

Instream water quality data for the calibration was retrieved from VADEQ, and was evaluated for potential use in the set-up, calibration, and validation of the water quality model. The existing E. coli loading was calculated based on current watershed conditions.

TMDL Calculations

The Total Maximum Daily Load (TMDL) represents the maximum amount of a pollutant that the stream can contain without exceeding the water quality standard. The load allocation for the selected scenarios was calculated using the following equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

Where,

WLA = wasteload allocation (point source contributions);

LA = load allocation (non-point source allocation); and

MOS = margin of safety.

The margin of safety (MOS) is a required component of the TMDL, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. The MOS was implicitly incorporated in this TMDL. Implicitly incorporating the MOS required that allocation scenarios be designed to meet the geometric mean E. coli standard of 126 CFU/100mL and the single sample maximum of 235 CFU/100mL at any time.

Typically, there are several potential allocation strategies that would achieve the TMDL endpoint and water quality standards. A number of load allocation scenarios were developed to determine the final TMDL load allocation scenario.

Based on the load-allocation scenario analyses, the TMDL allocation plans that will meet the calendar-month *E. coli* geometric mean water quality criterion of 126 cfu/100 mL and the instantaneous *E. coli* water quality criterion of 235 cfu/100 mL are presented in **Table E-1** to **E-2**.

Table E-1: Winn Creek Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Source	Annual Average E. coli Loads cfu/yr)		Percent Reduction
	Existing	Allocation	%
Forest	1.58E+12	1.58E+12	0.0%
Cropland	5.08E+11	1.52E+11	70.0%
Pasture	8.11E+12	2.43E+12	70.0%
High Intensity Urban	3.04E+10	9.12E+09	70.0%
Medium Intensity Urban	3.18E+10	9.54E+09	70.0%
Low Intensity Urban	7.69E+11	2.31E+11	70.0%
Developed Open Space	5.49E+11	1.65E+11	70.0%
Cattle Direct Deposition	2.20E+12	0.00E+00	100.0%
Wildlife Direct Deposition	1.74E+12	6.26E+11	64.0%
Failing Septics	9.04E+10	0.00E+00	100.0%
Future Growth (*)	0.00E+00	5.25E+10	
Total	**1.56E+13**	**5.25E+12**	**66.36%**

(*) there are no individual VPDES municipal point source dischargers; the WLA includes 1 percent of the TMDL to account for future growth

Table E-2: Banister River (BAN06A08) Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation			
Land Use/Source	**Average *E. coli* Loads (cfu/yr)**		**Percent Reduction (%)**
	Existing	**Allocation**	
Forest	6.03E+12	6.03E+12	0.0%
Cropland	7.93E+11	1.98E+11	75.0%
Pasture	2.32E+13	5.80E+12	75.0%
High Intensity Urban	2.63E+12	6.58E+11	75.0%
Medium Intensity Urban	3.63E+12	9.08E+11	75.0%
Low Intensity Urban	8.33E+12	2.08E+12	75.0%
Developed Open Space	3.01E+12	7.53E+11	75.0%
Cattle Direct Deposition	6.49E+12	0.00E+00	100.0%
Wildlife Direct Deposition	6.82E+12	5.12E+12	25.0%
Failing Septics	8.38E+11	0.00E+00	100.0%
Point Sources	5.87E+11	5.87E+11	-
Future Growth*	0.00E+00	5.87E+11	-
Total	**6.24E+13**	**2.27E+13**	**63.6%**

*Future Growth is equal to 1x the existing point source load (to give a total wasteload allocation of 2x the existing wasteload)

The summaries of the bacteria TMDL allocation plan loads are presented in the following tables. The bacteria TMDLs for Winn Creek are presented in **Tables E-3** and **E-4**.

Table E-3: Winn Creek TMDL (cfu/year) for *E. coli*				
Watershed	**WLA**	**LA**	**MOS**	**TMDL**
Winn Creek	**5.25E+10**	**5.20E+12**	**IMPLICIT**	**5.25E+12**

Table E-4: Winn Creek TMDL (cfu/day) for *E. coli*				
Watershed	**WLA**	**LA**	**MOS**	**TMDL**
Winn Creek	**1.43E+08**	**4.45E+10**	**IMPLICIT**	**4.46E+10**

The bacteria TMDLs for the Banister River are presented in **Tables E-5** and **E-6**.

Table E-5: Banister River TMDL for *E. coli* (cfu/year)				
Watershed	**WLA**	**LA**	**MOS**	**TMDL**
Banister River	**1.17E+12**	**2.15E+13**	**IMPLICIT**	**2.27E+13**

Table E-6: Banister River TMDL for *E. coli* (cfu/day)				
Watershed	**WLA**	**LA**	**MOS**	**TMDL**
Banister River	**2.21E+09**	**1.29E+11**	**IMPLICIT**	**1.32E+11**

Consideration of Seasonal Variability

The Clean Water Act requires that a TMDL be established with consideration of seasonable variations. This includes variations of the hydrologic flow regime and the water quality. In estimating existing conditions, the seasonable variation was accounted for by the incorporation of monthly sampling and the long-term data record.

Implementation

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in attainment of water quality standards. This report represents the culmination of that first step for the bacteria impairments on the Banister River and Winn Creek. The second step is to develop a TMDL implementation plan. The final step is to initiate recommendations outlined in the TMDL implementation plans and to monitor stream water quality to determine if water quality standards are being attained.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of VADEQ, VADCR, and other cooperating agencies.

Public Participation

Watershed stakeholders had opportunities to provide input and participated in the development of the TMDL during two public meetings held in the watershed. The meetings were held in Halifax, Virginia on November 1st, 2012 and April 4th, 2013. The first public meeting had nineteen attendees while the second public meeting had approximately ten attendees. Both meetings were followed by a 30-day public comment period.

1.0 Introduction

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (EPA, 2001).

The lead state regulatory agency for environmental matters in Virginia is the Department of Environmental Quality (VADEQ). VADEQ works in coordination with the Virginia Department of Conservation and Recreation (VADCR), the Department of Mines, Minerals, and Energy (VDMME), and the Virginia Department of Health (VDH) to develop and regulate a more effective TMDL process. VADEQ is the lead agency for the development of TMDLs statewide, and focuses its efforts on all aspects of reduction and prevention of pollution to state waters. VADEQ ensures compliance with the Federal Clean Water Act and the Water Quality Planning Regulations, as well as with the Virginia Water Quality Monitoring, Information, and Restoration Act (WQMIRA), passed by the Virginia General Assembly in 1997, and coordinates public participation throughout the TMDL development process. The role of VADCR is to initiate nonpoint source pollution control programs statewide through the use of federal grant money. VDMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for industrial and mining operations. Lastly, VDH monitors waters for fecal coliform, classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of bacterial contamination (VADEQ, 2001).

As required by the Clean Water Act and WQMIRA, VADEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. This list is referred to as the 303(d) List of Impaired Waters. In addition to 303(d) List development, WQMIRA directs VADEQ to develop and implement TMDLs for listed waters (VADEQ, 2001). Once TMDLs have been developed, they are distributed for public comment and then submitted to the EPA for approval.

1.2 Impairment Listing

This report addresses two bacteria impaired segments for recreational use within the cause group codes VAC-L71R-04-BAC of the Banister River watershed and VAC-L71R-06-BAC of the Winn Creek watershed (within the Banister River watershed). The segments VAC-L71R_BAN06A08 and VAC-L71R_WNN01A06 were first listed as bacteria impaired on Virginia's 2008 303(d) Total Maximum Daily Load Priority List and Reports due to exceedances of the state's water quality criteria for Escherichia coli (E. coli) bacteria. Banister River is located in the southern region of Virginia, within the borders of Halifax and Pittsylvania Counties, and empties into the Dan River (USGS Cataloging Unit 03010105).

The Banister River bacteria-impaired segment (Assessment unit VAC-L71R_BAN06A08), is 2.39 miles in length and goes from the confluence of Wolf Trap Creek to its mouth on the Dan River. Winn Creek, the second bacteria-impaired segment (Assessment unit VAC-L71R_WNN01A06), is 6.94 miles in length and stretches from its headwaters to the mouth on the Banister River. Based on monitoring data for the 2010 Water Quality Assessment (2003–2008) at stations 4-ABAN001.86 (Banister) and 4-AWNN000.99, the segments were found not to be supporting their recreational use goal due to exceedances of the instantaneous *E coli* bacteria criteria. **Table 1-1** summarizes the details of the impaired segment as listed in the 2010 Integrated Assessment.

Table 1-1: Impairment Summary for the 2013 Banister River TMDL

Cause Group Code	Assessment Unit	Segment Name	Boundaries	Listing Station ID	Impairment	Length (mi)	Cycle Listed	Exceedance Rate
VAC-L71R-04-BAC	VAC-L71R_BAN06A08	Banister River	Confluence of Wolf Trap Creek to its mouth on the Dan River.	4-ABAN001.86	*E. coli*	2.39	2008	2/11 (18%)
VAC-L71R-06-BAC	VAC-L71R_WNN01A06	Winn Creek	Headwaters to the mouth on the Banister River.	4-AWNN000.99	*E. coli*	6.94	2008	2/12 (17%)

*Exceedance rate listed in Virginia's 2010 305(b)/303(d) Water Quality Integrated Assessment

1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term 'water quality standards' is defined as:

> *"provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

1.3.1 Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10):

> *"…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 be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

1.3.2 Applicable Water Quality Criteria for Bacteria

Effective February 1, 2010, VADEQ specified a new bacteria standard in 9 VAC 25-260-170.A. These standards replaced the existing fecal coliform standard of 9 VAC 25-260-170. For a non-shellfish supporting waterbody to be in compliance with Virginia bacteria standards for primary contact recreation, the current criteria are as follows:

> *"E. coli bacteria shall not exceed a monthly geometric mean of 126 CFU/100 ml in freshwater...Geometric means shall be calculated using all data collected during any calendar month with a minimum of four weekly samples… If there are insufficient data to calculate monthly geometric means in freshwater, no more than 10% of the total samples in the assessment period shall exceed 235 E. coli CFU/100 ml."*

These criteria were adopted because there is a stronger correlation between the concentration of *E. coli* and the incidence of gastrointestinal illness than with fecal coliform. *E. coli* are bacteriological organisms that can be found in the intestinal tract of warm-blooded animals. Like fecal coliform bacteria, these organisms indicate the presence of fecal contamination.

1.4 TMDL Endpoint Identification

1.4.1 Selection of TMDL Endpoint and Water Quality Targets

One of the first steps in TMDL development is to determine a numeric endpoint, or water quality target, for each impaired segment. A water quality target compares the current stream conditions to the expected restored stream conditions after TMDL load reductions are implemented. Numeric endpoints for the bacteria impaired segments of the Banister River and Winn Creek are established in Virginia Water Quality Standards (9 VAC 25-260). These standards state that all waters in Virginia should be free from any substances that can cause the water to exceed the state numeric criteria, interfere with its designated uses, or adversely affect human health and aquatic life. The current water quality target for freshwater, non-shellfish waters; as stated in 9 VAC 25-260-170; is an *E. coli* geometric mean of no greater than 126 colony-forming units (cfu) per 100 ml (minimum of four weekly samples within a calendar month necessary to calculate the geometric mean), and no more than 10% exceedance of the maximum assessment criterion of 235 cfu per 100mL).

1.4.2 Critical Condition

The critical condition refers to the "worst case scenario" of environmental conditions in the Banister River and Winn Creek segments. Developing TMDLs to meet the water

quality targets under the critical condition will ensure that the targets would also be met under all other conditions.

EPA regulations, 40 CFR 130.7 (c)(1), require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of the impaired streams is protected during times when it is most vulnerable. Critical conditions are important because they describe the combination of factors that cause an exceedance of water quality criteria. They will help in identifying the actions that may have to be undertaken to meet water quality standards.

The Banister River and Winn Creek flow through a predominantly rural setting. The dominant land uses in the basin are forested (58%) and pasture (17%). Potential sources of *E. coli* include run-off from livestock grazing, manure applications, wildlife deposition, point source dischargers, and residential waste.

E. coli loadings result from sources that can contribute during wet weather and dry weather. The critical conditions were determined from the available in-stream water quality data and flow data obtained from a USGS flow monitoring station located within the TMDL watershed, upstream of the impaired segment (Station 02077000).

1.4.2.1 Banister River (VAC-L71R_BAN06A08)

Figure 1-1 shows the observed *E. coli* levels under different flow conditions at VADEQ water quality stations 4ABAN001.86, 4ABAN005.58, and 4ABAN008.30, which all are on the mainstem of the Banister River and have bacteria data sets that range from 2003 to 2010. The impairment listing station is 4ABAN001.86. The maximum assessment criterion is shown as a thick red line (235 *E. coli*/100 ml of water). Plotting *E. coli* data along with available stream flow data (**Figure 1-1**) revealed that exceedances occurred during all flow conditions except low flow.

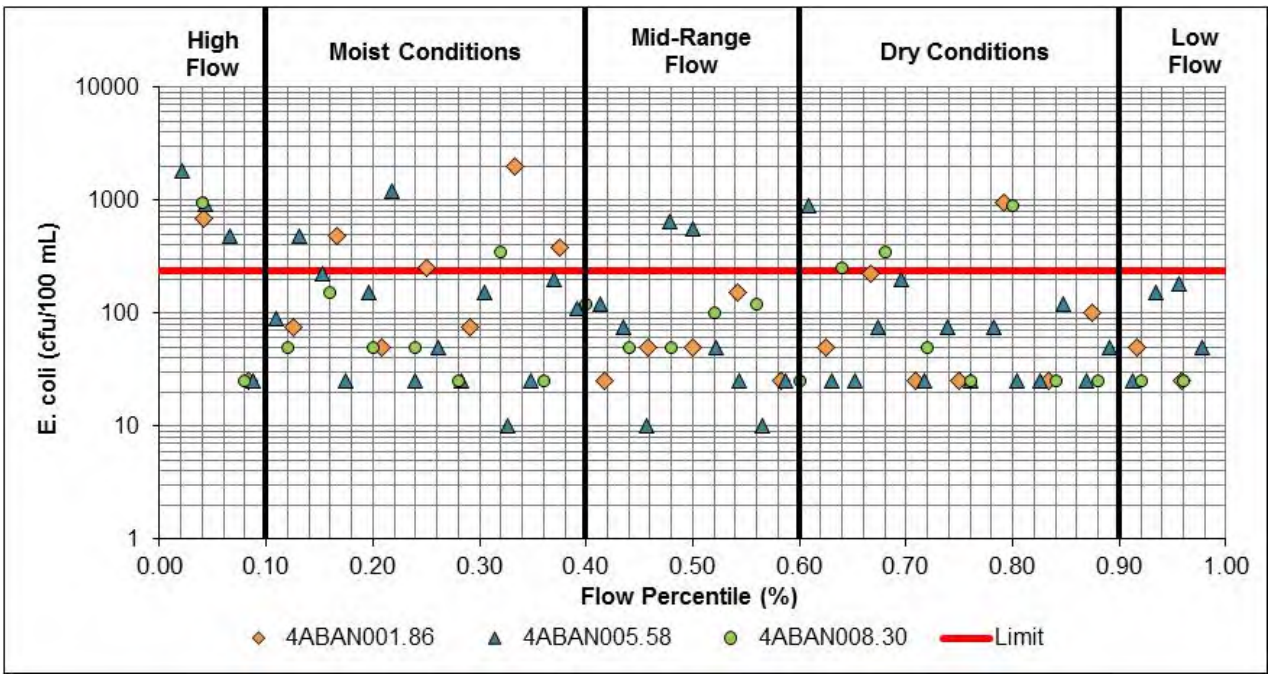

Figure 1-1: Flow Percentile and *E. coli* Concentrations for the Banister River (2003-2010)

Consequently, both higher and lower flow periods were considered as the critical conditions. Exceedances that occur under high-flow conditions would most likely be runoff based, indirect sources of bacteria, and would most likely exceed the maximum assessment criterion. Bacteria loads under low-flow conditions would likely occur from direct deposition sources of bacteria, and would most likely exceed both the maximum assessment and geometric mean criteria.

The TMDL is required to meet both the geometric mean and maximum assessment bacteria criteria. Therefore, it is necessary for the critical condition to consider both wet weather, high flow conditions, and dry weather, low flow conditions in order to comply with both bacteria criteria.

1.4.2.2 Winn Creek (VAC-L71R_WNN01A06)

Figure 1-2 shows the observed *E. coli* levels under different flow conditions at VADEQ water quality stations 4AWNN000.99 which has a bacteria data sets that range from 2003 to 2005. The maximum assessment criterion is shown as a thick red line (235 *E. coli*/100 ml of water). Plotting *E. coli* data along with available stream flow data (**Figure 1-1**) revealed that exceedances occurred during both moist and dry conditions.

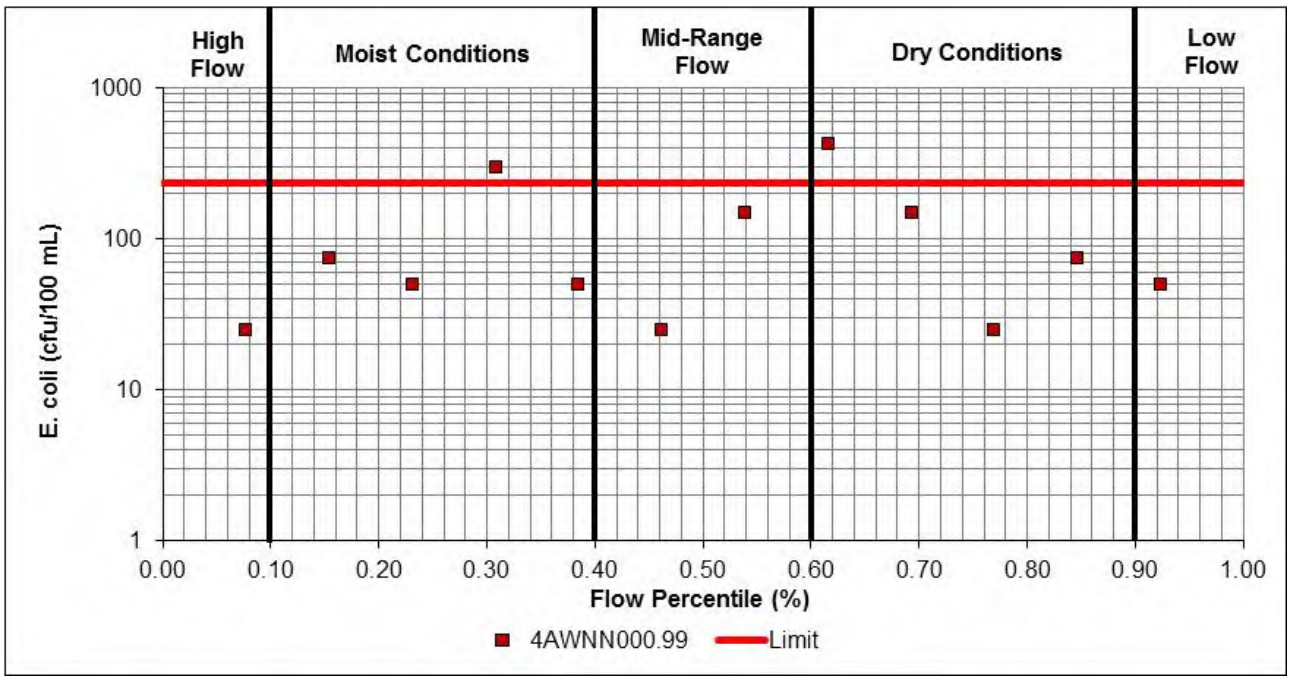

Figure 1-2: Flow Percentile and *E. coli* Concentrations for Winn Creek (2003-2005)

Consequently, both higher and lower flow periods were considered as the critical conditions. Exceedances that occur under high-flow conditions would most likely be runoff based, indirect sources of bacteria, and would most likely exceed the maximum assessment criterion. Bacteria loads under low-flow conditions would likely occur from direct deposition sources of bacteria, and would most likely exceed both the maximum assessment and geometric mean criteria.

The TMDL is required to meet both the geometric mean and maximum assessment bacteria criteria. Therefore, it is necessary for the critical condition to consider both wet weather, high flow conditions, and dry weather, low flow conditions in order to comply with both bacteria criteria.

1.5 Consideration of Seasonal Variations

Seasonal variations involve changes in stream flow and water quality because of hydrologic and climatological patterns. Seasonal variations were explicitly included in the modeling approach for this TMDL. The continuous simulation model developed for this TMDL explicitly incorporates the seasonal variations of rainfall, runoff, and fecal coliform wash-off by using an hourly time-step. In addition, fecal coliform accumulation

rates for each land use were developed on a monthly basis. This allowed for the consideration of temporal variability in fecal coliform loading within the watershed.

2.0 Watershed Description and Source Assessment

This section presents the types of data available and information collected for the development of a TMDL for the bacteria impaired segments of the Banister River watershed. VADEQ uses the collected data to characterize the waterbody and its watershed, and to inventory and identify potential point and nonpoint sources of bacteria in the watershed.

2.1 Data and Information Inventory

A wide range of data and information is needed in the development of these TMDLs. Categories of data used in watershed characterization and source assessment include the following:

(1) Physiographic data that describe physical conditions (i.e., topography, soils, and land use) within the watershed

(2) Hydrographic data that describe physical conditions within the waterbody, such as the stream network and connectivity

(3) Data related to uses of the watershed and other activities in the basin that can be used in the identification of potential E. coli sources

Table 2-1 shows the various data types and the data sources used in the Banister River TMDL development.

Table 2-1: Inventory of Data and Information Used in the TMDL Development

Data Category	Description	Source(s)
Watershed physiographic data	Watershed boundary	USGS HUC Boundaries
	Land use/land cover	NLCD 2006
	Soil data (*soil data mart*)	USDA-NRCS (SSURGO Data)
	Topographic data (USGS-30 meter DEM)	USDA-NRCS
Hydrographic data	Stream network and reaches	NHD
Watershed activities/ uses data and information related to bacteria production	Livestock inventory	USDA 2007Census of Agriculture
	Wildlife inventory	VA DGIF
	Septic systems inventory and failure rates	U.S. Census Bureau
	Pet estimates	AVMA, U.S. Census Bureau
Point sources and direct discharge data and information	Permitted facilities locations and discharge monitoring reports (DMRs)	VA DEQ, EPA Permit Compliance System (PCS)
Environmental monitoring data	Monitoring data (bacteria water quality) and station locations	VA DEQ
	Stream flow data	USGS
	Meteorological Data	NCDC

Notes:
AVMA: American Veterinary Medical Association
EPA: Environmental Protection Agency
HUC: Hydrologic Unit Code
NCDC: National Climatic Data Center
NHD: National Hydrography Dataset
NLCD: National Land Coverage Database
NRCS: Natural Resources Conservation Service
USDA: U.S. Department of Agriculture
USGS: U.S. Geological Survey
VA DEQ: Virginia Department of Environmental Quality
VA DGIF: Virginia Department of Game and Inland Fisheries

2.2 Watershed Description and Identification

The bacteria impaired segments and watershed are located in Halifax County. As shown in **Figure 2-1** the major roadways that run through the watershed are Route 360 which runs from North to South in the eastern portion of the watershed and Route 501 which runs from North to South in the western portion of the watershed. The watershed has a drainage area of 32,060 acres.

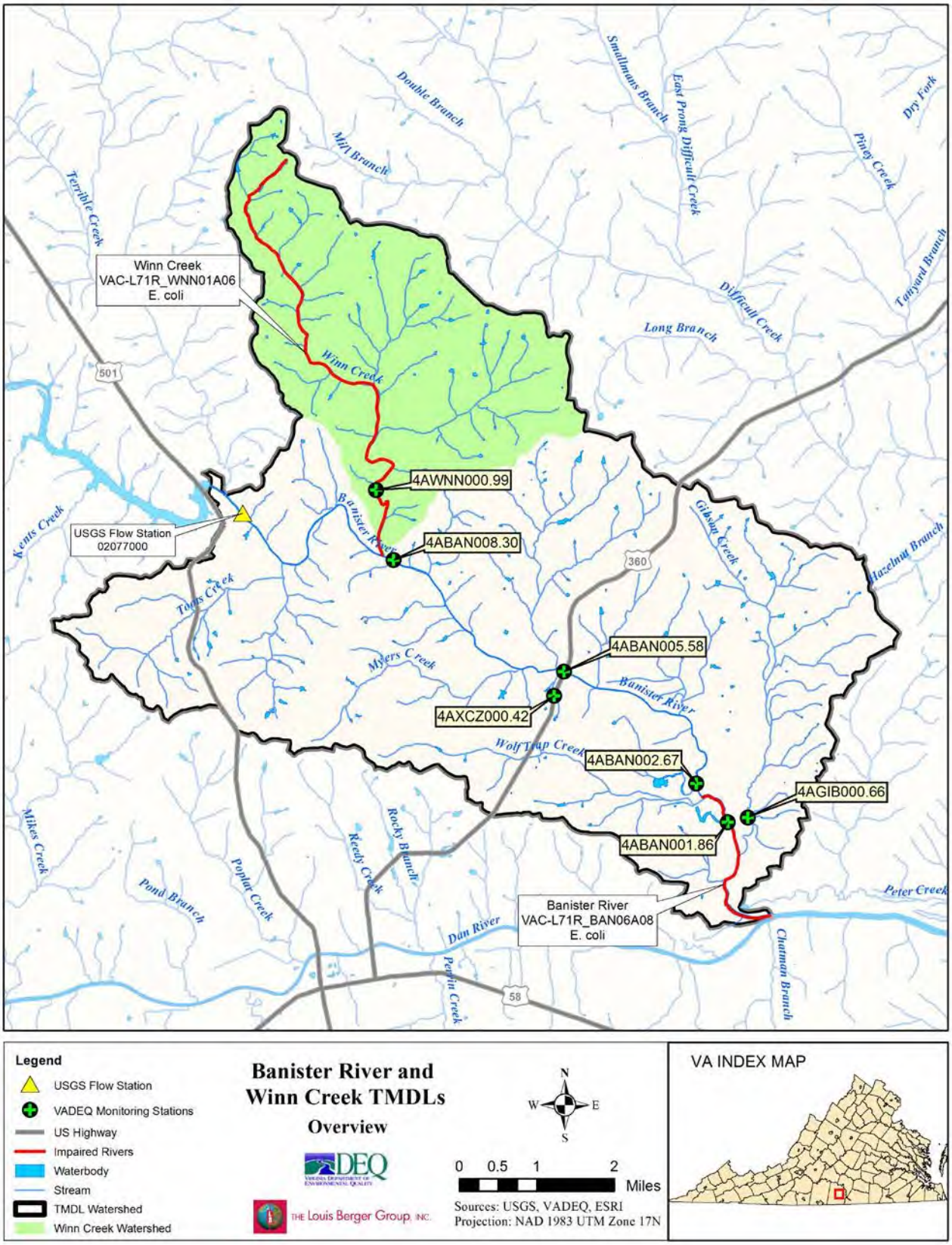

Figure 2-1: Impaired Segments in the Lower Banister River and Winn Creek TMDL Watershed

2.2.1 Topography

A digital elevation model (DEM) based on USGS National Elevation Dataset (NED) was used to characterize topography in the watershed. NED data were obtained from the Geospatial Data Gateway system maintained by the USDA Natural Resources Conservation Service. Elevation within the TMDL watershed ranges from 312 to 572 feet above mean sea level.

2.2.2 Soils Types and Hydrologic Soil Groups

This section details soil types and hydrologic groups for the Banister River and Winn Creek TMDL watershed. The soil characterization is based on data obtained from the Soil Survey Geographic (SSURGO) Database via *soil data mart*, a USGS- approved program that is a multi-purpose environmental analysis system integrating GIS, national watershed data, and environmental assessment and modeling tools.

The hydrologic soil groups represent different levels of infiltration capacity of the soils. Hydrologic soil group "A" designates soils that are well- to excessively well-drained, whereas hydrologic soil group "D" designates soils that are poorly drained. This means that soils in hydrologic group "A" allow a larger portion of the rainfall to infiltrate and become part of the ground water system. On the other hand, compared to the soils in hydrologic group "A," soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the ground water. Consequently, more rainfall becomes part of the surface water runoff. Descriptions of the hydrologic soil groups are presented in **Table 2-2**.

Table 2-2: Descriptions of Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	High infiltration rates. Soils are deep, well-drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well- and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover.

Table 2-3 details the hydrologic soil groups and soil map unit names for all soil types that comprise the Banister River and Winn Creek TMDL watershed.

Table 2-3: Soil Distribution in the Banister River and Winn Creek TMDL Watershed

Hydrologic Soil Group	Soil Map Unit Name	Soil Map Unit Area (Acres)	Hydrologic Soil Group Area (Acres)	Percent of Watershed
B	Appomattox clay loam	296.5	17,638.3	55.0%
	Clifford clay loam	5,334.2		
	Clifford sandy loam	3,797.6		
	Clifford-Urban land complex	228.1		
	Clover fine sandy loam	224.5		
	Clover-Bentley complex	130.8		
	Comus fine sandy loam	218.4		
	Dan River loam	399.3		
	Devotion-Rhodhiss complex	109.3		
	Fairview sandy loam	1,574.6		
	Georgeville silt loam	153.3		
	Herndon silt loam	71.2		
	Montonia-Goldston complex	173.6		
	Montonia-Nanford complex	17.3		
	Nathalie sandy loam	3,384.8		
	Pinkston fine sandy loam	19.7		
	Riverview loam	44.8		
	Stoneville loam	37.4		
	Straightstone loam	109.6		
	Tarrus-Badin complex	175.2		
	Toast sandy loam	1,138.1		
C	Banister-Kinkora complex	642.4	12,621.5	39.4%
	Bentley loamy sand	111.3		
	Chewacla and Wehadkee soils	4.5		
	Cid silt loam	80.9		
	Cid-Lignum complex	331.0		
	Codorus and Hatboro soils	1,692.8		
	Codorus loam	497.8		
	Danripple sandy loam	60.5		
	Goldston-Montonia complex	435.7		
	Halifax sandy loam	2,461.5		
	Lackstown fine sandy loam	1,758.0		
	Minnieville clay loam	427.5		
	Minnieville loam	44.4		
	Nanford-Badin complex	619.1		
	Oak Level loam	54.1		
	Rasalo-Orange complex	732.9		
	Spriggs sandy loam	347.9		
	Spriggs-Rasalo complex	2,175.0		
	Spriggs-Urban land complex	18.5		
	Turbeville fine sandy loam	4.6		
	Virgilina gravelly silt loam	56.4		

Table 2-3: Soil Distribution in the Banister River and Winn Creek TMDL Watershed

Hydrologic Soil Group	Soil Map Unit Name	Soil Map Unit Area (Acres)	Hydrologic Soil Group Area (Acres)	Percent of Watershed
	Virgilina-Poindexter complex	25.2		
	Yadkin fine sandy loam	39.6		
D	Delila sandy loam	28.7	**1,287.0**	**4.0%**
	Jackland-Orange complex	177.5		
	Wolftrap-Easthamlet complex	1,080.9		
Blank	Udorthents loamy	185.8	**513.9**	**1.6%**
	Urban land	44.9		
	Water	283.2		
Total		**32,060.6**	**32,060.6**	**100%**

The major hydrologic group within the Banister River watershed is group B, with 55.0% of the watershed containing these soils. Hydrologic soil group B is defined as having moderate infiltration rates. Soils are deep to moderately deep, moderately well- and well-drained soils with moderately coarse textures. The second major hydrologic group within the watershed is group C, with 39.4% of the watershed containing these soils. Soil group C is defined as having moderate to slow infiltration rates. Soils contain layers impeding downward movement of water or soils with moderately fine or fine textures.

2.2.3 Land Use

The 2006 National Land Use Dataset (NLCD) is the basis for the land use characterization in the Banister River and Winn Creek TMDL. **Table 2-4** presents the distribution of land uses in the watershed, by land area and percentage. Dominant land uses in the watershed are Forest (58%) and Agriculture (18%). Descriptions of each land use category can be found in **Table2-5**. **Figure 2-2** depicts the land use distribution within the Banister River and Winn Creek TMDL watershed.

Table 2-4: Land Use in the Banister River and Winn Creek TMDL Watershed

General Land Use Category	NLCD 2006 Land Use Category	Acres	Total Acres	Percentage of Watershed	Total Percent
Developed	Developed High Intensity	156.2	2,396	0.5%	7.5%
	Developed Medium Intensity	149.1		0.5%	
	Developed Low Intensity	368.0		1.1%	
	Developed Open Space	1,722.8		5.4%	
Agricultural	Cultivated Crops	125.3	5,703	0.4%	17.8%
	Hay/Pasture	5,578.0		17.4%	
Forest	Deciduous Forest	12,588.9	18,648	39.3%	58.2%
	Evergreen Forest	4,434.4		13.8%	
	Mixed Forest	1,624.3		5.1%	
Wetland	Emergent Herbaceous Wetland	52.7	2,112	0.2%	6.6%
	Woody Wetlands	2,059.6		6.4%	
Water	Open Water	239.3	239	0.7%	0.7%
Other	Scrub/Shrub	731.8	2,962	2.3%	9.2%
	Grassland/Herbaceous	2,193.2		6.8%	
	Barren Land	36.9		0.1%	
Total		**32,060.6**	**32,060.6**	**100%**	**100%**

Table 2-5: Descriptions of Land Use Types

Land Use Type	Description
Developed, High Intensity	Includes highly developed areas where people reside or work in high numbers. Impervious surfaces account for 80 to 100 percent of the total cover.
Developed, Medium Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 to 79 percent of the total cover.
Developed, Low Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 21 to 49 percent of total cover.
Developed Open Space	Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover.
Cultivated Crops	Areas used for the production of annual crops. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle and not tilled. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Deciduous Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Palustrine Aquatic Bed	Includes tidal and non-tidal wetlands and deepwater habitats in which salinity due to ocean-derived salts is below 0.5 percent and which are dominated by plants that grow and form a continuous cover principally on or at the surface of the water. These include algal mats, detached floating mats, and rooted vascular plant assemblages.
Palustrine Emergent Wetland	Includes all tidal and non-tidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Plants generally remain standing until the next growing season. Total vegetation cover is greater than 80 percent.
Palustrine Forested Wetland	Includes all tidal and non-tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent.

Table 2-5: Descriptions of Land Use Types	
Palustrine Scrub/Shrub Wetland	Includes all tidal and non tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent. The species present could be true shrubs, young trees and shrubs, or trees that are small or stunted due to environmental conditions (Cowardin et al. 1979).
Estuarine Emergent Wetland	Includes all tidal wetlands dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens) and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent and that are present for most of the growing season in most years. Perennial plants usually dominate these wetlands.
Estuarine Forested Wetland	Includes all tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Estuarine Scrub/Shrub Wetland	Includes all tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Open Water	All areas of open water, generally with less than 25 percent cover of vegetation or soil.
Scrub/Shrub	Areas dominated by shrubs less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
Bare Land	Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earth material. Generally, vegetation accounts for less than 10 percent of total cover.
Grassland/Herbaceous	Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Unconsolidated Shore	Unconsolidated material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms representing this class.
Source: Coastal NLCD Classification Scheme, NOAA Coastal Services Center	

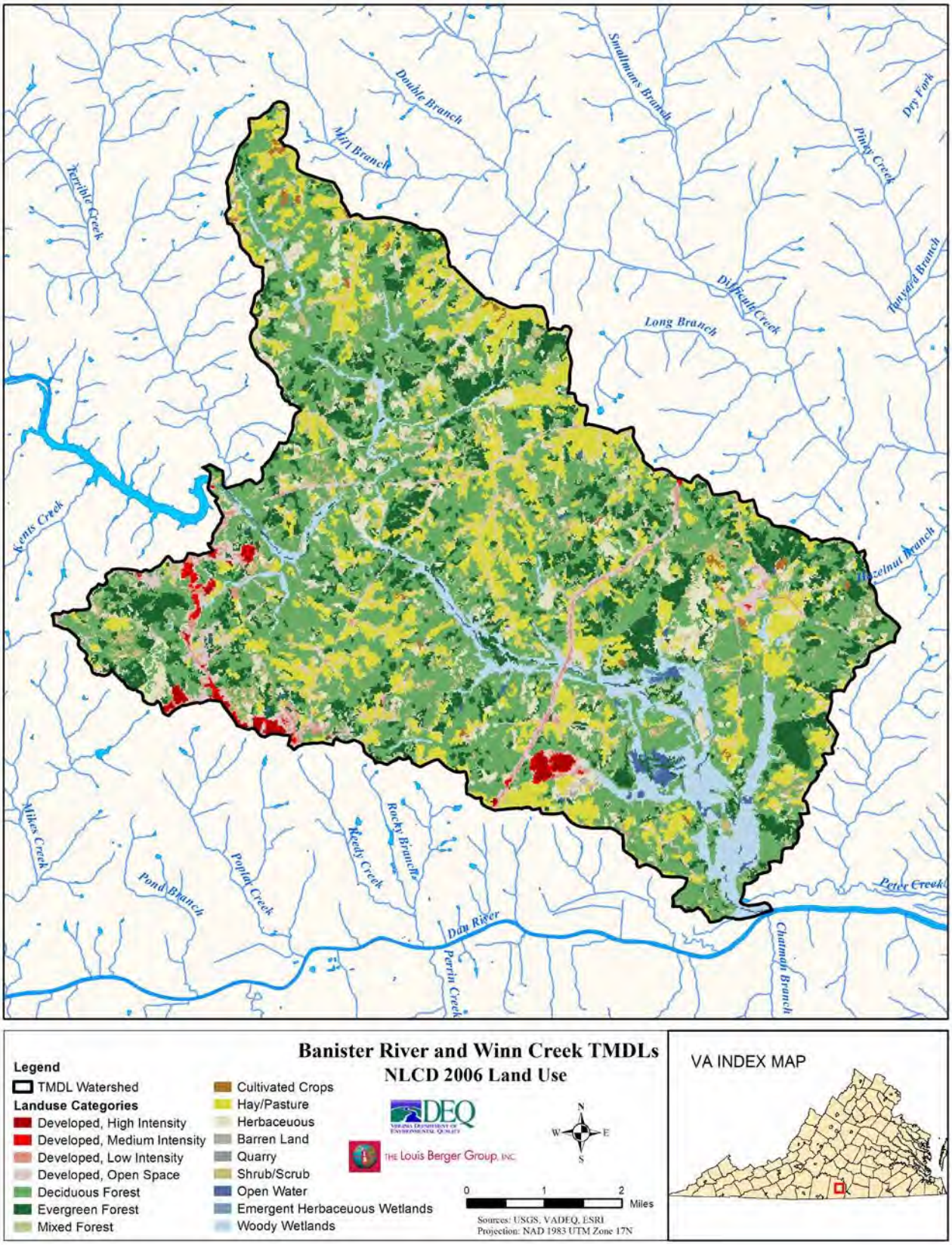

Figure 2-2: Land Use for the Banister River and Winn Creek TMDL Watershed

2.3 Bacteria Ambient Water Quality Data for Bacteria

VADEQ conducts environmental monitoring efforts for collecting bacteria data in the TMDL watershed. VADEQ compared all available bacteria data within the TMDL watershed against the VA DEQ bacteria standards for recreation use. VA DEQ collected bacteria samples for the indicators fecal coliform and E. coli at one water quality monitoring station (4ABAN005.58), and only E. coli at the other stations. **Table 2-6** summarizes VA DEQ monitoring efforts for all bacteria indicators at station 4ABAN001.86, 4ABAN005.58, 4ABAN008.30, and 4AWNN000.99.

Table 2-6: Summary of Instream Monitoring Stations for Bacteria in the Banister River and Winn Creek TMDL Watershed

Station ID	Stream	Indicator	Sample Date	
			First	Last
4ABAN001.86	Banister River	Fecal Coliform	N/A	N/A
		E. coli	8/28/2003	12/7/2010
4ABAN005.58	Banister River	Fecal Coliform	1/8/1990	7/23/2012
		E. coli	8/28/2003	7/23/2012
4ABAN008.30	Banister River	Fecal Coliform	N/A	N/A
		E. coli	8/28/2003	12/7/2010
4AWNN000.99	Winn Creek	Fecal Coliform	N/A	N/A
		E. coli	8/28/2003	6/8/2005

Table 2-7 shows the number of samples, the minimum, maximum and average bacteria concentrations observed, and the total number and percentage of samples exceeding the E. coli criterion of 235 cfu/ 100 ml for E. coli. **Figure 2-3** presents all of the E. coli measurements taken on the mainstem of the Banister River, and **Figure 2-4** presents all of the E. coli measurements taken at station 4-AWNN000.99 (Winn Creek).

Table 2-7: Summary of VA DEQ E. coli Exceedances in the Banister River Watershed

Station ID	Number of Samples	CFU/ 100 mL			Total Exceed.*	Total % Exceed.
		Min	Max	Average		
4-ABAN001.86	23	25	2000	252	6	26%
4-ABAN005.58	55	10	2000	235	11	20%
4-ABAN008.30	24	25	950	159	5	21%
4-AWNN000.99	12	25	420	116	2	17%

*Exceedances of the E. coli criterion of 235 CFU/100mL

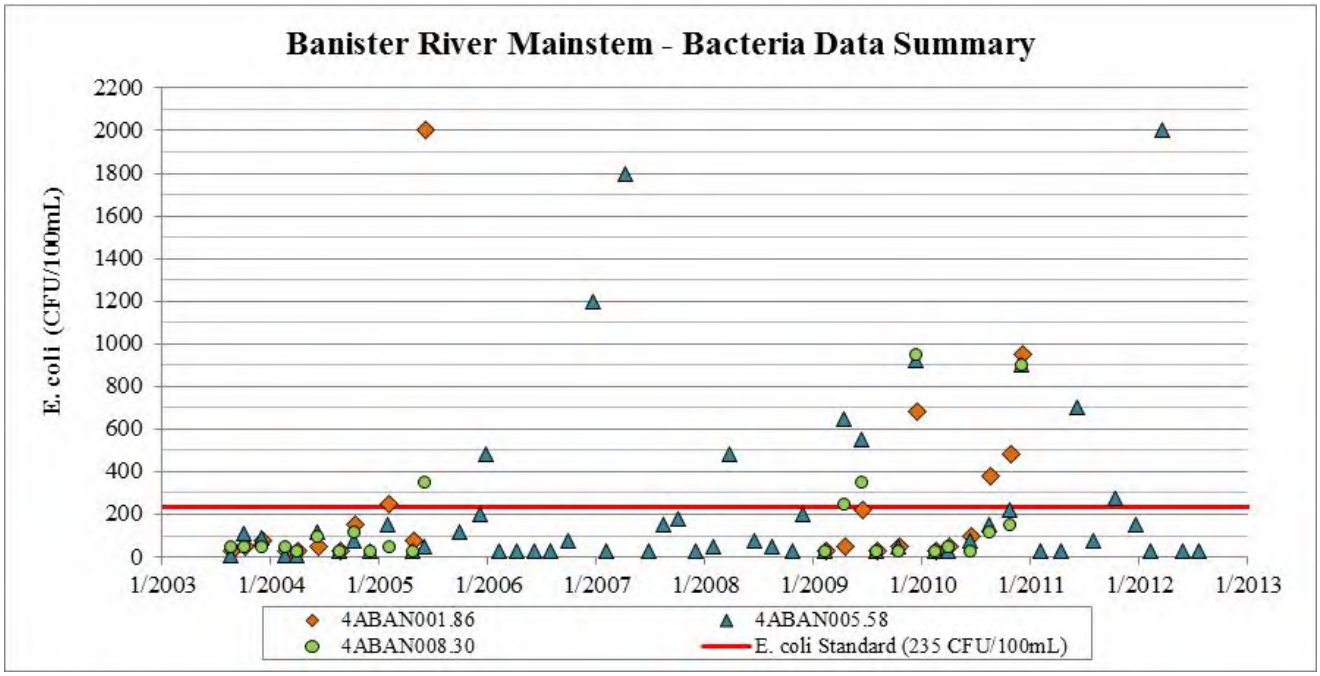

Figure 2-3: E. coli Measurements for the Banister River Mainstream

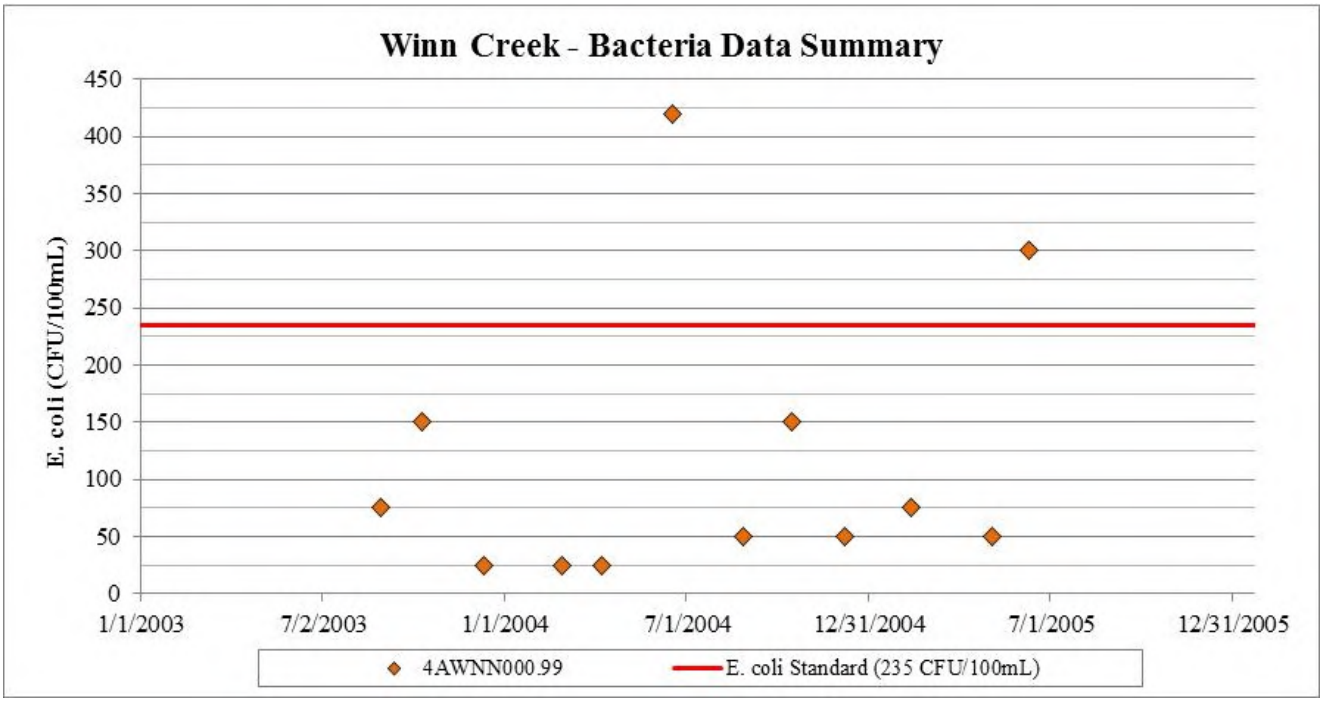

Figure 2-4: E. coli Measurements for Winn Creek

2.4 Stream Flow Data

Daily flow data were available from one USGS stream flow-gauging stations within the TMDL study area, station 02077000. The station is located below Banister Lake and the confluence of Terrible Creek and the Banister River. Data collected at this station ranges from 2003 through 2011. Location of the USGS station is shown in **Figure 2-1**.

2.5 Bacteria Source Assessment

This section focuses on characterizing the sources that potentially contribute to the bacteria loading in the TMDL watershed. These sources include permitted facilities, septic systems/straight pipes, livestock, wildlife, and pets. The distribution of source loads was determined using EPA's Bacteria Indicator Tool (EPA, 2001b). Individual bacteria sources such as human sources, pets, livestock, and wildlife were accounted using the Environmental Protection Agency's (EPA) Bacterial Indicator Tool to distribute E. coli loadings among the various sources for the TMDL watershed. The EPA Bacterial Indicator Tool is a spreadsheet model using Microsoft Excel that estimates daily accumulated bacteria loads per source. The Bacterial Indicator Tool employs user-supplied land use acreage, animal population, septic systems and unit load data to estimate the fecal coliform loads from various sources in a watershed environment. It is assumed that the distribution of E. coli load is identical to the distribution of fecal coliform load from the same source categories. Thus, the Bacteria Indicator Tool results were used to estimate the E. coli distribution for human, pet, livestock and wildlife bacteria sources in the TMDL watershed.

2.5.1 Permitted Facilities

Based on data obtained from VA DEQ, there are four VPDES and seven domestic permitted facilities in the Banister River watershed (**Tables 2-8** and **2-9)**. The VPDES permits are for Jones Patio Doors Inc. (Permit # VA0001643), Cowford Rd Waste Water Treatment Plant (Permit # VA0020320), Scottsburg Waste Water Treatment Plant (Permit # VA0062103), and Lakewood Partners LLC (Permit # VA0063282). There was no bacteria data for the permitted facilities because there are no bacteria limits or

standards for the listed permitted facilities. **Figure 2-5** presents the locations of the permitted facilities within the Banister River and Winn Creek TMDL watershed.

Table 2-8: VPDES Permitted Dischargers in the Banister River and Winn Creek TMDL Watershed

Permit No	Facility Name	Receiving Stream	Status	Size	Category	Design Flow (MGD)	Permitted to Discharge Bacteria? (Y/N)
VA0001643	Jones Patio Doors Inc	Banister River	History	Minor	Industrial	0.753	N
VA0020320	Cowford Rd WWTP	Banister River	Active	Minor	Municipal	0.3	N
VA0062103	Scottsburg WWTP	Banister River	Active	Minor	Municipal	0.03	N
VA0063282	Lakewood Partners LLC	Banister River/U.T.	History	Minor	Municipal	0.008	N

Table 2-9: Domestic Permits in the Banister River and Winn Creek TMDL Watershed

Permit No	Facility	Receiving Stream	Classification	Discharge Point
VAG404183	Residence	Banister River UT	Active	Y
VAG404088	Residence	Gibson Creek UT	Active	N
VAG404087	Residence	Banister River UT	Active	N
VAG407219	Residence	dry ditch	Application	N
VAG407286	Residence	UT of Morris Branch	Active	N
VAG407296	Residence	UT, Banister River	Active	Y
VAG407283	Residence	UT to Banister River	Active	N

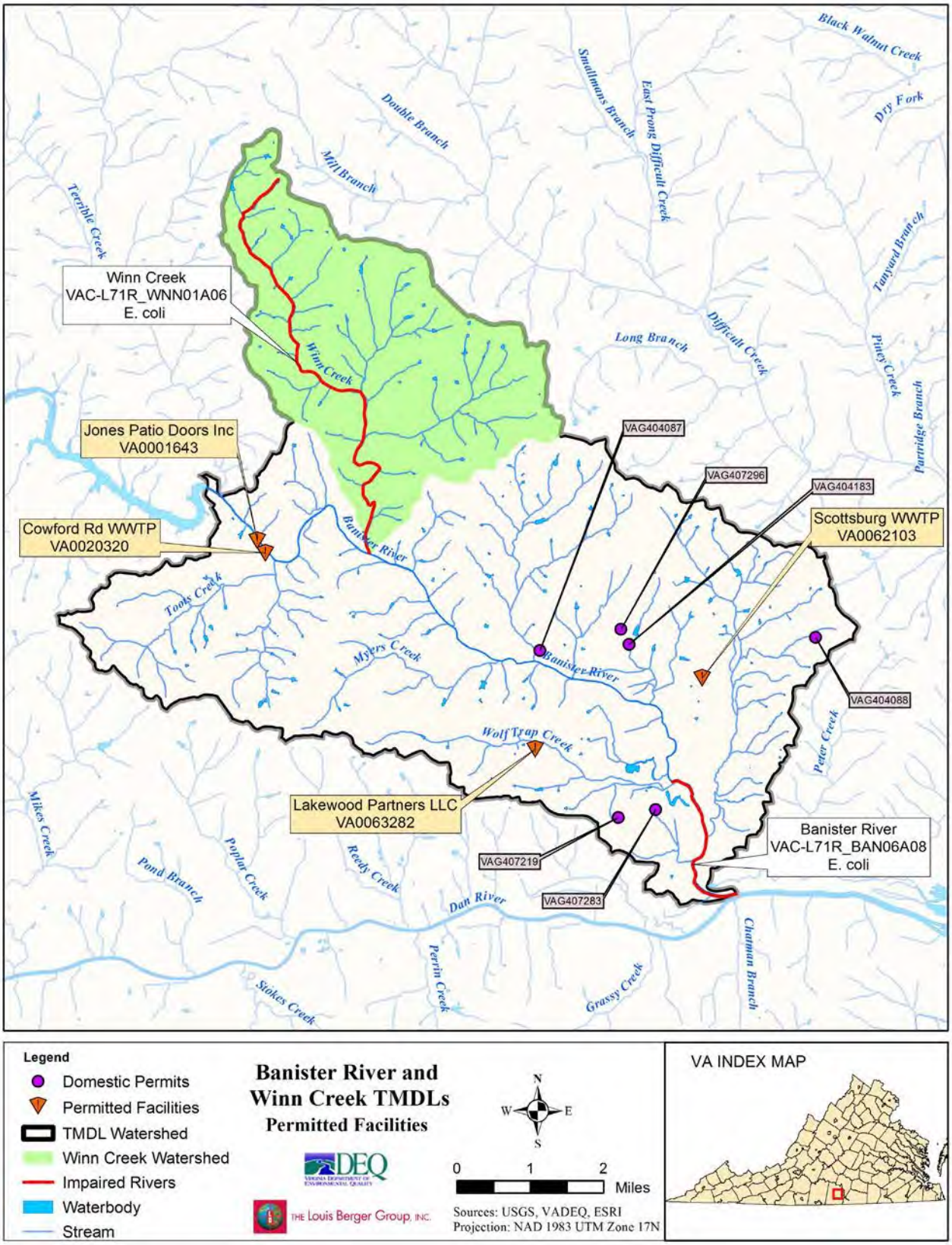

Figure 2-5: Permitted Facilities in the Banister River and Winn Creek TMDL Watershed

2.5.2 Sanitary Sewer System, Septic Tanks, and Straight Pipes

Houses can be connected to a public sanitary sewer, a septic tank, or the sewage can be disposed of by other means. Estimates of the total number of households using each type of waste disposal are presented in this section.

The number of residences in the TMDL watershed was estimated by manually counting homes using aerial imagery. The 1990 census data is the most recent data that documents the distribution of houses on sewage systems, septic systems, and other means (considered to be straight pipes). These 1990 estimated distributions (**Table 2-10**) were applied to the 2012 housing unit numbers by assuming the distributions in 1990 and 2012 are the same and multiplying the total number of houses in 2012 by the percent distributions in 1990 to estimate the number of houses on public sewers, septic tanks and other means in 2012.

Table 2-10:1990 Census - Halifax County Waste Disposal Methods

Sewer Disposal	Septic Disposal	Other Means Disposal
13.8%	76.7%	9.5%

To determine the amount of bacteria contributed by human sources, it is necessary to estimate the failure rates of septic systems. The number of failing septic systems in the Banister River watershed was based on consultation with VDH. The number of failed septic systems was determined by multiplying the number of houses by the 4% failed septic rate. **Table 2-11** shows the estimated population, number of houses, number of houses on public sewer, number of houses on septic systems, number of houses on other means, and number of failing septic systems in the TMDL watershed.

Table 2-11: Housing and Sewage Disposal Methods for the Banister River and Winn Creek TMDL Watershed

TMDL Watershed	Number of Houses[1]	Number of Houses Public Sewer[2]	Number of Houses on Septic Systems[2]	Number of Houses on "Other Means"[2]	Number of Houses with a Failing Septic System[3]
Banister River	1,957	270	1,501	186	60
Winn Creek	371	51	284	35	11

[1] Manual count using Imagery

[2] Based upon 1990 census breakdown of sewage disposal

[3] Based on a septic failure rate of 4% (VDH, 2013)

The 1990 U.S Census Report category "other means" includes the houses that dispose of sewage in other ways than by public sanitary sewer or a private septic system. Typically, the houses included in this category are assumed disposing of sewage directly via straight pipes, if located within 200 feet of a stream. Using GIS and aerial imagery house counts, 44 houses were determined to be within 200 feet of streams, and were assumed to all be either septic or straight pipes. Of these 44 houses, 4% were assumed to be failing septic systems and 9.5% were assumed to be straight pipes discharging directly to streams. **Table 2-12** shows the number of homes with a failing sewage disposal system (includes failure rates for both homes on septic systems and homes on "other means") within 200 feet of streams.

Table 2-12: Sewage Disposal Methods within 200 feet of Streams

Houses within 200ft of Streams	Houses with Direct Pipe to Stream (9.5%)	Failing Septic Systems (4%)	Total Number of Failing Systems
44	4	2	6

2.5.3 Agricultural Practices

The following section describes the different agricultural sources of bacteria including livestock and land application of manure.

2.5.3.1 Livestock

An inventory of the livestock of the Banister River watershed was conducted using data and information provided by United States Department of Agriculture (USDA) Census of Agriculture (2007). To estimate the livestock numbers within the TMDL watershed, VADEQ determined a ratio of pastureland within the watershed to the total pastureland within the county. Apply this ratio to the total number of each livestock animal in the county to estimate of the number of livestock animals within the TMDL watershed. **Table 2-13** shows the results of these calculations for each reported livestock animal.

Example Using Hypothetical Numbers:

$$\frac{\text{Acres of Pastureland in Impaired Watershed}^{*}}{\text{Acres of Pastureland in County}^{\#}} = \frac{\text{Number of Horses in Impaired Watershed}}{\text{Number of Horses in County}^{\#}}$$

$$\frac{20 \text{ acres}}{100 \text{ acres}} = \frac{X}{50 \text{ horses}}$$

$$X = 10 \text{ horses}$$

*****Obtained from NLCD Land Use GIS Layer*
 # Obtained from the 2007 Agricultural Census

Table 2-13: Livestock Present in the Banister River Watershed

Livestock	Banister River TMDL Watershed	Winn Creek Watershed
Beef Cows	611	184
Milk Cows	11	5
Other Cattle	443	133
Hogs/Pigs	910	274
Chickens (Layers)	36	11
Horses	43	13

The determination of the fecal coliform loading by livestock in the watershed used the livestock inventory. **Table 2-14** shows the average fecal coliform production per animal per day contributed by each type of livestock (which are consistent with the 2007 Banister River Bacteria TMDL).

Table 2-14: Daily Fecal Coliform Production Rates for Livestock Present in TMDL Watersheds

Livestock Type	Daily Fecal Coliform Production (cfu/day)	Reference
Beef Cows	3.3E+10	Virginia Tech, 2000
Dairy Cows	2.52E+10	Virginia Tech, 2000
Other Dairy Cow (including heifers)	1.16E+10	Virginia Tech, 2000
Hogs	1.08E+10	ASAE, 1998
Horses	4.20E+08	Virginia Tech, 2000
Chickens	1.36E+08	ASAE, 1998

The impact of fecal coliform loading from livestock is dependent upon whether loadings are directly deposited into the stream, or indirectly delivered to the stream via surface

runoff. For this TMDL, fecal coliform deposited while livestock were in confinement or grazing was considered indirect deposit, and fecal coliform deposited when livestock directly defecate into the stream was considered direct deposit. The distribution of daily fecal coliform loading between direct and indirect deposits was based on livestock daily schedules. The Dodd Creek TMDL was the basis of the initial estimates of the beef cattle daily schedule for the Banister River and Winn Creek watersheds.

Table 2-15 presents the daily schedule for beef cattle. **Table 2-16** shows the daily schedule for dairy cows. Both schedules match what was used to develop the 2007 Banister River Bacteria TMDLs. The time beef cattle and dairy cows spend in the pasture or loafing was used to determine the fecal coliform load deposited indirectly. The directly deposited fecal coliform load from livestock was based on the amount of time they spend in the stream.

Table 2-15: Daily Schedule for Beef Cattle

Month	Time Spent in		
	Pasture (Hour)	Stream (Hour)	Loafing Lot (Hour)
January	23.50	0.50	0
February	23.50	0.50	0
March	23.25	0.75	0
April	23.00	1.00	0
May	23.00	1.00	0
June	22.75	1.25	0
July	22.75	1.25	0
August	22.75	1.25	0
September	23.00	1.00	0
October	23.25	0.75	0
November	23.25	0.75	0
December	23.50	0.50	0

Source: Dodd Creek TMDL Report, DCR 2002.

Table 2-16: Daily Schedule for Dairy Cows

Month	Time Spent in		
	Pasture (Hour)	Stream (Hour)	Loafing Lot (Hour)
January	7.45	0.25	16.30
February	7.45	0.25	16.30
March	8.10	0.50	15.40
April	9.35	0.75	13.90

Table 2-16: Daily Schedule for Dairy Cows

Month	Time Spent in		
	Pasture	Stream	Loafing Lot
	(Hour)	(Hour)	(Hour)
May	10.05	0.75	13.20
June	10.30	1.00	12.70
July	10.80	1.00	12.20
August	10.80	1.00	12.20
September	11.05	0.75	12.20
October	11.00	0.50	12.50
November	10.30	0.50	13.20
December	9.15	0.25	14.60

Source: Dodd Creek TMDL Report, DCR 2002.

2.5.3.2 Land Application of Manure

Land application of the manure that cattle produce while in confinement is a typical agricultural practice. Both dairy operations and beef cattle are present in the watershed. The manure produced by confined livestock was directly applied on the pasturelands, and was treated as an indirect source in the development of the Banister River TMDLs.

2.5.4 Wildlife

Similar to livestock contributions, wildlife contributions of bacteria can be indirect or direct. Indirect sources are those that are carried to the stream from the surrounding land via rain and runoff events, whereas direct sources are those that are directly deposited into the stream.

The Department of Game and Inland Fisheries (DGIF) wildlife density estimates served as the basis for the wildlife inventory in the TMDL watershed. The geese and duck densities came from a recently approved bacteria TMDL located near the Banister River watershed, the Reed Creek Bacteria TMDL (VADEQ, 2012). One can estimate wildlife populations by combining the wildlife densities with their appropriate habitats. **Table-2-17** presents the typical wildlife densities provided by DGIF. **Table 2-18** shows the wildlife inventory for the TMDL watershed**.**

Table 2-17: Wildlife Densities and Habitat for the Banister River and Winn Creek TMDL Watershed		
Wildlife Type	**Habitat**	**TMDL estimates (#/acre or #/mile)**
Deer	Entire watershed except open water, high intensity development	0.047
Raccoon	Upland Forest	0.01563
	Bottomland forest, marsh, swamp, within 600 feet of streams	0.07813
Muskrat	per mile of medium sized stream intersecting pasture fields	8
	per mile of pond or lake edge	10
	per mile of ditch or medium sized stream intersecting agriculture crop fields	16
	per mile of slow-moving river	50
Beaver	per mile of stream and rivers	4.8
Turkey	Forest	0.01
Canadian Geese	Urban, residential, grassland, pasture, wetland, scrub/shrub, barren within 300 feet of streams and ponds	0.094
Ducks	Urban, residential, grassland, pasture, wetland, scrub/shrub, barren within 300 feet of streams and ponds	0.078

Table 2-18: Banister River 2012 Wildlife Inventory		
Wildlife	**Banister River TMDL Watershed**	**Winn Creek Watershed**
Deer	1,482	369
Raccoon	904	224
Muskrat	981	87
Beaver	171	42
Wild Turkey	187	46
Canadian Geese	627	152
Ducks	518	126

Table 2-19 presents the fecal coliform production and percentage of the day in stream access for each wildlife animal.

Table 2-19: Daily Schedule and Fecal Coliform Production for Wildlife		
Wildlife Type	**Daily Fecal Coliform Production (cfu/day)**	**Percentage of Day Spent in Stream**
Deer	3.47E+08	1%
Raccoons	1.13E+08	10%
Muskrat	2.50E+07	25%
Beaver	2.00E+05	25%
Wild Turkey	9.30E+07	5%
Goose	7.99E+08	50%
Ducks	2.43E+09	75%

*Source: Reed Creek Pathogen TMDL, VADEQ 2012

2.5.5 Pets

Cats and Dogs were the two types of domestic pets considered as potential bacteria sources in this watershed. To estimate the number of pets where no information was provided, multiply the number of houses manually counted via aerial imagery in the watershed by national average estimates of the number of pets per household, which are 0.632 dogs per household and 0.713 cats per household (American Veterinary Medical Association). **Table 2-20** shows the estimated number of pets in the Banister River and Winn Creek TMDL.

Table 2-20: Pet Inventory for the Banister River 2012 TMDL Watershed

TMDL Watershed	Households	Dogs	Cats
Banister River	1,957	1,237	1,395
Winn Creek	371	234	264

3.0 Modeling Approach

This section describes the modeling approach used in TMDL development. The primary focus is on the sources represented in the model, assumptions used, model set-up, model calibration and validation, and the existing load.

3.1 Modeling Goals

The goals of the modeling approach were to develop a predictive tool for the waterbody that can:

- represent the watershed characteristics
- represent the point and non-point sources of fecal coliform and their respective contribution
- use input time series data (rainfall and flow) and kinetic data (die-off rates of fecal coliform)
- estimate the instream pollutant concentrations and loadings under the various hydrologic conditions
- allow for direct comparisons between the instream conditions and the water quality standard

3.2 Watershed Boundaries

The bacteria impaired segments of the Banister River and Winn Creek are located in the hydrologic unit (HUC) 0301010 in the lower part of the larger Banister River watershed (**Figure 3-1**). In 2007, VADEQ developed Bacteria TMDLs to address impairments in the upper Banister River watershed (VADEQ, 2007). The drainage area of the upper Banister watershed (shown in green in **Figure 3-1**) is approximately 355,300 acres and is hydrologically connected to the lower Banister River watershed (shown in purple in **Figure 3-1**) through Banister Lake.

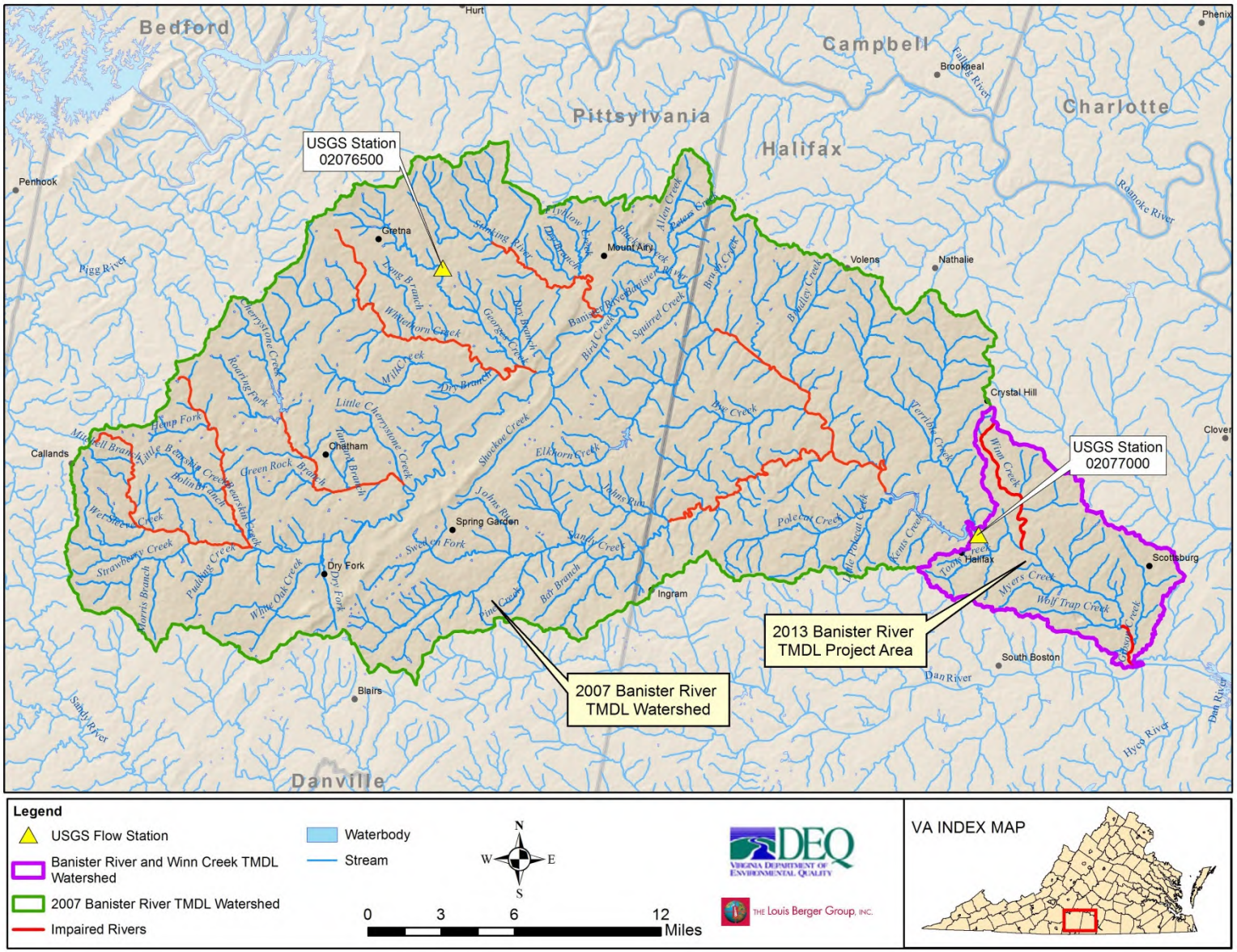

Figure 3-1: Watershed Boundaries and Hydrologic Modeling Area

3.3 Modeling Strategy

The Hydrologic Simulation Program-Fortran (HSPF) model was used to develop the 2007 bacteria TMDLs to predict the instream water quality conditions under varying scenarios of rainfall and fecal coliform loading. HSPF is a hydrologic, watershed-based water quality model. Consequently, HSPF can explicitly account for the specific watershed conditions, the seasonal variations in rainfall and climate conditions, and activities and uses related to fecal coliform loading. The results from the developed HSPF model were subsequently used to develop the TMDL allocations for the upper Banister watershed.

The modeling strategy for the development of bacteria TMDLs in the lower Banister River uses the existing HSPF model developed for the upper Banister River and extends its application to include the bacteria impairments in Winn Creek (WNN01A06) and Banister River (BAN06A08). For the development of the Banister River and Winn Creek TMDLs, VADEQ assumed the upper Banister River TMDL watershed (see Figure 3-1) was meeting water quality standards in order to capture the water quality issues locally. The modeling process uses the following steps:

- delineate the lower Banister River watershed into smaller subwatersheds
- enter the physical data that describe each subwatershed and stream segment
- link the newly developed model-segments to the existing HSPF model for the upper Banister watershed
- enter values for the rates and constants that describe the sources and the activities related to the fecal coliform loading in the lower Banister River watershed

3.4 Watershed Delineation

For this TMDL, the Banister River and Winn Creek watersheds were delineated into 29 smaller subwatersheds to represent the watershed characteristics and to improve the accuracy of the HSPF model. Creation of the watershed delineation used a Digital Elevation Model (DEM), stream reaches obtained from the National Hydrography Dataset (NHD), and instream water quality data. **Table 3-1** presents the size distributions

of the 29 subwatersheds. **Figure 3-2** shows the delineated subwatersheds for the Hydrologic Modeling Area as well as the locations of the USGS flow station. **Figure 3-3** shows the weather stations used in modeling. Hydrologic modeling used the Hydrologic Modeling Area, including all 29 subwatersheds.

Table 3-1: TMDL Hydrologic Modeling Area Segments

Segment Name	HSPF Model Segment	Area (Acres)
Banister River Mainstem 1	69	891.4
Banister River Mainstem 2	68	1,624.3
Banister River Mainstem 3	67	433.4
Banister River Mainstem 4	66	1,594.4
Banister River Mainstem 5	65	1,255.8
Banister River Mainstem 6	64	635.9
Banister River Trib 1	89	1,293.7
Banister River Trib 2	88	793.2
Banister River Trib 3	87	519.8
Banister River Trib 4	86	986.8
Banister River Trib 5	85	1,510.8
Banister River Trib 6	84	571.8
Banister River Trib 7	72	1,573.9
Gibson Creek 1	90	1,104.8
Gibson Creek 2	91	1,778.6
Gibson Creek 3	92	1,440.1
Myers Creek 1	75	940.2
Myers Creek 2	73	780.3
Toots Creek 1	71	1,432.8
Toots Creek 2	70	801.6
Winn Creek 1	81	789.7
Winn Creek 2	80	583.0
Winn Creek 3	83	1,244.7
Winn Creek 4	82	957.1
Winn Creek 5	79	1,532.2
Winn Creek 6	78	1,626.9
Winn Creek 7	77	1,150.3
Wolf Trap Creek 1	76	1,423.8
Wolf Trap Creek 2	74	789.2
	Total	**32,060**

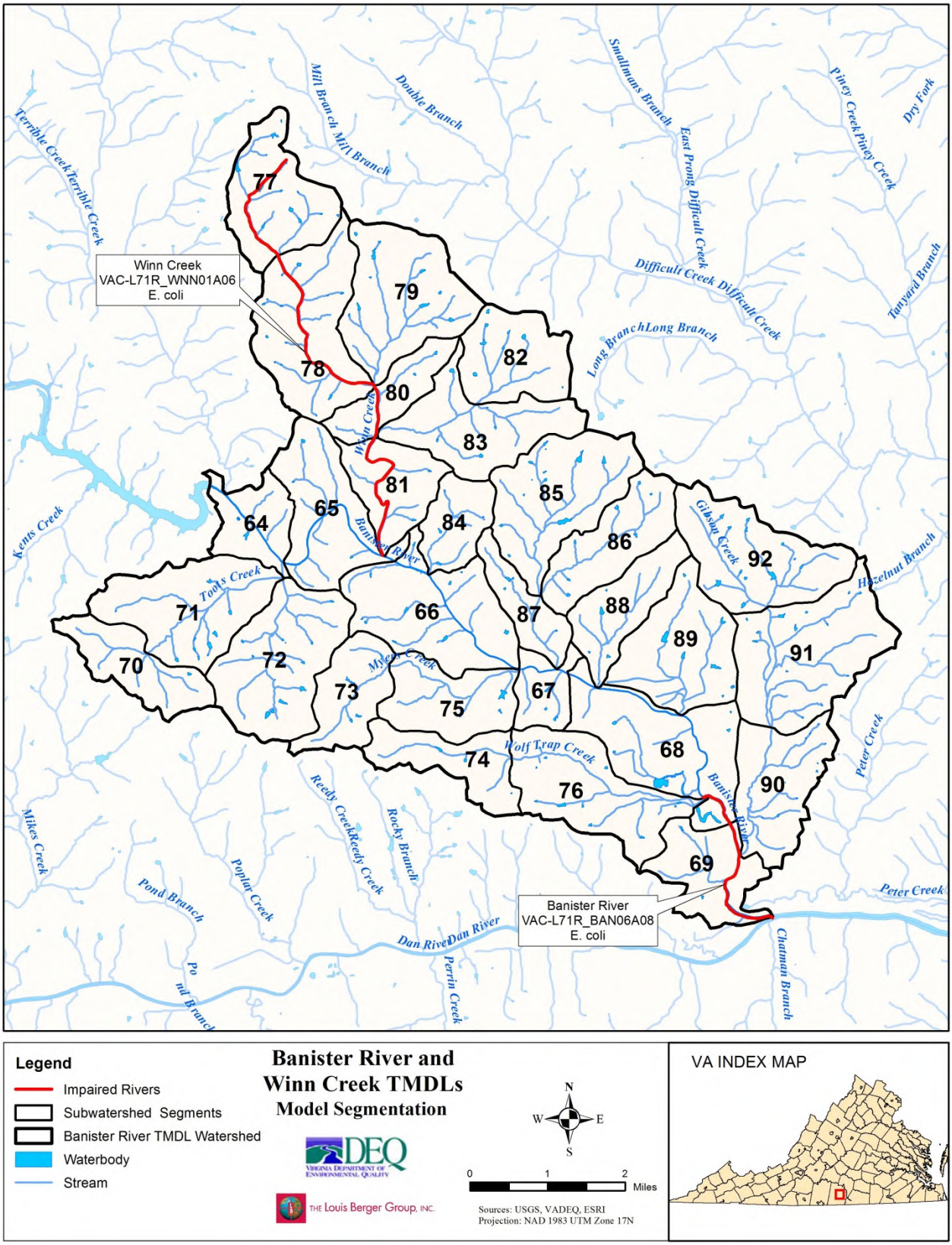

Figure 3-2: TMDL Hydrologic Modeling Area Segments

3.5 Land Use

Appendix A presents the distribution of land uses in the hydrologic modeling area, by land area and percentage. Dominant land uses in the modeling area are Deciduous Forest (39%), Pasture (17%) and Evergreen Forest (14%).

3.6 Land Use Reclassification

There are 21 land use classes present in the hydrologic modeling area. These land use types were consolidated into eight land use categories to meet modeling goals, facilitate model parameterization, and reduce modeling complexity. This reclassification reduced the 21 land use types to a representative number of categories that best describe conditions and the dominant fecal coliform source categories in the watersheds. Land use reclassification was based on similarities in hydrologic characteristics and potential fecal coliform production characteristics. The reclassified land uses are presented in **Table 3-2**.

Table 3-2: Model Segment Landuse Reclassification - NLCD 2006

Segment Name	Forest	Cropland	Pasture	High Residential	Medium Residential	Low Residential	Developed Open Space	Water/ Wetland	Total
Banister River Mainstem 1	456.0	3.6	94.9	0.0	0.0	0.0	19.2	311.9	885.6
Banister River Mainstem 2	742.8	4.4	234.2	0.0	0.0	0.0	35.5	607.1	1,624.1
Banister River Mainstem 3	196.5	0.0	111.2	0.0	0.0	24.6	45.8	55.3	433.4
Banister River Mainstem 4	997.8	7.7	357.7	0.0	0.0	2.2	58.4	170.4	1,594.2
Banister River Mainstem 5	810.4	0.0	305.3	0.0	0.0	1.8	52.0	84.9	1,254.4
Banister River Mainstem 6	437.5	0.0	50.0	4.4	7.9	26.5	48.5	57.2	632.0
Banister River Trib 1	744.3	4.0	317.6	0.0	0.0	0.0	30.6	197.0	1,293.5
Banister River Trib 2	535.4	0.0	182.9	0.0	0.0	14.6	39.8	20.5	793.1
Banister River Trib 3	267.0	0.0	205.7	0.0	0.0	3.4	22.0	21.6	519.7
Banister River Trib 4	644.4	2.6	265.6	0.0	1.2	7.2	59.8	5.0	985.8
Banister River Trib 5	870.6	1.4	530.5	0.0	0.0	3.4	85.2	17.6	1,508.7
Banister River Trib 6	372.6	0.0	165.7	0.0	0.0	2.4	28.0	3.0	571.8
Banister River Trib 7	976.6	0.0	330.5	36.8	27.2	43.4	128.4	29.6	1,572.5
Gibson Creek 1	673.0	0.0	193.7	0.0	0.0	0.0	26.8	206.9	1,100.4
Gibson Creek 2	1,228.1	12.0	385.6	0.0	0.3	4.7	79.6	64.0	1,774.3
Gibson Creek 3	939.7	25.8	317.1	0.0	4.8	21.8	114.6	12.2	1,436.1
Myers Creek 1	691.4	4.4	148.7	0.0	0.0	4.0	34.0	57.7	940.2
Myers Creek 2	464.5	0.0	222.1	0.0	3.5	22.8	64.5	1.3	778.6
Toots Creek 1	883.8	0.0	140.3	24.5	53.5	74.6	215.3	37.1	1,429.1
Toots Creek 2	518.1	0.0	145.9	22.3	15.9	29.1	65.3	0.0	796.6

Table 3-2: Model Segment Landuse Reclassification - NLCD 2006									
Segment Name	**Forest**	**Cropland**	**Pasture**	**High Residential**	**Medium Residential**	**Low Residential**	**Developed Open Space**	**Water/ Wetland**	**Total**
Winn Creek 1	502.5	0.0	201.5	0.0	0.0	3.3	44.5	37.8	789.6
Winn Creek 2	442.5	0.0	85.8	0.0	0.0	0.0	18.5	36.1	582.9
Winn Creek 3	732.6	0.0	415.6	0.0	0.0	5.6	60.0	29.8	1,243.7
Winn Creek 4	487.4	11.6	416.9	0.0	0.0	0.0	27.9	9.1	952.8
Winn Creek 5	916.2	4.6	507.2	0.0	0.0	1.5	66.4	32.9	1,528.7
Winn Creek 6	1,073.1	8.2	418.6	0.0	0.0	6.1	65.3	51.9	1,623.2
Winn Creek 7	614.6	33.5	390.8	0.0	0.5	16.9	46.8	40.3	1,143.4
Wolf Trap Creek 1	618.2	0.0	433.1	64.9	29.4	40.7	95.9	139.1	1,421.3
Wolf Trap Creek 2	508.8	0.8	206.3	3.1	4.7	7.0	43.1	10.7	784.4
TOTAL	**19,346.4**	**124.6**	**7,781.0**	**156.0**	**148.9**	**367.6**	**1,721.7**	**2,348.0**	**31,994.1**

3.7 Hydrographic Data

Hydrographic data describing the stream network were obtained from the National Hydrography Dataset (NHD). This data was used for HSPF model development and TMDL development. Stream channels in the hydrologic modeling area were represented as trapezoidal channels. The channel slopes were estimated using the reach length and the corresponding change in elevation from DEM data. **Appendix B** presents the model representation of the stream reach segments**.**

3.8 Fecal Coliform Sources Representation

This section demonstrates how the fecal coliform sources identified in Chapter 2 were included or represented in the model. These sources include permitted sources, human sources (failing sewage disposal systems), livestock, wildlife, pets, and land application of manure.

3.8.1 Permitted Facilities

Based on data obtained from VA DEQ, there are four facilities that are addressed under the Virginia Pollutant Discharge Elimination System (VPDES) Program. **Table 2-7** presents the permit number, facility name, and design flow for the facilities.

For TMDL development, average discharge flow values were considered representative of flow conditions at the permitted facility, and were used in HSPF model set-up and

calibration. For TMDL allocation development, the permitted facility was represented as a constant source discharging at its maximum permitted design flow and bacteria concentration.

3.8.2 Failing Sewage Disposal Systems

Failed septic system loading to the watershed can be direct (point) or land-based (indirect or nonpoint), depending on the proximity of the septic system to the stream. As explained in Chapter 2, the estimate of the total number of septic systems in the watershed is 1,501 systems. For TMDL development, it was assumed that a 4% failure rate for septic systems would be representative of conditions in the watershed. This results in an estimated 60 failing septic systems within the watershed.

In cases where the septic system is within the 200 foot stream buffer, the failed septic system was represented in the model as a constant source (similar to a permitted facility). Based on GIS data, only approximately 44 of the households on septic systems were located within the 200 foot stream buffer. Using a failure rate of 4%, this corresponds to two failed septic systems directly discharging to the stream. To account for uncontrolled discharges in the watershed and failed septic systems within the stream buffer, four straight pipes were included in the model. The 1990 Census data rate of 9.5% of systems disposed of sewage by other means was the basis of the estimation for straight pipes.

In each subwatershed, the load from failing septic systems was calculated as the product of the total number of septic systems, septic systems failure rate, flow rate of septic discharge, typical fecal concentration in septic outflow, and the average household size in the watershed. The septic systems' fecal coliform load calculations used a design flow of 75 gallons per person per day and a fecal coliform concentration of 10,000 cfu/100mL (Horsley & Whitten, 1996). Fecal coliform loading from failed septic systems that are not within the 200 feet buffer of the stream is considered a predominantly indirect source. Failed septic systems within the stream buffer and straight pipes were represented as constant sources of fecal coliform. The distribution of sewage disposal systems by subwatershed is shown in **Appendix C**.

3.8.3 Livestock

Livestock contribution to the total fecal coliform load in the watershed was represented in a number of ways, which are presented in **Figure 3-3**. The model accounts for fecal coliform directly deposited in the stream, fecal coliform deposited while livestock are in confinement and later spread onto the crop and pasture lands in the watershed (land application of manure), and finally, land-based fecal coliform deposited by livestock while grazing.

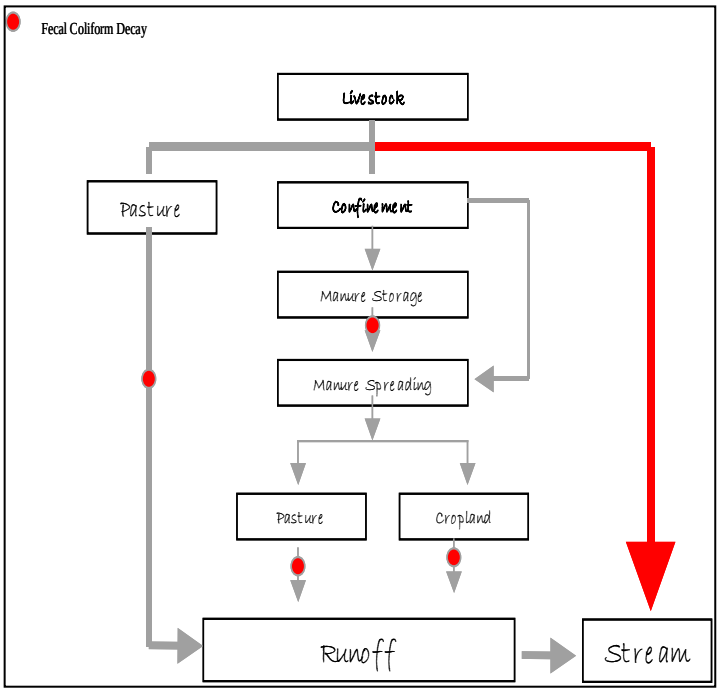

Figure 3-3: Livestock Contribution to the Impaired TMDL Watersheds

Based on the inventory of livestock in the watershed, it was determined that beef cows, cattle and hogs/pigs are the predominant types of livestock, though other livestock are also present in the watershed.

The distribution of the daily fecal coliform load between direct instream and indirect (land-based) loading was based on livestock daily schedules. The direct deposition load from livestock was estimated from the number of livestock in the watershed, the daily fecal coliform production per animal, and the amount of time livestock spent in the stream. The amount of time livestock spend in the stream was presented in Chapter 2. The distribution of livestock by subwatershed is shown in **Appendix C**.

The land-based load of fecal coliform from livestock while grazing was determined based on the number of livestock in the watershed, the daily fecal coliform production per animal, and the percent of time each animal spends in pasture.

3.8.4 Land Application of Manure

Beef cattle are present in the watershed. Because there are no known feedlots or large manure storage facilities present in the watershed, the daily produced manure is applied to pastureland in the watershed, and was treated as an indirect source in the development of the TMDLs. Beef cattle spend the majority of their time on pastureland and are not confined. Thus, fecal coliform loading from beef cattle was accounted for via the methods described above. Dairy cattle do spend time in confinement, and their fecal coliform load was included in the calculation of land application of manure. Fecal coliform loading from land application of manure was estimated based on the total number of dairy cows in the watershed, the fecal coliform production per animal per day, and the percent of time dairy cows were in confinement.

3.8.5 Wildlife

Fecal loading from wildlife was estimated in the same way as loading from livestock. As with livestock, fecal coliform contributions from wildlife can be both indirect and direct. The distribution between direct and indirect loading was based on estimates of the amount of time each type of wildlife spends on the surrounding land versus in the stream.

Daily fecal coliform production per animal and the amount of time each type of wildlife spends in the stream was presented previously in the wildlife inventory (Chapter 2). The direct fecal coliform load from wildlife was calculated by multiplying the number of each type of wildlife in the watershed by the fecal coliform production per animal per day, and by the percentage of time each animal spends in the stream. Indirect (land-based) fecal coliform loading from wildlife was estimated as the product of the number of each type of wildlife in the watershed, the fecal coliform production per animal per day, and the percent of time each animal spends on land within the watersheds. The resulting fecal coliform load was then distributed to forest and pasture land uses, which represent the most likely areas in the watershed where wildlife would be present and defecate. This was accomplished by converting the indirect fecal coliform load to a unit loading (cfu/acre), then multiplying the unit loading by the total area of forest and pasture in each subwatershed. The distribution of wildlife by subwatershed is shown in **Appendix C**.

3.8.6 Pets

For the TMDL, pet fecal coliform loading was considered a land-based load that was primarily deposited in urban land within the watershed. The daily fecal coliform loading was calculated as the product of the number of pets in the watershed and the daily fecal coliform production per type of pet. The distribution of pets by subwatershed is shown in **Appendix C**.

3.9 Fecal Coliform Die-off Rates

Representative fecal coliform decay rates were included in the HSPF model developed for the watershed. Three fecal coliform die-off rates required by the model to accurately represent watershed conditions included:

1. **In-storage fecal coliform die-off**. Fecal coliform concentrations are reduced while manure is in storage facilities.

2. **On-surface fecal coliform die-off**. Fecal coliform deposited on the land surfaces undergoes decay prior to being washed into streams.

3. **In-stream fecal coliform die-off**. Fecal coliform directly deposited into the stream, as well as fecal coliform entering the stream from indirect sources, will also undergo decay.

For the TMDL, in-storage die-off was not included in the model because there is no manure storage facility located in the study area. Decay rates of 1.37 and 1.152 per day were used to estimate die-off rates for on surface and instream fecal coliform, respectively (EPA, 1985).

3.10 Model Set-up, Hydrology Calibration, and Validation

Hydrologic calibration of the HSPF model involves the adjustment of model parameters to control various flow components (e.g. surface runoff, interflow and base flow, and the shape of the hydrographs) and make simulated values match observed flow conditions during the desired calibration period.

The model credibility and stakeholder faith in the outcome hinges on developing a model that has been calibrated and validated. Model calibration is a reality check. The

calibration process compares the model results with observed data to ensure the model output is accurate for a given set of conditions. Model validation establishes the model's credibility. The validation process compares the model output to the observed data set, which is different from the one used in the calibration process, and estimates the model's prediction accuracy. Water quality processes were calibrated following calibration of the hydrologic processes of the model.

3.10.1 Model Set-Up

3.10.1.1 Stream Flow Data

There are two USGS stations that record streamflow in the Banister River watershed (**Figure 3-1**); USGS Station 02076500 (Georges Creek at Gretna VA) and USGS Station 02077000 (Banister River near Halifax, VA). The development of the 2007 upper Banister River TMDLs uses the streamflow at USGS Station 02076500. This station was selected because of its unrestricted flow within the watershed. The HSPF streamflow calibration for the lower Banister TMDLs uses streamflow at USGS Station 02077000. This station is located at the headwaters of the study area, below Banister Lake, and drives the hydrologic regime in the lower Banister River. A 6-year period (2003-2008) was selected as the calibration period for the hydrologic model. The hydrology validation period selected was from 2008 through 2011.

3.10.1.2 Rainfall and Climate Data

Weather data from the Lynchburg Municipal Airport station were obtained from NCDC. The data include meteorological (hourly precipitation) and surface airways data (including wind speed/direction, ceiling height, dry bulb temperature, dew point temperature, and solar radiation). **Figure 3-4** shows the location of both the USGS station used for modeling as well as the main meteorological station. Weather observations from the Chatham Airport weather data were also used to fill gaps in weather data. .

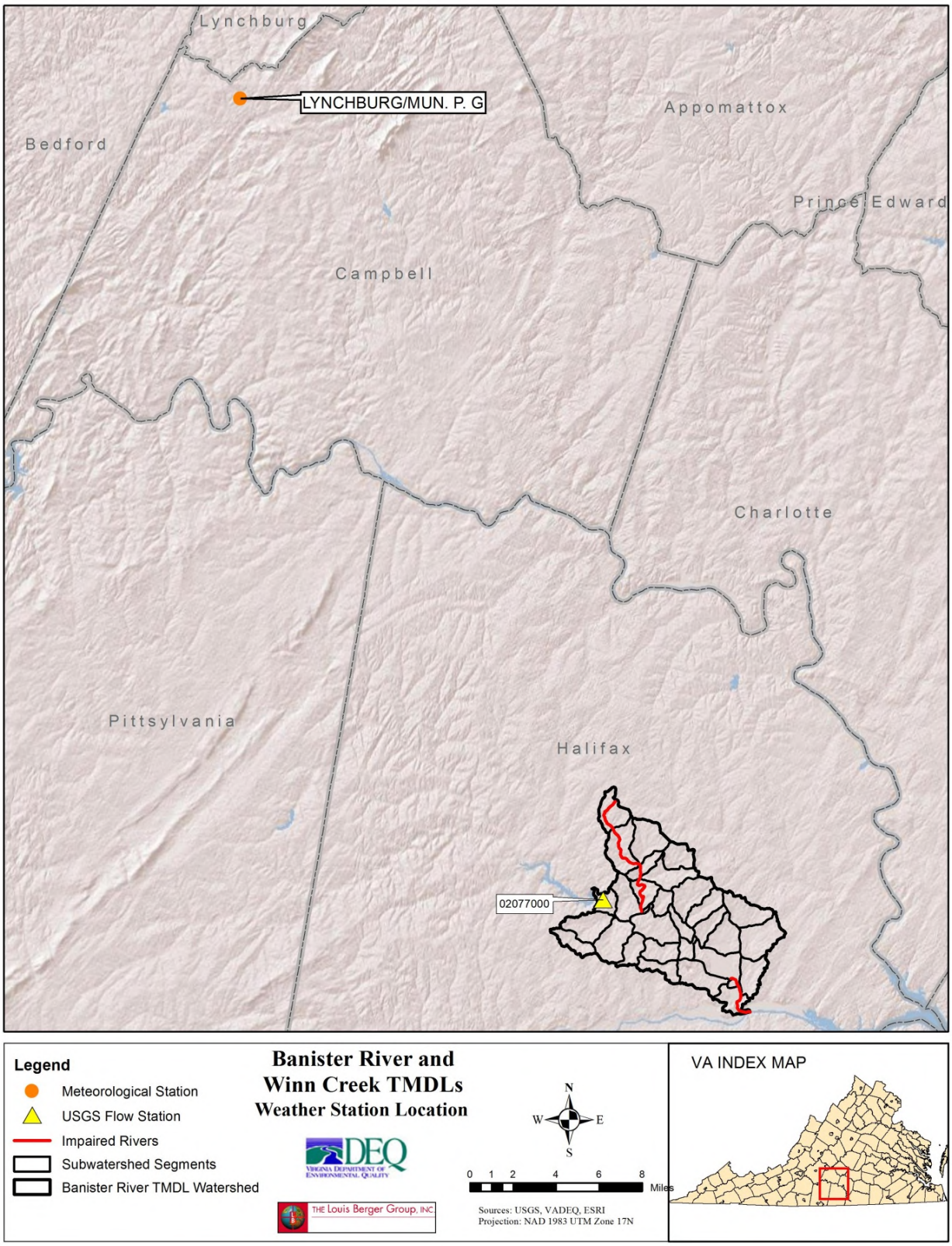

Figure 3-4: **Locations of NCDC Weather Station and USGS Flow Calibration Station**

3.10.2 Model Hydrologic Calibration Results

Calibration of the hydrology of the hydrologic modeling area used the Expert System for Calibration of the Hydrological Simulation Program-FORTRAN (HSPEXP) software. After each model's iteration, summary statistics were calculated to compare model results with observed values, in order to provide guidance on parameter adjustment according to built-in rules. The rules were derived from the experience of expert modelers and listed in the HSPEXP user manual (Lumb and Kittle, 1993).

Using the recommended default criteria as target values for an acceptable hydrologic calibration, the hydrologic model was calibrated from January 2003 to December 2008 at the flow station 02077000 (Banister River near Halifax, VA). Calibration results at station USGS 02077000 are presented in **Table 3-3**, showing the simulated and observed values for eight flow characteristics. The error statistics summary for seven flow conditions are presented in **Table 3-4**. The error statistics indicate that the validation results were within the recommended ranges except for the seasonal volume error. The model results and the observed daily average flow at the calibration station are plotted in **Figure 3-5**.

Table 3-3: USGS 02077000 Model Calibration Results

Category	Simulated	Observed
Total runoff, in inches	55.930	54.530
Total of highest 10% flows, in inches	25.330	24.051
Total of lowest 50% flows, in inches	8.39	8.92
Total storm volume, in inches	29.34	28.15
Baseflow recession rate	0.950	0.940
Summer flow volume, in inches	9.26	8.568
Winter flow volume, in inches	16.370	15.846

Table 3-4: USGS 02077000 Model Calibration Error Statistics

Category	Current	Criterion
Error in total volume	+2.6	± 10.000
Error in low flow recession	0.010	± 0.010
Error in 50% lowest flows	-5.9	± 10.000
Error in 10% highest Flow	+14.2	± 15.000
Seasonal volume error	+4.9	± 10.000

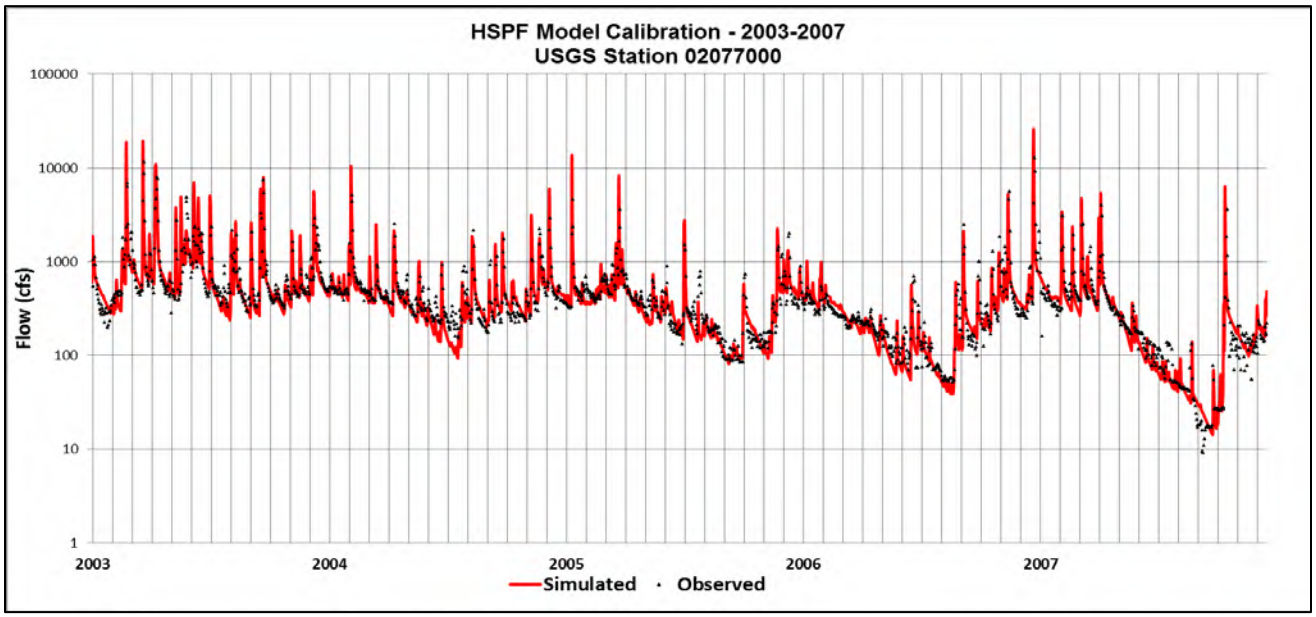

Figure 3-5: USGS 02077000 (Banister River near Halifax, VA) Model Hydrologic Calibration Results

3.10.3 Model Hydrologic Validation Results

The period of January 2008 to December 2011 was used to validate the HSPF model. Validation results at USGS Station 02077000 are presented in **Table 3-5**, which shows the simulated and observed values for nine flow characteristics. The error statistics summary for seven flow conditions is presented in **Table 3-6**. The model results and the observed daily average flow at the calibration station are plotted in **Figure 3-6**.

Table 3-5: USGS 02077000 Model Validation Results

Category	Simulated	Observed
Total runoff, in inches	32.97	30.05
Total of highest 10% flows, in inches	13.66	13.02
Total of lowest 50% flows, in inches	4.87	4.59
Total storm volume, in inches	7.68	7.02
Baseflow recession rate	0.96	0.95
Summer flow volume, in inches	1.68	1.49
Winter flow volume, in inches	11.087	9.65

Table 3-6: USGS 02077000 Model Validation Error Statistics

Category	Current	Criterion
Error in total volume	+9.7	± 10.000
Error in low flow recession	-0.010	± 0.010
Error in 50% lowest flows	+5.7	± 10.000
Error in 10% highest Flow	+4.9	± 15.000
Seasonal volume error	+13.8	± 10.000

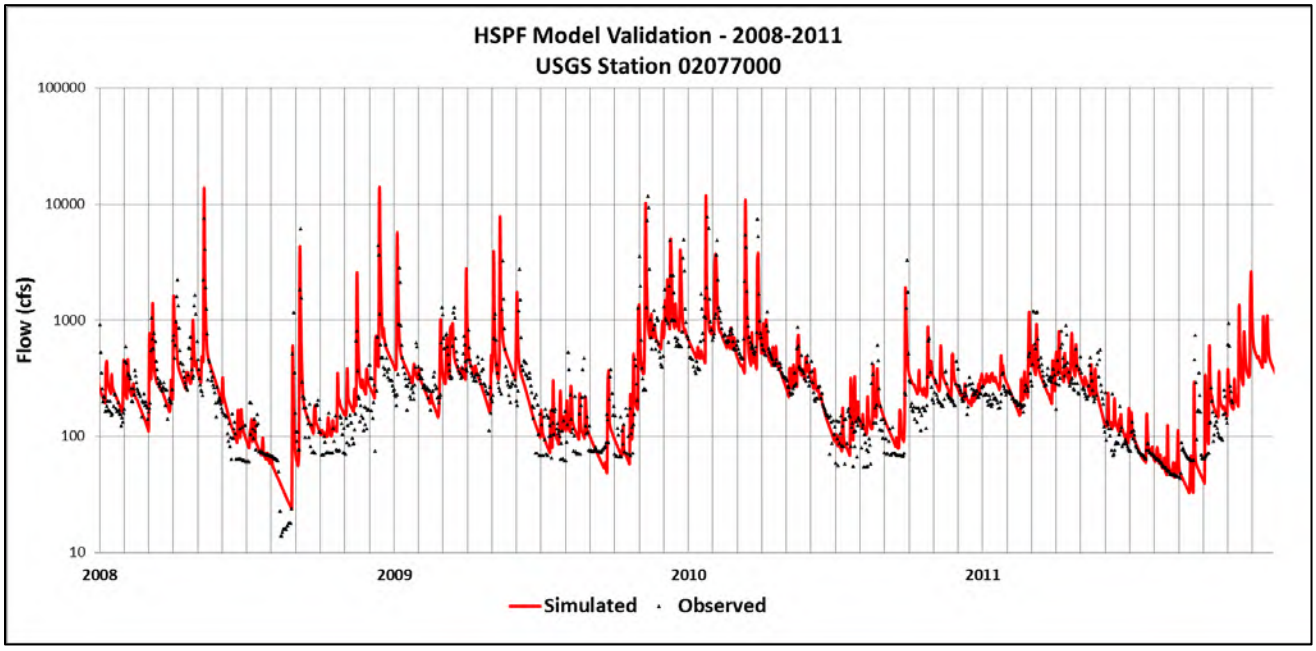

Figure 3-6: USGS 02077000 (Banister River near Halifax, VA) Model Hydrologic Validation Results

Overall, there is a very good agreement between the observed and simulated stream flow, indicating that the model parameterization is representative of the hydrologic characteristics of the watershed. Model results closely match the observed flows during low flow conditions, base flow recession, and storm peaks

3.10.4 Water Quality Calibration

Calibrating the water quality component of the HSPF model involves setting up the build-up, wash-off, and kinetic rates for fecal coliform that best describe fecal coliform sources and environmental conditions in the watershed. It is an iterative process in which the model results are compared to the available instream fecal coliform data, and the model parameters are adjusted until there is an acceptable agreement between the observed and simulated instream concentrations and the build-up and wash-off rates are within the acceptable ranges.

The availability of water quality data is a major factor in determining calibration and validation periods for the model. In Chapter 2, instream monitoring stations on the impaired segments were listed and sampling events conducted on the Banister River and

on Winn Creek were summarized and presented. **Table 3-7** lists the stations used in the water quality calibration for each impaired segment.

Table 3-7: Water Quality Stations used in the HSPF Fecal Coliform Simulations

Stream	Water Quality Station	Model Segment
Winn Creek	4-AWNN000.99	Winn Creek 1
Banister River	4-ABAN001.86	Banister River Mainstem 2

The water quality is first calibrated used observed *E.* coli data at Winn Creek (4-AWNN000.99) followed by the water quality calibration at the Banister River (4-ABAN001.86). The period used for water quality calibration of the model, and the period used for model validation depended on the time the water quality observations were collected. It is important to keep in mind that the observed *E.* coli concentrations are instantaneous values that are highly dependent on the time and location the sample was collected. The model simulates fecal coliform concentrations since all the source assessment and model input parameters were based on fecal coliform. The *E. coli* concentrations in the impaired segments were then calculated from the simulated fecal coliform concentrations using a regression based instream translator, which is presented below:

$$E.\ coli\ concentration\ (cfu/100\ ml) = 2^{-0.0172} \times (FC\ concentration\ (cfu/100ml))^{0.91905}$$

These E. coli concentrations were then compared to the E. coli concentrations measured at the various VADEQ monitoring stations in each of the impaired segment. **Figure 3-7** presents the calibration results of the HSPF *E.* coli simulations at Winn Creek 4-AWNN000.99. The simulation period presented in Figure 3-7 extends from January 2003 to December 2005 using all the existing E. coli observed data at this station.

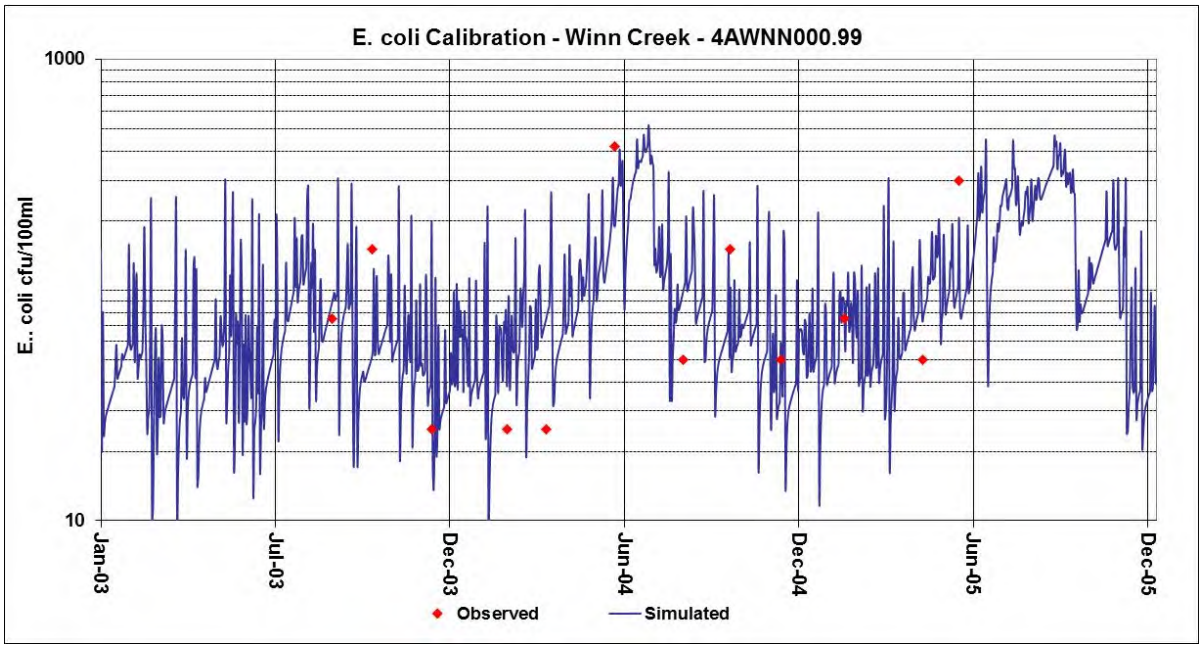

Figure 3-7: *E. coli* Calibration at Winn Creek - 4-AWNN000.99

Figure 3-8 presents the calibration results of the HSPF *E*. coli simulations at Banister River 4-ABAN001.86. The simulation period presented in Figure 3-8 extends from January 2003 to December 2010 presenting all the existing E. coli observed data at this station. E. coli data was collected at this station between 2003-and 2005 and 2009 to 2010. There were no E. coli data collected at this station from January 2006 to December 2008.

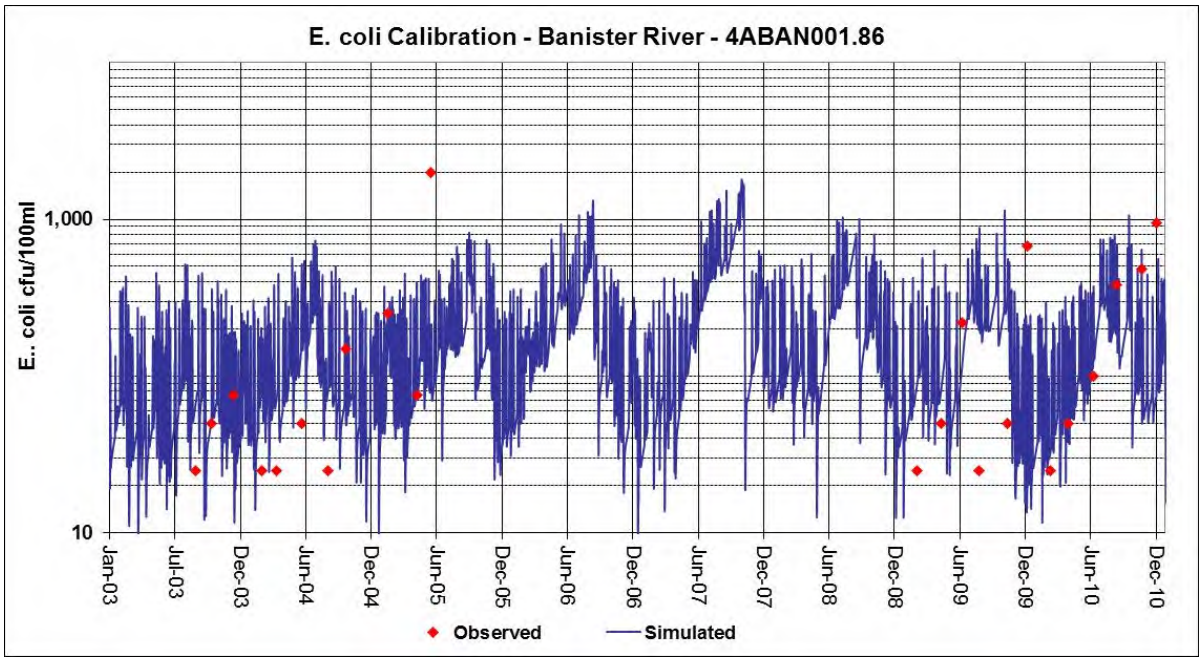

Figure 3-8: *E. coli* Calibration at Banister River - 4-ABAN001.86

The goodness of fit for the water quality calibration was first evaluated visually followed by a comparison of the observed and simulated geometric mean and the exceedances of instantaneous *E.* coli criterion. **Table 3-8** presents the observed and simulated E. coli geometric means and the exceedance rates of the exceedance rates of the 235 cfu/100 ml maximum *E. coli* criterion.

Table 3-8: Observed and Simulated Geometric Mean *E. coli* Concentration

Water Quality Station	Reach	Period	Geometric Mean (cfu/100ml)		Exceedance Rate Instantaneous Criterion	
			Simulated	Observed	Simulated	Observed
Winn Creek	69	2003 -2005	77.7	74.9	13.2%	16.6%
Banister River	81	2003-2010	122.3	93.4	26.2%	26.1%
Banister River	81	2003-2005	92.3	74.8	16.3%	18.2%
Banister River	81	2009-2010	116.5	114.5	31.9%	33.3%

3.11 Existing Conditions Bacteria Loading

The existing conditions *E.*coli loadings by source for Winn Creek and the Lower Banister River watersheds were calculated based on current watershed conditions reflected by the most recent time period spanning from 2005 to 2010. Distribution of the existing *E. coli* load in Winn Creek (4-AWNN000.99) and the lower Banister River (4-ABAN001.86) are presented in **Tables 3-9 and 3-10** respectively.

Table 3-9: Winn Creek (4-AWNN000.99) E. *coli* Existing Load Distribution

Source	Annual Average E. coli Loads	
	cfu/yr	%
Forest	1.58E+12	10.1%
Cropland	5.08E+11	3.3%
Pasture	8.11E+12	52.0%
High Intensity Urban	3.04E+10	0.2%
Medium Intensity Urban	3.18E+10	0.2%
Low Intensity Urban	7.69E+11	4.9%
Developed Open Space	5.49E+11	3.5%
Cattle Direct Deposition	2.20E+12	14.1%
Wildlife Direct Deposition	1.74E+12	11.2%
Failing Septics	9.04E+10	0.6%
Total	**1.56E+13**	**100%**

Table 3-9 indicates that bacteria loadings from pastures are the predominant sources of bacteria consisting of 52% of the total E. coli annual load in the Winn Creek watershed. Direct bacteria deposition of bacteria from cattle, wildlife, and failed septics constitutes 26

percent of the total bacteria load. Urban nonpoint sources (High/Medium/Low Intensity Urban and Developed Open Space) loading are approximately 9 percent of the total load in the Winn Creek watershed.

Table 3-10: Banister River (4-ABAN001.86) E. *coli* Existing Load Distribution

Source	Annual Average E. coli Loads	
	cfu/yr	%
Forest	6.03E+12	9.8%
Cropland	7.93E+11	1.3%
Pasture	2.32E+13	37.6%
High Intensity Urban	2.63E+12	4.3%
Medium Intensity Urban	3.63E+12	5.9%
Low Intensity Urban	8.33E+12	13.5%
Developed Open Space	3.01E+12	4.9%
Cattle Direct Deposition	6.49E+12	10.5%
Wildlife Direct Deposition	6.82E+12	11.0%
Failing Septics	8.38E+11	1.4%
Total	**6.18E+13**	**100%**

Table 3-10 indicates that bacteria loadings from pastures land and urban contribute 38 and 29 percent, respectively of the total bacteria load in the lower Banister River (4-ABAN001.86). Direct bacteria deposition of bacteria from cattle, wildlife, and failed septics constitutes 22 percent of the total bacteria load in the lower Banister River watershed.

4.0 Allocation

Allocation analysis was the third stage in the development of the Banister River and Winn Creek Bacteria TMDLs. The purpose of this third stage was to develop the framework for reducing bacteria loading under the existing watershed conditions so that water quality standards may be met. The TMDLs represents the maximum amount of pollutant that the stream can receive without exceeding the water quality criteria. The load allocations for the selected scenarios were calculated using the following equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

Where,

WLA = waste load allocation (point source contributions);

LA = load allocation (non-point source allocation); and

MOS = margin of safety.

Typically, several potential allocation strategies would achieve the TMDL endpoint and water quality standards. Available control options depend on the number, location, and character of pollutant sources.

4.1 Incorporation of Margin of Safety

The margin of safety (MOS) is a required component of the TMDL to account for any lack of knowledge concerning the relationship between effluent limitations and water quality. According to EPA guidance (*Guidance for Water Quality-Based Decisions: The TMDL Process, 1991*), the MOS can be incorporated into the TMDL using one of two methods:

- Implicitly incorporating the MOS using conservative model assumptions to develop allocations.
- Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS will be implicitly incorporated into this TMDL. Implicitly incorporating the MOS will require that allocation scenarios be designed to meet the monthly geometric

mean criterion of 126 cfu/100 mL for *E. coli* bacteria. In addition, it is required that final allocation scenarios be designed so that there is no more than a 10% exceedance rate of the maximum assessment criterion for *E. coli* of 235 cfu/100 mL.

4.2 Allocation Scenario Development

Allocation scenarios were modeled using the calibrated HSPF model to adjust the existing conditions until the water quality criteria were attained. The Banister River and Winn Creek TMDLs were based on the Virginia water quality criteria for *E. coli*. As detailed in Section 1.3, the *E. coli* criterion states that the calendar-month geometric mean concentration shall not exceed 126 cfu/100 mL, and that a maximum single sample concentration of *E. coli* shall not exceed 235 cfu/100 mL more than 10 percent of the time. According to the guidelines put forth by the VADEQ (VADEQ, 2011) for modeling *E. coli* with HSPF, the model was set up to estimate loads of fecal coliform, and then the model output was converted to concentrations of *E. coli* with the following equation:

$$\log_2 EC\ (cfu/100mL) = -0.0172 + 0.91905 * \log_2 FC\ (cfu/100mL)$$

Where: EC = E. coli bacteria concentration

FC = Fecal coliform bacteria concentration

The pollutant concentrations were simulated over the entire duration of a representative modeling period, and pollutant loads were adjusted until the criteria was met. The pollutant loads were calculated at the outlet of the impaired segments. The development of the allocation scenarios was an iterative process requiring numerous runs where each run was followed by an assessment of source reduction against the water quality target. The long-term average *E. coli* loads and coefficient of variations were determined to implement the final allocation scenarios and to express the TMDL on a daily basis. Assuming a log-normal distribution of data and a probability of occurrence of 95%, the maximum daily loads were determined using the following equation (*USEPA OWOW 2007 Options for Expressing Daily Loads in TMDLs*):

$$MDL = LTA \times Exp[z\sigma - 0.5\sigma^2]$$ Where;

MDL = maximum daily limit (cfu/day)

LTA = long-term average (cfu/day)

z = z statistic of the probability of occurrence

$\sigma^2 = \ln(CV^2+1)$

CV = coefficient of variation

Daily expressions for aggregate WLAs and LAs were calculated using the above method. The daily expression of individual WLAs, presented in Tables 4-6, were calculated based on the average annual individual WLAs divided by 365 days in a year. These daily average values are not intended to represent maximum allowable daily loads. Rather, they represent the average daily loadings that may be expected to occur over the long term. The following sections present the waste load allocation (WLA) and load allocations (LA) for the impaired segment.

4.3 Wasteload Allocation Development

The allocated *E.* coli load for VPDES facilities permitted to discharge bacteria is based on the actual design flow of the system as presented in **Table 2-7** and a maximum *E. coli* concentration of 126 cfu/100 ml. The existing load for general domestic permits is based on the allowable flow rate of 1,000 gallons/day and a maximum *E. coli* concentration of 126 cfu/100 ml. Future growth was accounted for by setting 1% of the TMDL in the watersheds without any point sources. For watersheds with point sources, a growth factor of 2 times the existing load was allocated for future growth.

4.4 Load Allocation Development

The reduction of loadings from nonpoint sources, including livestock and wildlife direct deposition, is incorporated into the load allocation. A number of load allocation scenarios were implemented in order to determine the final TMDL load allocation. Fecal coliform loading and instream fecal coliform concentrations were estimated for each potential scenario using the HSPF model for the hydrologic period of January 2000 to December 2005. **Table 4-1** depicts the key load allocation scenarios that were implemented to arrive at the final TMDL allocations. It should be noted that these key scenarios were implemented for all segments. However, additional scenarios were also implemented when deemed necessary to attain the final TMDL.

Table 4-1: TMDL Load Allocation Scenarios (%Reduction)					
Scenario	**Failed Septic & Pipes**	**Direct Livestock**	**NPS (Agriculture)**	**NPS (Urban)**	**Direct Wildlife**
0	0	0	0	0	0
1	100	0	0	0	0
2	100	100	0	0	0
3	100	100	50		0
4	100	100	50	50	0
5	100	100	50	50	100
6	100	100	70	70	

4.5 Winn Creek WNN01A06

This section presents the wasteload and load allocation plan and TMDL summary for the Winn Creek impaired segment.

4.5.1 Winn Creek Wasteload Allocation

There are no municipal VPDES permitted facilities that discharge into the Winn Creek bacteria impaired watershed. However, an explicit allocation (equivalent to 1% of the TMDL for the watershed) was provided for the future growth of VPDES permitted point sources in the watershed.

4.5.2 Winn Creek Load Allocation Plan and TMDL Summary

The requirements to meet the calendar month *E. coli* geometric mean water quality standard of 126 cfu/100mL and the instantaneous water quality standard of 235 cfu/100mL for the Winn Creek impaired segment (WNN01A06) are:

- 100 % reduction of the human sources (failed septic systems and straight pipes)
- 100% reduction of the direct livestock instream loading
- 70% reduction of bacteria loading from agricultural and urban nonpoint sources.
- 64% reduction of bacteria loading from direct deposition from wildlife
- No reductions from the forested land (wildlife indirect loads) is required

The estimated load reductions and percent exceedances under each allocation modeling scenario for the Winn Creek impaired segment is presented in **Table 4-2**. **Table 4-3** details the existing loads, allocated loads, and percent reductions to meet the allocations for each landuse/source for Winn Creek.

Table 4-2: Winn Creek Load Reductions Under 30-Day Geometric Mean and Maximum Assessment Criteria for *E. coli*

Scenario	Failing Sewage Disposal Systems	Direct Deposition from Cattle	Non-Point Source Agriculture	Non-Point Source Urban	Non-Point Source Forest (Wildlife)	Direct Deposition from Wildlife	Exceedance of the E. Coli Geometric Mean Criterion	Exceedance of the E. Coli Maximum Assessment Criterion
0							43%	31%
1	100						42%	31%
2	100	100					25%	7%
3	100	100	50				22%	6%
4	100	100	50	50			22%	5.5%
5	100	100	50	50		100	0%	0%
6	100	100	70	70			22%	4.7%
7	100	100	70	70		50	4%	0%
8	**100**	**100**	**70**	**70**		**64**	**0%**	**0%**

Table 4-3: Winn Creek Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Source	Annual Average E. coli Loads cfu/yr)		Percent Reduction
	Existing	Allocation	%
Forest	1.58E+12	1.58E+12	0.0%
Cropland	5.08E+11	1.52E+11	70.0%
Pasture	8.11E+12	2.43E+12	70.0%
High Intensity Urban	3.04E+10	9.12E+09	70.0%
Medium Intensity Urban	3.18E+10	9.54E+09	70.0%
Low Intensity Urban	7.69E+11	2.31E+11	70.0%
Developed Open Space	5.49E+11	1.65E+11	70.0%
Cattle Direct Deposition	2.20E+12	0.00E+00	100.0%
Wildlife Direct Deposition	1.74E+12	6.26E+11	64.0%
Failing Septics	9.04E+10	0.00E+00	100.0%
Future Growth (*)	0.00E+00	5.25E+10	
Total	**1.56E+13**	**5.25E+12**	**66.36%**

(*) there are no individual VPDES municipal point source dischargers; the WLA includes 1 percent of the TMDL to account for future growth

Tables 4-4 and **4-5** presents the summaries of the TMDL allocation plan loads for Winn Creek (Segment WNN01A06).

Table 4-4: Winn Creek TMDL (cfu/year) for *E. coli*

Watershed	WLA	LA	MOS	TMDL
Winn Creek - WNN01A06	**5.25E+10**	**5.20E+12**	**IMPLICIT**	**5.25E+12**

Table 4-5: Winn Creek TMDL (cfu/day) for *E. coli*				
Watershed	**WLA**	**LA**	**MOS**	**TMDL**
Winn Creek - WNN01A06	**1.43E+08**	**4.45E+10**	**IMPLICIT**	**4.46E+10**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 4-1** and **Figure 4-2. Figure 4-1** shows the calendar month geometric mean *E. coli* concentrations for existing as well as under the allocation conditions. **Figure 4-2** shows the instantaneous *E. coli* concentrations under the allocations, as well as under existing conditions.

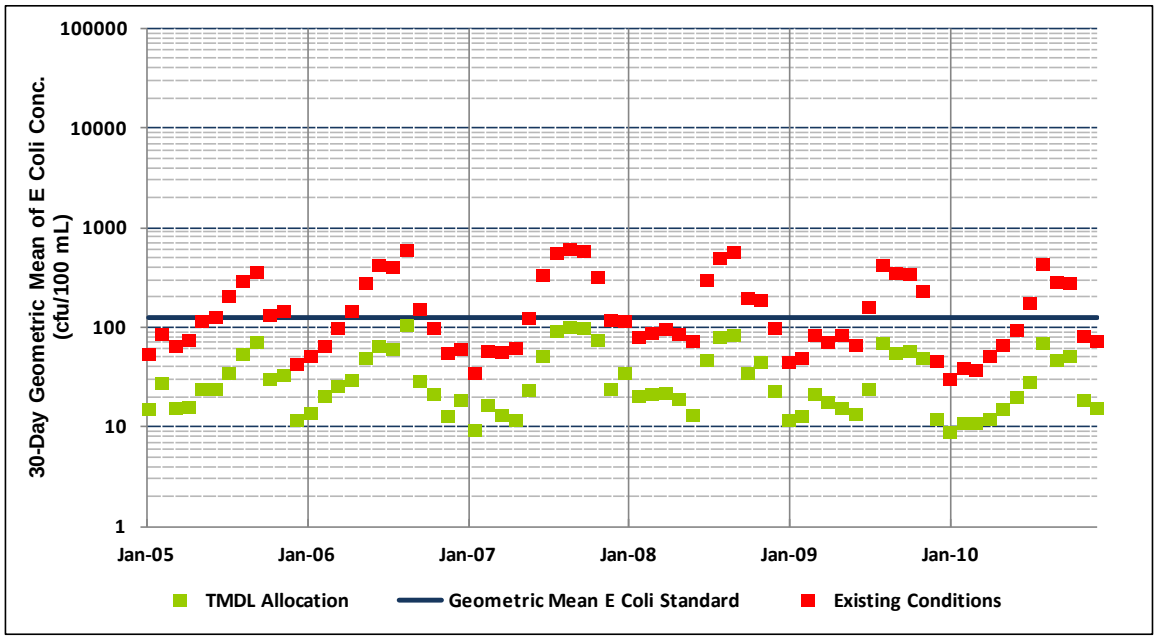

Figure 4-1: Winn Creek Geometric Mean *E. coli* Concentrations under Existing and TMDL Conditions

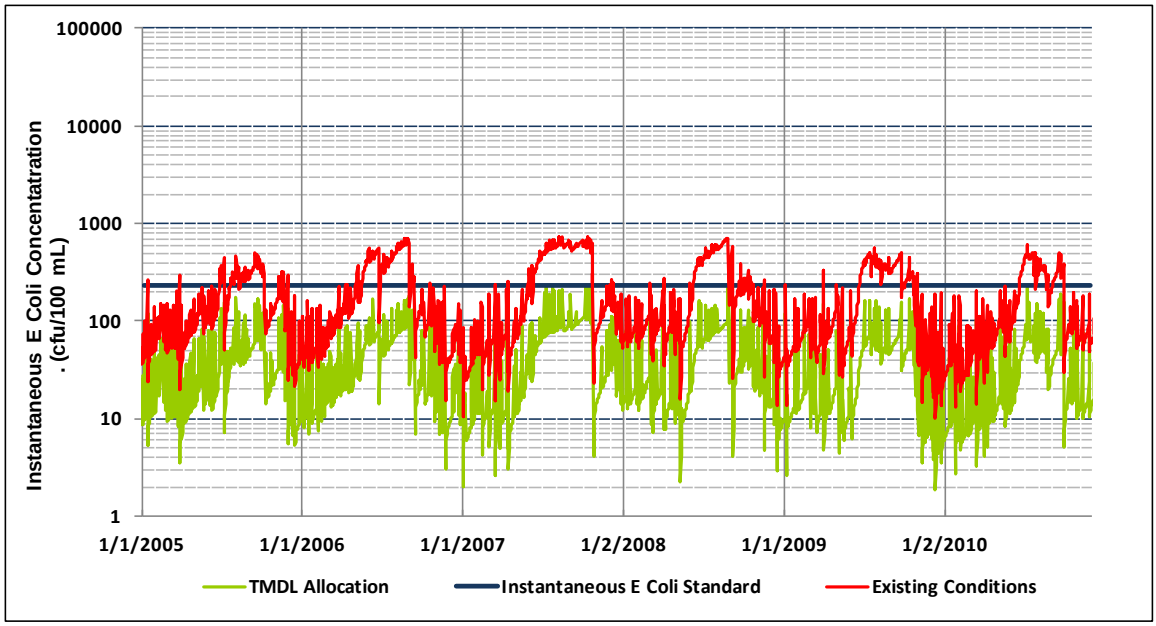

Figure 4-2: Winn Creek Instantaneous *E. coli* Concentrations under Existing and TMDL Conditions

4.6 Banister River BAN06A08

The Banister load allocation plan is developed following the competition of theTMDL for Winn Creek (WNN01A06). In fact, the estimated bacteria load reductions for Winn Creek (**Table 4-3**) are directly incorporated in the allocation modeling scenarios for the lower Banister River segment (BAN06A08). In addition, the bacteria allocations reductions estimated for the various TMDL segments in the upper Banister River (VADEQ 2007) are also included in the allocation modeling scenarios. In other words, the bacteria load allocation plan and TMDL for the Banister River BAN06A08 are developed assuming that the bacteria water quality at the outlet of Winn Creek and the upper Banister River watersheds meet the bacteria standards.

The following section presents the wasteload and load allocation plan and TMDL summary for the Banister River impaired segment.

4.6.1 Banister River Wasteload Allocation

There are two permitted wastewater treatment facilities discharging bacteria to the lower Banister River (BAN06A08). In addition, there are seven general-domestic sewage permitted facilities. For this TMDL, the waste load allocation for such facilities is to assume the discharge at twice the design flow limits and bacteria concentrations at the

existing *E. coli* standard of 126 cfu/100mL. **Table 4-6** shows the existing and allocated loads of dischargers in Banister River (Segment BAN06A08).

Table 4-6: Banister River (BAN06A08) Wasteload Allocations

Permit No.	Facility Name	Existing Load (cfu/yr)	Allocated Load (cfu/yr)
VA0020320	Cowford Rd WWTP	5.22E+11	5.22E+11
VA0062103	Scottsburg WWTP	5.22E+10	5.22E+10
VAG404183	Residence	1.74E+09	1.74E+09
VAG404088	Residence	1.74E+09	1.74E+09
VAG404087	Residence	1.74E+09	1.74E+09
VAG407219	Residence	1.74E+09	1.74E+09
VAG407286	Residence	1.74E+09	1.74E+09
VAG407296	Residence	1.74E+09	1.74E+09
VAG407283	Residence	1.74E+09	1.74E+09
	Future Growth*	0.00E+00	5.87E+11
	Total	**5.87E+11**	**1.17E+12**

*Future Growth is equal to 1x the existing load (to give a total allocation of 2x the existing load)

4.6.2 Banister River Load Allocation Plan and TMDL Summary

The requirements to meet the calendar month *E. coli* geometric mean water quality standard of 126 cfu/100mL and the instantaneous water quality standard of 235 cfu/100mL for the Winn Creek impaired segment (BAN06A08) are:

- 100 % reduction of the human sources (failed septic systems and straight pipes)
- 100% reduction of the direct livestock instream loading
- 75% reduction of bacteria loading from agricultural and urban nonpoint sources.
- 25% reduction of bacteria loading from direct deposition from wildlife
- No reductions from the forested land (wildlife indirect loads)

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The estimated load reductions and percent exceedances under each allocation modeling scenario for the Winn Creek impaired segment is presented in **Table 4-7. Table 4-8** details the existing loads, allocated loads, and percent reductions to meet the allocations for each landuse/source in the Banister River TMDL watershed.

Table 4-7: Banister River (BAN06A08) Load Reductions Under 30-Day Geometric Mean and Maximum Assessment Criteria for *E. coli*

Scenario	Failing Sewage Disposal Systems	Direct Deposition from Cattle	Non-Point Source Agriculture	Non-Point Source Urban	Non-Point Source Forest (Wildlife)	Direct Deposition from Wildlife	Exceedance of the E. Coli Geometric Mean Criterion	Exceedance of the E. Coli Maximum Assessment Criterion
0							15.3%	5.3%
1	100						14.6%	4.9%
2	100	100					8.3%	3.1%
3	100	100	50				6.9%	1.4%
4	100	100	50	50			2.8%	1.0%
5	100	100	50	50		100	0.0%	0.0%
6	100	100	70	70			2.8%	0.8%
7	100	100	75	75			0.7%	1.4%
8	100	100	75	75		50	0%	0%
9	**100**	**100**	**75**	**75**		**25**	**0%**	**0%**

Table 4-8: Banister River (BAN06A08) Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Average *E. coli* Loads (cfu/yr)		Percent Reduction (%)
	Existing	Allocation	
Forest	6.03E+12	6.03E+12	0.0%
Cropland	7.93E+11	1.98E+11	75.0%
Pasture	2.32E+13	5.80E+12	75.0%
High Intensity Urban	2.63E+12	6.58E+11	75.0%
Medium Intensity Urban	3.63E+12	9.08E+11	75.0%
Low Intensity Urban	8.33E+12	2.08E+12	75.0%
Developed Open Space	3.01E+12	7.53E+11	75.0%
Cattle Direct Deposition	6.49E+12	0.00E+00	100.0%
Wildlife Direct Deposition	6.82E+12	5.12E+12	25.0%
Failing Septics	8.38E+11	0.00E+00	100.0%
Point Sources	5.87E+11	5.87E+11	-
Future Growth*	0.00E+00	5.87E+11	-
Total	**6.24E+13**	**2.27E+13**	**63.6%**

*Future Growth is equal to 1x the existing point source load (to give a total wasteload allocation of 2x the existing wasteload)

Summaries of the TMDL allocation plan loads for Banister River (Segment BAN06A08) are presented in **Tables 4-9** and **4-10**.

Table 4-9: Banister River TMDL for *E. coli* (cfu/year)

Watershed	WLA	LA	MOS	TMDL
Banister River	**1.17E+12**	**2.15E+13**	**IMPLICIT**	**2.27E+13**

Table 4-10: Banister River TMDL for *E. coli* (cfu/day)				
Watershed	**WLA**	**LA**	**MOS**	**TMDL**
Banister River	**2.21E+09**	**1.29E+11**	**IMPLICIT**	**1.32E+11**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 4-3** and **Figure 4-4. Figure 4-3** shows the calendar month geometric mean *E. coli* concentrations for existing as well as under the allocation conditions. **Figure 4-4** shows the instantaneous *E. coli* concentrations under the allocations, as well as under existing conditions.

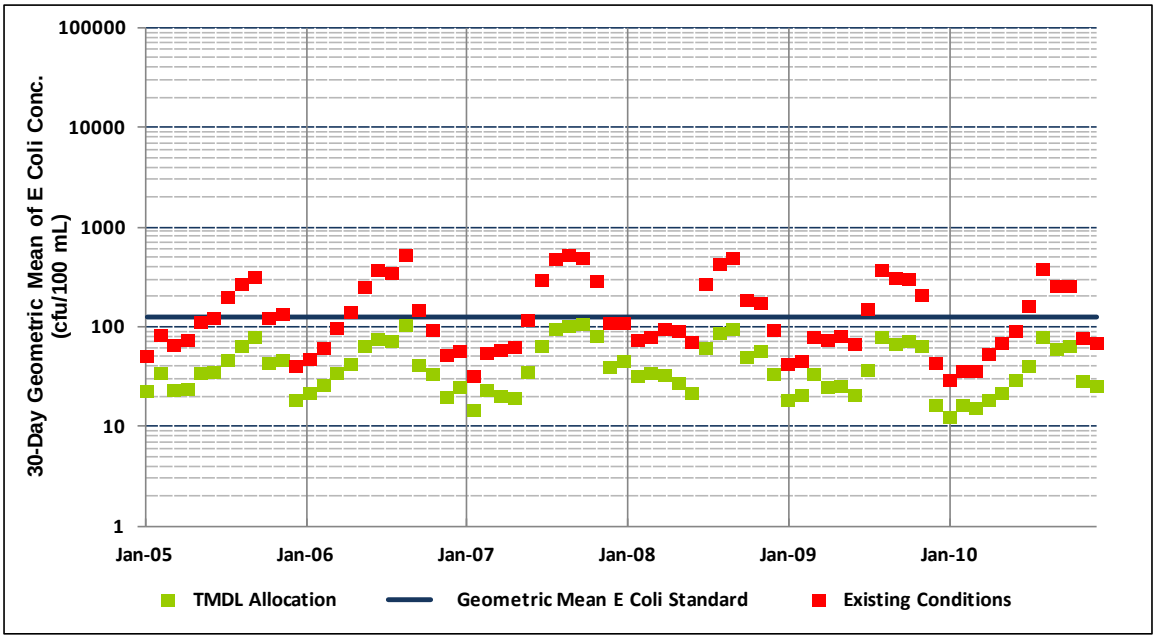

Figure 4-3: Banister River Geometric Mean *E. coli* Concentrations under Existing TMDL Conditions

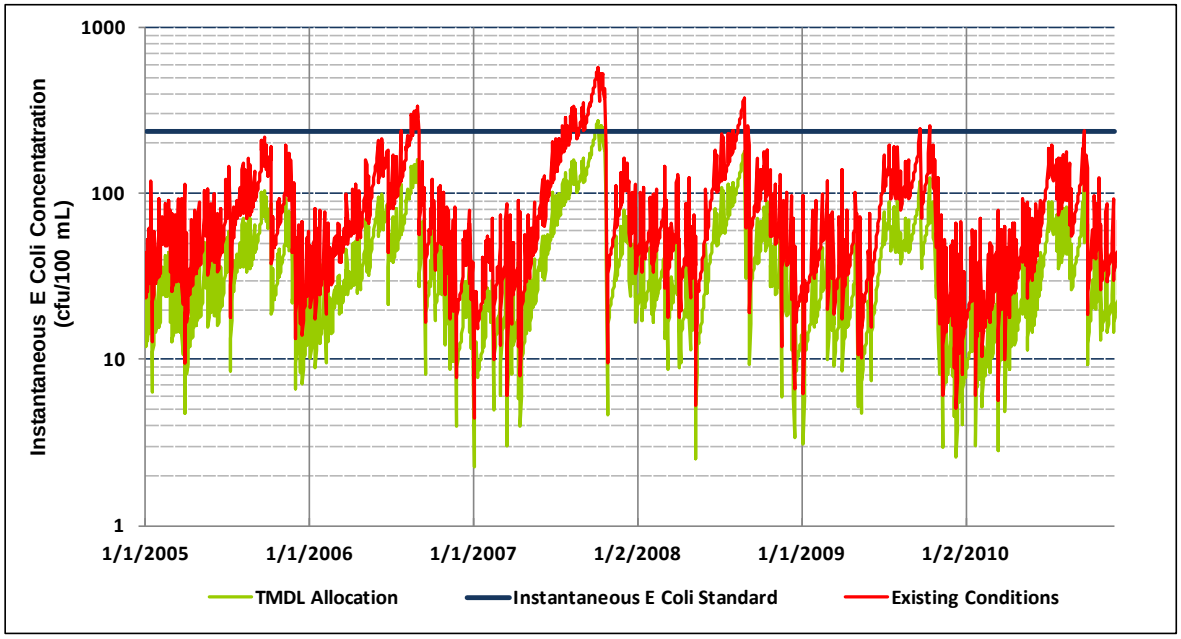

Figure 4-4: Banister River Instantaneous *E. coli* Concentrations under Existing and Conditions

5.0 TMDL Implementation

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point and non point sources in the stream. For point sources, all new or revised VPDES/NPDES permits must be consistent with the TMDL WLA pursuant to 40 CFR '122.44 (d)(1)(vii)(B) and must be submitted to EPA for approval. Implementation is an iterative process and includes the measures for non-point source reductions, such as the use of better treatment technology and the installation of best management practices (BMPs). The "TMDL Implementation Plan Guidance Manual", published in July 2003, describes the process for developing an implementation plan (http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/ipguide.pdf). With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

5.1 Staged Implementation

In general, Virginia intends for the required bacteria reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. For example, in agricultural areas of the watershed, the most promising management practice is livestock exclusion from streams. Livestock exclusions have proven to be very effective in lowering bacteria concentrations in streams, both by reducing the cattle deposits themselves and by providing additional riparian buffers.

Additionally, in both urban and rural areas, reducing the human bacteria loading from failing septic systems should be a primary implementation focus because of its health implications. Strategies to implement this could include education on septic tank pump-outs as well as a septic system repair/replacement program and the use of alternative waste treatment systems.

A sanitary sewer inspection and management program in urban areas could reduce the human bacteria loading from leaking sewer lines. Other BMPs that might be appropriate for controlling urban wash-off from parking lots and roads may include more restrictive

ordinances to reduce fecal loads from pets, improved garbage collection and control, and improved street cleaning.

The iterative implementation of BMPs in the watershed has several benefits:

1. It enables tracking of water quality improvements following BMP implementation through follow-up stream monitoring;

2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;

3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;

4. It helps ensure that the most cost effective practices are implemented first; and

5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan.

5.2 Reasonable Assurance for Implementation

5.2.1 Follow-Up Monitoring

Following the development of the TMDL, the Department of Environmental Quality (DEQ) will continue to monitor the impaired stream in accordance with its ambient monitoring program. DEQ's Ambient Watershed Monitoring Plan for conventional pollutants calls for watershed monitoring to take place on a rotating basis, bi-monthly for two consecutive years of a six-year cycle. VADEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders, will determine the purpose, location, parameters, frequency, and duration of the monitoring. Whenever possible, the location of the follow-up monitoring station(s) will be the same as the listing station. At a minimum, the monitoring station must be representative of the original

impaired segment. The Annual Water Monitoring Plan prepared by each DEQ Regional Office will outline the details of the follow-up monitoring. Other agency personnel, watershed stakeholders, etc. may provide input on the Annual Water Monitoring Plan. September 30 of each year is the deadline for the recommendations made to the DEQ regional TMDL coordinator.

DEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders, will continue to use data from the ambient monitoring stations to evaluate reductions in pollutants ("water quality milestones" as established in the IP), the effectiveness of the TMDL in attaining and maintaining water quality standards, and the success of implementation efforts. Recommendations may then be made, when necessary, to target implementation efforts in specific areas and continue or discontinue monitoring at follow-up stations.

In some cases, watersheds will require monitoring above and beyond what is included in DEQ's standard monitoring plan. Sometimes ancillary monitoring by citizens', watershed groups, local government, or universities is an option for additional data. VADEQ will review ancillary monitoring to ensure collection efforts follow established QA/QC guidelines in order to maximize compatibility with DEQ monitoring data. In instances where citizens' monitoring data is not available and additional monitoring is needed to assess the effectiveness of targeting efforts, TMDL staff may request of the monitoring managers in each regional office an increase in the number of stations or monitor existing stations at a higher frequency in the watershed. The additional monitoring beyond the original bimonthly single station monitoring will be contingent on staff resources and available laboratory budget. More information on citizen monitoring in Virginia and QA/QC guidelines is available at http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/CitizenMonitoring.aspx.

To demonstrate that the watershed is meeting water quality standards in watersheds where corrective actions have taken place (whether or not a TMDL or TMDL Implementation Plan has been completed), DEQ must meet the minimum data requirements from the original listing station or a station representative of the originally

listed segment. The minimum data requirement for conventional pollutants (bacteria, dissolved oxygen, etc) is bimonthly monitoring for two consecutive years. For biological monitoring, the minimum requirement is two consecutive samples (one in the spring and one in the fall) in a one-year period.

5.2.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. EPA also requires that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the TMDL WLA pursuant to 40 CFR §122.44 (d)(1)(vii)(B).

Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

For the implementation of the WLA component of the TMDL, the Commonwealth intends to utilize the Virginia NPDES (VPDES) program, which typically includes consideration of the WQMIRA requirements during the permitting process. Do not duplicate the requirements of the permit process in the TMDL process, and with the exception of stormwater related permits, permitted sources are not usually addressed during the development of a TMDL implementation plan.

For the implementation of the TMDL's LA component, a TMDL implementation plan addressing at a minimum the WQMIRA requirements will be developed.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDL implementation plan. Regional and local offices of DEQ, DCR, and other cooperating agencies are technical resources to assist in this endeavor.

In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

DEQ staff will present both EPA-approved TMDLs and TMDL implementation plans to the State Water Control Board for inclusion in the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning.

DEQ staff will also request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9VAC 25-720), except in those cases when permit limitations are equivalent to numeric criteria contained in the Virginia Water Quality Standards, such as is the case for bacteria. This regulatory action is in accordance with §2.2-4006A.4.c and §2.2-4006B of the Code of Virginia. SWCB actions relating to water quality management planning are described in the public participation guidelines referenced above and can be found on DEQ's web site under http://www.deq.state.va.us/tmdl/pdf/ppp.pdf

5.2.3 Stormwater Permits

It is the intention of the Commonwealth that the TMDL will be implemented using existing regulations and programs. One of these regulations is the Virginia Stormwater Management Program (VSMP) Permit Regulation (4 VAC 50-60-10 et. seq). Section 4VAC 50-60-380 describes the requirements for stormwater discharges. Also, federal regulations state in 40 CFR §122.44(k) that NPDES permit conditions may consist of

"Best management practices to control or abate the discharge of pollutants when:…(2) Numeric effluent limitations are infeasible,…". Information on Virginia's Stormwater Management program and a downloadable menu of Best Management Practices and Measurable Goals Guidance can be found at http://www.dcr.virginia.gov/sw/stormwat.htm.

5.2.4 Implementation Funding Sources

Cooperating agencies, organizations and stakeholders must identify potential funding sources available for implementation during the development of the implementation plan in accordance with the "Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans". Potential sources for implementation may include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, EPA Section 319 funds, the Virginia State Revolving Loan Program, Virginia Agricultural Best Management Practices Cost-Share Programs, the Virginia Water Quality Improvement Fund, tax credits and landowner contributions. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

5.2.5 Attainability of Primary Contact Recreation Use

In some streams for which TMDLs have been developed, water quality modeling indicates that even after removal of all bacteria sources (other than wildlife), the stream will not attain standards under all flow regimes at all times. These streams may not be able to attain standards without some reduction in wildlife load. **Virginia and EPA are not proposing the elimination of wildlife to allow for the attainment of water quality standards.** While managing overpopulations of wildlife remains as an option to local stakeholders, the reduction of wildlife or changing a natural background condition is not the intended goal of a TMDL. Additionally, other factors may prevent the stream from attaining the primary contact recreation use.

To address this issue, Virginia proposed during its latest triennial water quality standards review a new "secondary contact" category for protecting the recreational use in state

waters. On March 25, 2003, the Virginia State Water Control Board adopted criteria for "secondary contact recreation" which means "a water-based form of recreation, the practice of which has a low probability for total body immersion or ingestion of waters (examples include but are not limited to wading, boating and fishing)". These new criteria became effective on February 12, 2004 and can be found at http://www.deq.virginia.gov/wqs/rule.html.

In order for the new criteria to apply to a specific stream segment, the primary contact recreational use must be removed. To remove a designated use, the state must demonstrate 1) that the use is not an existing use, 2) that downstream uses are protected, and 3) that the source of contamination is natural and uncontrollable by effluent limitations and by implementing cost-effective and reasonable best management practices for nonpoint source control (9 VAC 25-260-10). This and other information is collected through a special study called a Use Attainability Analysis (UAA). All site-specific criteria or designated use changes must be adopted as amendments to the water quality standards regulations. Watershed stakeholders and EPA will be able to provide comment during this process. Additional information can be obtained at http://www.deq.virginia.gov/wqs/WQS03AUG.pdf

The process to address potentially unattainable reductions based on the above is as follows: First is the development of a stage 1 scenario such as those presented previously in this chapter. The pollutant reductions in the stage 1 scenario are targeted only at the controllable, anthropogenic bacteria sources identified in the TMDL, setting aside control strategies for wildlife except for cases of nuisance overpopulations. During the implementation of the stage 1 scenario, all controllable sources would be reduced to the maximum extent practicable using the iterative approach described in Section 6-2 above. DEQ will re-assess water quality in the stream during and subsequent to the implementation of the stage 1 scenario to determine if the water quality standard is attained. This effort will also evaluate if the modeling assumptions were correct. If water quality standards are not being met, and no additional cost-effective and reasonable best management practices can be identified, a UAA may be initiated with the goal of re-designating the stream for secondary contact recreation.

5.3 Links to Ongoing Restoration Efforts

In 2007, VADEQ developed bacteria TMDLs for the Upper Banister River and some of its tributaries, upstream of the current TMDL watershed (VADEQ, 2007). VA DCR recently completed two bacterial TMDL implementation plans for the Upper Banister River TMDLs (VADEQ, 2011, 2012). In reducing the bacteria load in the upper portions of the watershed, there could be an improvement in the water quality for the lower portion of the watershed. The implementation plans focused on reductions in direct and indirect bacteria loads from agricultural and residential areas. The primary agricultural implementation actions suggested include livestock exclusion by fencing streams, improved pasture management, additional waste storage units, and reforestation of erodible pastureland. The primary residential implementation actions include identification and replacement of straight pipes with on-site sewage disposal systems, repair/replacement of failing septic systems, connection of homes to the sewer system, septic tank pump-outs, residential BMPs such as bioretention, and educational programs to inform citizens of proper pet waste disposal.

When VADEQ develops the implementation plan for the Banister River and Winn Creek TMDLs, linking or possibly amending the implementation plan to the Upper Banister River would provide even greater reasonable assurance in ensuring the improvement of water quality for the entire watershed.

6.0 Public Participation

The development of the Banister River and Winn Creek bacteria TMDLs would not have been possible without public participation. Two public meetings were held within the watershed. The following is a summary of the meetings.

Public Meeting No. 1: The first public meeting was held on November 1st, 2012 at the Halifax County Mary Bethune Complex in Halifax Virginia. The meeting presented the process for TMDL development, the Banister River and Winn Creek bacteria impaired segments, data that caused the segments to be on the 303(d) list and identify data and information needed for TMDL development. In addition, a preliminary source assessment was presented to the stakeholders and public. Nineteen people attended the meeting. Copies of the presentation were available for public distribution as well as it being available online. This meeting was publicly noticed in the *Virginia Register*. Written comments were received during the 30-day comment period of November 2nd to December 2nd, 2012 from VADCR and incorporated into the development of the TMDL.

Public Meeting No. 2: The second public meeting was held on April 4th, 2013 in Halifax, Virginia. The meeting was public noticed in *The Virginia Register of Regulations.* The final bacteria source assessment, the modeling calibration/validation, and TMDL equations were presented to the approximate ten people in attendance. Written comments were received during the 30-day comment period of April 5th to May 5th, 2013 from VADCR and incorporated into the development of the TMDL.

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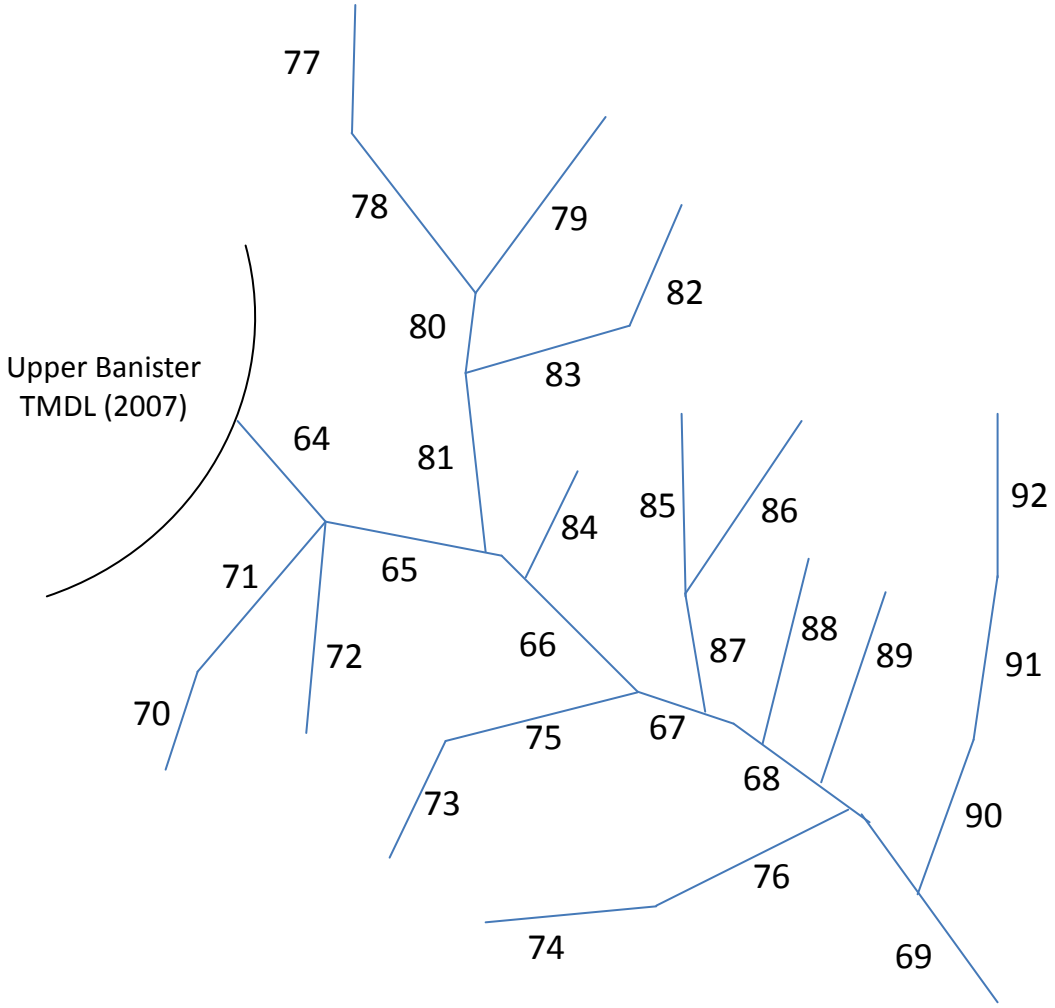
APPENDIX A:
Segmentation Landuse (NLCD 2006)

Table A-1. Segmentation Landuse - NLCD 2006

Row Labels	Barren Land	Cultivated Crops	Deciduous Forest	Developed, High Intensity	Developed, Low Intensity	Developed, Medium Intensity	Developed, Open Space	Emergent Herbaceous Wetlands	Evergreen Forest	Pasture/ Hay	Herbaceous	Mixed Forest	Open Water	Shrub/ Scrub	Woody Wetlands	Grand Total
Banister River Mainstem 1		3.6	346.5				19.2		52.7	89.1	5.8	40.5	19.1	16.2	292.8	**885.6**
Banister River Mainstem 2		4.4	567.9				35.5	28.6	101.0	154.7	79.5	38.2	100.5	35.7	478.0	**1624.1**
Banister River Mainstem 3			160.1		24.6		45.8		20.3	70.6	40.7	15.9	1.1	0.1	54.2	**433.4**
Banister River Mainstem 4	1.9	7.7	662.1		2.2		58.4		199.8	299.4	56.3	121.3	15.6	14.6	154.9	**1594.2**
Banister River Mainstem 5	1.1		560.1		1.8		52.0	1.8	122.2	186.9	117.3	70.5	3.8	57.5	79.3	**1254.4**
Banister River Mainstem 6			300.9	4.4	26.5	7.9	48.5		79.3	26.8	23.2	45.4	12.5	11.9	44.6	**632.0**
Banister River Trib 1		4.0	326.1				30.6	18.1	300.1	124.9	192.7	73.6	30.0	44.5	148.8	**1293.5**
Banister River Trib 2			319.7		14.6		39.8		148.1	146.9	36.0	57.7	2.1	9.9	18.4	**793.1**
Banister River Trib 3			204.0		3.4		22.0		32.8	183.6	22.1	25.7		4.4	21.6	**519.7**
Banister River Trib 4	1.1	2.6	308.7		7.2	1.2	59.8	1.1	221.2	172.2	92.3	107.6		6.9	3.9	**985.8**
Banister River Trib 5		1.4	596.3		3.4		85.2		133.1	462.7	67.8	80.7	8.2	60.5	9.4	**1508.7**
Banister River Trib 6			290.8		2.4		28.0		46.0	146.9	18.8	33.3		2.4	3.0	**571.8**
Banister River Trib 7	0.3		657.4	36.8	43.4	27.2	128.4		182.7	254.5	75.8	61.3	4.9	75.2	24.7	**1572.5**
Gibson Creek 1	1.6		368.8				26.8		247.7	163.8	28.3	37.6	8.0	18.9	199.0	**1100.4**
Gibson Creek 2		12.0	862.8		4.7	0.3	79.6		253.6	280.6	105.0	64.3		47.3	64.0	**1774.3**
Gibson Creek 3		25.8	496.5		21.8	4.8	114.6		317.0	220.9	96.2	73.8	4.0	52.5	8.2	**1436.1**
Myers Creek 1		4.4	476.9		4.0		34.0		120.5	113.7	35.0	63.2	7.3	30.9	50.3	**940.2**
Myers Creek 2			337.6		22.8	3.5	64.5		87.8	189.0	33.1	35.5	1.3	3.6		**778.6**
Toots Creek 1	8.5		441.5	24.5	74.6	53.5	215.3		297.6	76.2	55.7	108.8	1.3	35.9	35.8	**1429.1**
Toots Creek 2			310.5	22.3	29.1	15.9	65.3		125.0	51.0	94.9	34.1		48.4		**796.6**
Winn Creek 1			303.4		3.3		44.5		143.1	93.1	108.5	47.7	0.1	8.3	37.7	**789.6**
Winn Creek 2			231.8				18.5		152.6	26.7	59.1	43.5	1.1	14.5	35.0	**582.9**
Winn Creek 3			429.5		5.6		60.0		209.6	282.0	133.6	76.9		16.6	29.8	**1243.7**
Winn Creek 4		11.6	206.0				27.9		208.4	300.5	116.4	48.7	1.3	24.3	7.7	**952.8**
Winn Creek 5	4.2	4.6	638.4		1.5		66.4		191.4	421.7	81.3	63.3	2.9	23.1	30.0	**1528.7**
Winn Creek 6		8.2	786.5		6.1		65.3		208.6	213.7	204.8	51.6		26.4	51.9	**1623.2**
Winn Creek 7		33.5	516.3		16.9	0.5	46.8	3.1	59.8	343.1	47.6	21.3	2.7	17.2	34.5	**1143.4**
Wolf Trap Creek 1	18.2		481.2	64.9	40.7	29.4	95.9		76.9	299.5	115.4	42.2	11.1	17.9	128.0	**1421.3**
Wolf Trap Creek 2		0.8	380.1	3.1	7.0	4.7	43.1		87.0	161.7	44.6	36.8		4.8	10.7	**784.4**
Total	**36.9**	**124.6**	**12,568.4**	**156**	**367.6**	**148.9**	**1,721.7**	**52.7**	**4,425.9**	**5,556.4**	**2,187.8**	**1,621**	**238.9**	**730.4**	**2,056.2**	**31,994.1**

Appendix B

Model Representation of Stream Reach Networks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Upper Banister
TMDL (2007)
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APPENDIX C:
Sewage Disposal, Livestock, Wildlife, and Pet Inventories by Subwatershed

Table C-1: Sewage Disposal Estimates by Subwatershed

Watershed Segment	Total Number of Houses Counted	Number of Houses Public Sewer[2]	Number of Houses on Septic Systems[2]	Number of Houses on "Other Means"[2]	Number of Houses with a Failing Septic System[3]
Banister River Mainstem 1	12	2	9	1	0
Banister River Mainstem 2	17	2	13	2	1
Banister River Mainstem 3	33	5	25	3	1
Banister River Mainstem 4	60	8	46	6	2
Banister River Mainstem 5	44	6	34	4	1
Banister River Mainstem 6	70	10	54	7	2
Banister River Trib 1	11	2	8	1	0
Banister River Trib 2	30	4	23	3	1
Banister River Trib 3	41	6	31	4	1
Banister River Trib 4	36	5	28	3	1
Banister River Trib 5	80	11	61	8	2
Banister River Trib 6	65	9	50	6	2
Banister River Trib 7	251	35	192	24	8
Gibson Creek 1	22	3	17	2	1
Gibson Creek 2	60	8	46	6	2
Gibson Creek 3	85	12	65	8	3
Myers Creek 1	54	7	42	5	2
Myers Creek 2	145	20	111	14	4
Toots Creek 1	241	33	185	23	7
Toots Creek 2	115	16	88	11	4
Winn Creek 1	82	11	63	8	3
Winn Creek 2	20	3	15	2	1
Winn Creek 3	86	12	66	8	3
Winn Creek 4	26	4	20	2	1
Winn Creek 5	64	9	49	6	2
Winn Creek 6	63	9	48	6	2
Winn Creek 7	30	4	23	3	1
Wolf Trap Creek 1	55	8	42	5	2
Wolf Trap Creek 2	59	8	45	6	2
Total	1,957	272	1,499	187	62

[1] Manual count using Imagery

[2] Based upon 1990 census breakdown of sewage disposal

[3] Based on a septic failure rate of 4% (VDH)

Table C-2: Livestock Inventory by Subwatershed						
Segment Name	**Beef Cows**	**Milk Cows**	**Other Cattle**	**Hogs/Pigs**	**Chickens (Layers)**	**Horses**
Banister River Mainstem 1	10		7	15	1	1
Banister River Mainstem 2	17		12	25	1	1
Banister River Mainstem 3	8		6	12		1
Banister River Mainstem 4	33	1	24	49	2	2
Banister River Mainstem 5	21		15	31	1	2
Banister River Mainstem 6	3		2	4		0
Banister River Trib 1	14		10	20	1	1
Banister River Trib 2	16		12	24	1	1
Banister River Trib 3	20		15	30	1	1
Banister River Trib 4	19		14	28	1	1
Banister River Trib 5	51	1	37	76	3	4
Banister River Trib 6	16		12	24	1	1
Banister River Trib 7	28	1	20	42	2	2
Gibson Creek 1	18		13	27	1	1
Gibson Creek 2	31	1	22	46	2	2
Gibson Creek 3	24	1	18	36	1	2
Myers Creek 1	12		9	19	1	1
Myers Creek 2	21		15	31	1	2
Toots Creek 1	8		6	13	1	1
Toots Creek 2	6		4	8		0
Winn Creek 1	10		7	15	1	1
Winn Creek 2	3		2	4		0
Winn Creek 3	31	1	22	46	2	2
Winn Creek 4	33	1	24	49	2	2
Winn Creek 5	46	1	34	69	3	3
Winn Creek 6	23	1	17	35	1	2
Winn Creek 7	38	1	27	56	2	3
Wolf Trap Creek 1	33	1	24	49	2	2
Wolf Trap Creek 2	18		13	27	1	1
Total	**611**	**11**	**443**	**910**	**36**	**43**

Table C-3: Wildlife Inventory by Subwatershed							
Segment Name	**Deer**	**Raccoon**	**Muskrat**	**Beaver**	**Wild Turkey**	**Canadian Geese**	**Mallard**
Banister River Mainstem 1	41	26	102	2	4	18	15
Banister River Mainstem 2	72	44	223	4	7	33	27
Banister River Mainstem 3	20	11	42	1	2	10	8
Banister River Mainstem 4	74	49	130	0	10	32	26
Banister River Mainstem 5	59	40	124	0	8	26	21
Banister River Mainstem 6	29	19	75	1	4	10	8
Banister River Trib 1	59	34	15	10	7	25	21
Banister River Trib 2	37	24	8	6	5	15	13
Banister River Trib 3	24	14	6	5	3	11	9
Banister River Trib 4	46	27	10	6	6	19	16
Banister River Trib 5	71	42	23	6	8	33	28
Banister River Trib 6	27	19	5	0	4	12	10
Banister River Trib 7	72	45	20	10	9	33	27
Gibson Creek 1	51	37	7	11	7	24	20
Gibson Creek 2	83	52	24	17	12	39	33
Gibson Creek 3	67	40	25	3	9	32	26
Myers Creek 1	44	27	10	12	7	16	13
Myers Creek 2	37	19	9	2	5	12	10
Toots Creek 1	66	36	13	11	8	24	20
Toots Creek 2	36	21	1	0	5	12	10
Winn Creek 1	37	26	3	10	5	14	12
Winn Creek 2	27	18	6	2	4	10	8
Winn Creek 3	58	32	9	7	7	21	18
Winn Creek 4	45	21	15	0	5	18	15
Winn Creek 5	72	44	20	6	9	32	26
Winn Creek 6	76	51	12	12	10	32	26
Winn Creek 7	54	32	22	5	6	25	21
Wolf Trap Creek 1	61	33	16	17	6	26	21
Wolf Trap Creek 2	37	21	6	5	5	13	10
Total	**1482**	**904**	**981**	**171**	**187**	**627**	**518**

Table C-4: Pet Inventory by Subwatershed			
Watershed Segment	**Total Number of Houses**	**Dogs**	**Cats**
Banister River Mainstem 1	12	8	9
Banister River Mainstem 2	17	11	12
Banister River Mainstem 3	33	21	26
Banister River Mainstem 4	60	38	43
Banister River Mainstem 5	44	28	31
Banister River Mainstem 6	70	44	50
Toots Creek 1	241	152	172
Toots Creek 2	115	73	82
Winn Creek 1	82	52	58
Winn Creek 2	20	13	14
Winn Creek 3	86	54	61
Winn Creek 4	26	16	19
Winn Creek 5	64	40	46
Winn Creek 6	63	40	45
Winn Creek 7	30	19	21
Banister River Trib 7	251	159	179
Banister River Trib 6	65	41	46
Banister River Trib 5	80	51	57
Banister River Trib 4	36	23	26
Banister River Trib 3	41	26	29
Banister River Trib 2	30	19	21
Banister River Trib 1	11	7	8
Gibson Creek 1	22	14	16
Gibson Creek 2	60	38	43
Gibson Creek 3	85	54	61
Myers Creek 1	54	34	39
Myers Creek 2	145	92	103
Wolf Trap Creek 1	55	35	39
Wolf Trap Creek 2	59	37	42
Total	**1,957**	**1,239**	**1,398**

Appendix D

Abbreviations and Glossary

Abbreviations

AVMA: American Veterinary Medical Association
BMP: Best Management Practice
CWA: Clean Water Act
DEM: Digital Elevation Model
EPA: Environmental Protection Agency
HSPEXP: Expert System for Calibration of the Hydrological Simulation Program-FORTRAN
HSPF: Hydrologic Simulation Program-Fortran
HUC: Hydrologic Unit Code
LA: Load Allocation
MS4: Municipal separate storm sewer system
NCDC: National Climatic Data Center
NHD: National Hydrography Dataset
NLCD: National Land Coverage Database
NOAA: National Oceanic and Atmospheric Association
NPDES: National Pollution Discharge Elimination System
NRCS: Natural Resources Conservation Service
MOS: Margin of Safety
SSURGO: Soil Survey Geographic
SWCB: State Water Control Board
SWCD: Soil and Water Conservation District
TMDL: Total Maximum Daily Load
USGS: U.S. Geological Survey
VADCR: Virginia Department of Conservation and Recreation
VADEQ: Virginia Department of Environmental Quality
VADGIF: Virginia Department of Game and Inland Fisheries
VDH: Virginia Department of Health
VDMME: Virginia Department of Mines, Minerals, and Energy
VPDES: Virginia Pollutant Discharge Elimination System
VSMP: Virginia Stormwater Management Program
UAA: Use Attainability Analysis
USDA: United States Department of Agriculture
WLA: Wasteload Allocation
WQIF: Water Quality Improvement Fund
WQMIRA: Water Quality Monitoring, Information, and Restoration Act

Glossary

303(d). A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

Allocations. That portion of receiving water's loading capacity attributed to one of its existing or future pollution sources (non-point or point) or to natural background sources. (A wasteload allocation [WLA] is that portion of the loading capacity allocated to an existing or future point source, and a load allocation [LA] is that portion allocated to an existing or future non-point source or to natural background levels. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading.)

Ambient water quality. Natural concentration of water quality constituents prior to mixing of either point or non-point source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.

Anthropogenic. Pertains to the [environmental] influence of human activities.

Bacteria. Single-celled microorganisms. Bacteria of the coliform group are considered the primary indicators of fecal contamination and are often used to assess water quality.

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

Biosolids. Also known as Sewage sludge, is the name for the solid, semisolid, or liquid materials removed during the treatment of domestic sewage in a treatment facility. Biosolids include, but are not limited to, solids removed during primary, secondary, or advanced wastewater treatment, scum, domestic septage, portable toilet pumpings, Type III marine sanitation device pumpings, and sewage sludge products. When properly treated and processed, sewage sludge becomes "biosolids" which can be safely recycled and applied as fertilizer to improve and maintain productive soils and stimulate plant growth.

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

Clean Water Act (CWA). The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to

restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.

Concentration. Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).

Contamination. The act of polluting or making impure; any indication of chemical, sediment, or biological impurities.

Cost-share program. A program that allocates project funds to pay a percentage of the cost of constructing or implementing a best management practice. The remainder of the costs is paid by the producer(s).

Critical condition. The critical condition can be thought of as the "worst case" scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence.

Designated uses. Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.

Domestic wastewater. Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.

Drainage basin. A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.

Existing use. Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).

Fecal Coliform. Indicator organisms (organisms indicating presence of pathogens) associated with the digestive tract.

Geometric mean. A measure of the central tendency of a data set that minimizes the effects of extreme values.

GIS. Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

Infiltration capacity. The capacity of a soil to allow water to infiltrate into or through it during a storm.

Interflow. Runoff that travels just below the surface of the soil.

Loading, Load, Loading rate. The total amount of material (pollutants) entering the system from one or multiple sources; measured as a rate in weight per unit time.

Load allocation (LA). The portion of a receiving waters loading capacity attributed either to one of its existing or future non-point sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and non-point source loads should be distinguished (40 CFR 130.2(g)).

Loading capacity (LC). The greatest amount of loading a water body can receive without violating water quality standards.

Margin of safety (MOS). A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (CWA section 303(d)(1)©). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).

Mean. The sum of the values in a data set divided by the number of values in the data set.

Monitoring. Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

Narrative criteria. Non-quantitative guidelines that describe the desired water quality goals.

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

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

Point source. Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water waterbody or river.

Pollutant. Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).

Pollution. Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water.

Poultry Litter. A material used as bedding in poultry operations. Common litter materials are woodshavings, sawdust, peanut hulls, shredded sugar cane, straw, and other dry, absorbent, low-cost organicmaterials. After use, the litter consists primarily of poultry manure, but also contains the original littermaterial, feathers, and spilled feed.

Privately owned treatment works. Any device or system that is (a) used to treat wastes from any facility whose operator is not the operator of the treatment works and (b) not a publicly owned treatment works.

Public comment period. The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).

Publicly owned treatment works (POTW). Any device or system used in the treatment (including recycling and reclamation) of municipal sewage or industrial wastes of a liquid nature that is owned by a state or municipality. This definition includes sewers, pipes, or other conveyances only if they convey wastewater to a POTW providing treatment.
Raw sewage. Untreated municipal sewage.

Receiving waters. Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.

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

Riparian zone. The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.

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

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

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

Slope. The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).

Stakeholder. Any person with a vested interest in the TMDL development.

Surface area. The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.

Surface runoff. Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of non-point source pollutants.

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

Topography. The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.

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

VADEQ. Virginia Department of Environmental Quality.

VDH. Virginia Department of Health.

Virginia Pollutant Discharge Elimination System (NPDES). The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.

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

Wastewater. Usually refers to effluent from a sewage treatment plant. See also **Domestic wastewater**.

Wastewater treatment. Chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.

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

Water quality criteria. Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water quality standard. Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

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

WQIA. Water Quality Improvement Act.