Bacteria TMDL Development for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Smith River, Sandy Creek, and Sandy River Watersheds

Submitted by

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Executive Summary

This report presents the development of bacteria TMDLs for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds. These water bodies were listed as impaired on Virginia's 303(d) Total Maximum Daily Load Priority List and Reports (DEQ, 1998, 2002, 2004, 2006) because of violations of the state's water quality standards for *E. coli* and fecal coliform bacteria.

Description of the Study Area

The Dan River watershed is located within the borders of Carroll, Floyd, Franklin, Halifax, Henry, Mecklenburg, Patrick, and Pittsylvania counties in Virginia, as well as Caswell, Forsyth, Granville, Guilford, Orange, Person, Rockingham, Stokes, and Surry counties in North Carolina. Within the watershed's boundaries there are also the cities of Danville, Martinsville, and South Boston in Virginia. All impaired streams are located in the Dan River (USGS Cataloging Units 03010103 and 03010104). The entire Dan River watershed is approximately 2,117,103 acres.

Impairment Description

Segments of the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River were listed as impaired for bacteria on Virginia's 1996, 1998, 2002 and/or 2004 303(d) Total Maximum Daily Load Priority List and Reports (DEQ, 1996) due to violations of the state's water quality standard for fecal coliform bacteria and/or *E. coli*. The impaired segments are located in the Dan River Basin in Virginia. The watershed is located in the hydrologic unit (HUC) 3010103. The impaired watersheds include portions of Carroll, Floyd, Franklin, Halifax, Henry, Mecklenburg, Patrick, and Pittsylvania counties in Virginia, as well as Caswell, Forsyth, Granville, Guilford, Orange, Person, Rockingham, Stokes, and Surry counties in North Carolina.

One segment of the Dan River was identified as impaired for *E. coli* on VA DEQ's 2004 305(b)/303(d) Water Quality Assessment Integrated Report. First listed as impaired in the 2002 305(b)/303(d) Water Quality Assessment Integrated Report, the upstream impaired segment (VAC-L60R-01) of the Dan River is 36.79 miles long and includes the Dan River from Country Line Creek to Cherry Branch near the base of the watershed. Between January 1, 1998, and December 31, 2002, 5 of 13 samples (38%) collected at the listing station (4ADAN042.80) exceeded the *E. coli* instantaneous criterion of 235 cfu/100 mL, and 3 of 13 samples (23%) collected at the listing station (4ADAN015.30) exceeded the *E. coli* instantaneous criterion of 235 cfu/100 mL.

The impaired segment of Blackberry Creek (VAW-L52R-02), which is 14.82 miles and includes the entire creek from its headwaters to the confluence of the Smith River, was first listed as having a bacteria impairment on the 2002 305(b)/303(d) Water Quality Assessment Integrated Report and is currently listed on the 2004 305(b)/303(d) Water Quality Assessment Integrated Report for recreational use exceedances of the fecal coliform standard of 1000 cfu/100 ml. Between January 1, 1998 and December 31, 2002, 3 out of 20 samples (15%) collected at the listing station (4ABRY000.05) exceeded the fecal coliform criterion of 1000 cfu/100 ml.

The impaired segment of Byrds Branch (VAC-L62R-04) extends for 2.98 miles from its headwaters to the mouth of the Dan River. This segment is listed on the 2004 305(b)/303(d) Water Quality Assessment Integrated Report. Between January 1, 1998 and December 31, 2002 at the listing station (4ABYR002.13), 3 out of 9 fecal coliform samples (33%) exceeded the fecal coliform standard instantaneous of 400 cfu/100 ml, and at the listing station (4ABYR000.08), 4 out of 9 samples (44%) exceeded the fecal coliform instantaneous standard of 400cfu/ml.

The impaired segment of Double Creek (VAC-L62R-03) was first listed on the 2002 305(b)/303(d) Water Quality Assessment Integrated Report. This segment of Double Creek is impaired for fecal coliform for 8.28 miles, from its headwaters to the mouth of the Dan River. Between January 1, 1998 and December 31, 2002, at the listing station (4ADBC002.19), 3 out of 28 samples (11%) collected exceeded the instantaneous fecal coliform bacteria standard of 400 (cfu/100mL).

The impaired segment of Fall Creek (VAC-L61R-01) extends for 2.3 miles from the confluence of Little Fall Creek to the Dan River. This segment is listed on the 2004 305(b)/303(d) Water Quality Assessment Integrated Report. Between January 1, 1998 and December 31, 2002, 5 out of 25 samples (20%) collected at station 4AFAL001.58 were recorded as exceeding the instantaneous fecal coliform bacteria criterion of 400 (cfu/100mL).

The impaired segment of Leatherwood Creek (VAW-L56R-01) extends 8.34 miles and was first listed for bacteria impairment on the 2002 305(b)/303(d) Water Quality Assessment Integrated Report and extends from the Martinsville City intake extending to the Smith River. Three out of 18 samples (16%) collected at listing station (4ALWD002.54) between January 1, 1998 and December 31, 2002, exceeded the fecal coliform instantaneous standard of 400 cfu/100 mL.

The impaired segment of Marrowbone Creek (VAW-L55R-01) was first listed on the 2002 305(b)/303(d) Water Quality Assessment Integrated Report. This segment of Marrowbone Creek is impaired for bacteria for 4.33 miles, beginning at the Henry County PSA Wastewater Treatment Plant extending downstream to the confluence of the Smith River. Between January 1, 1998 and December 31, 2002, at the listing station (4AMRR000.02), 4 out of 29 samples (14%) collected exceeded the instantaneous fecal coliform bacteria standard of 400 (cfu/100mL).

The impaired segment of the North Fork Mayo River (VAW-L46R-01) extends for 22.46 miles from the confluence of Laurel Branch and Polebridge Creek extending downstream to the Virginia-North Carolina state line. This segment is listed on the 2004 305(b)/303(d) Water Quality Assessment Integrated Report with a bacteria impairment. Between January 1, 1998 and December 31, 2002, two stations recorded fecal coliform violations. At station 4ANMR020.13, 3 out of 9 samples (33%) were recorded as exceeding the instantaneous fecal coliform bacteria criterion of 400 (cfu/100mL), and at station 4ANMR002.60, 3 out of 25 samples (12%) were recorded as exceeding the instantaneous fecal coliform bacteria criterion of 400 (cfu/100mL).

The impaired segment of the South Fork Mayo River (VAW-L45R-01) extends for 10.86 miles from the mouth of Spoon Creek extending downstream to the Virginia-North Carolina state line. This segment is listed on the 2004 305(b)/303(d) Water Quality Assessment Integrated Report with a bacteria impairment. Between January 1, 1998 and December 31, 2002, station 4ASMR004.14 recorded 2 out of 16 samples (13%) as exceeding the instantaneous fecal coliform bacteria criterion of 400 (cfu/100mL).

The impaired segment of Sandy Creek (VAC-L59R-01), first listed in 2004, extends for 9.17 miles from its headwaters downstream to its confluence with Little Sandy Creek. This segment is impaired for fecal coliform. Between January 1, 1998 and December 31, 2002, at the listing station (ASCR007.06), 5 out of 25 samples (20%) collected exceeded the instantaneous fecal coliform bacteria standard of 400 (cfu/100mL).

The impaired segment of the Sandy River (VAC-L58R-01) was first listed on the 2002 305(b)/303(d) Water Quality Assessment Integrated Report. This segment of the Sandy River is impaired for fecal coliform for 7.21 miles, beginning at the Hickory Forest Creek mouth and extending downstream to the confluence of the Dan River. Between January 1, 1998, and December 31, 2002, 7 out of 25 samples (28%) collected at the listing station (4ASRV000.20) exceeded the instantaneous fecal coliform bacteria standard of 400 (cfu/100mL).

Two segments of the Smith River were identified as impaired for bacteria on VA DEQ's 2004 305(b)/303(d) Water Quality Assessment Integrated Report. Segment VAW-L54R-01, the downstream segment extending fro 13.77 miles from the Martinsville Dam to the mouth of Turkey Pen Branch, was first listed as impaired in the 2002 305(b)/303(d) Water Quality Assessment Integrated Report. Two stations recorded violations for this segment of the Smith River. Each station, 4ASRE021.58 and 4ASRE015.43, recorded 6 out of 35 (17%) sample violations between January 1, 1998 and December 31, 2002. The upstream impaired segment of the Smith River (VAW-L53R-01) is 6.95 miles long extending from the mouth of Reed Creek to the backwaters of the Martinsville Dam. Between January 1, 1998 and December 31, 2002, 9 of 59 samples (15%) collected at the listing station (4ASRE033.19) exceeded the fecal coliform instantaneous criterion of 400 cfu/100 mL.

Applicable Water Quality Standards

At the time of the initial listing of Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River segments, the Virginia Bacteria Water Quality Standard was expressed in fecal coliform bacteria; however, the bacteria water quality standard has been recently changed and is now expressed in *E. coli*. Virginia's bacteria water quality standard currently states that *E. coli* bacteria shall not exceed a geometric mean of 126 *E. coli* counts per 100 mL of water for two or more samples within a calendar month or an *E. coli* concentration of 235 counts per 100 mL of water at anytime. However, since sampling for *E. coli* is a recent method, the loading rates for watershed-based modeling from past sampling are available only in terms of the previous standard, fecal coliform bacteria. Therefore, the TMDL was expressed in *E. coli* by converting modeled daily fecal coliform concentrations to daily *E. coli* concentrations using an in-stream translator. This TMDL was required to meet both the geometric mean and instantaneous *E. coli* water quality standard.

Watershed Characterization

The land use characterization for the Dan River watershed was based on land cover data from the National Land Use Land cover data set (NLCD) using 2001 reference data. Dominant land uses in the watershed are forest (64%) and agriculture (19%) account for a combined 83% of the total land area in the watershed.

The potential sources of fecal coliform include run-off from livestock grazing, manure applications, industrial processes, residential, and domestic pet waste. Some of these sources are driven by dry weather and others are driven by wet weather. The potential sources of fecal coliform in the watershed were identified and characterized. These sources include permitted point sources, failed septic systems and straight pipes, livestock, wildlife, and pets.

Bacteria Source Tracking

For the Dan River Watershed TMDLs, the Antibiotic Resistance Analysis (ARA) method of Bacteria Source Tracking (BST) was used. ARA has been the most widely used and published BST method to date and has been employed in Virginia, Florida, Kansas, Oregon, South Carolina, Tennessee, and Texas. Advantages of ARA include low cost per sample, and fast turnaround times for analyzing samples. The method can also be performed on large numbers of isolates; typically 48 isolates per unknown source such as an in-stream water quality sample.

BST was conducted monthly from January 2006 to December 2006 at stations 4ASCR007.06, 4ASRV000.20, 4ABYR000.80, 4ADAN015.30, 4ADAN042.80, 4ADB002.19, 4AFAL001.58, 4AMRY000.82, 4ABRY000.05, 4ABRY010.27, 4ABRY011.44, 4ALWD002.54, 4AMRR000.02, 4ANMR002.60, 4ASMR004.14, 4ASRE015.43, 4ASRE019.00, and 4ASRE033.19. Results from both sampling periods indicate that bacteria from human, livestock, wildlife, and pet sources are present in the Dan River.

TMDL Technical Approach

The Hydrologic Simulation Program-Fortran (HSPF) model was selected and used as a tool to predict the in-stream water quality conditions of 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. Basically, 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 Dan River watershed was delineated into 125 smaller subwatersheds to represent the watershed characteristics and to improve the accuracy of the HSPF model. This delineation was based on topographic characteristics, and was created using a Digital Elevation Model (DEM), stream reaches obtained from the RF3 dataset and the National Hydrography Dataset (NHD), and stream flow and in-stream 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 data used in the model include meteorological data (hourly precipitation) and surface airways data (including wind speed/direction, ceiling height, dry bulb temperature, dew point temperature, and solar radiation).

The period of January 1995 to December 2005 was used for HSPF hydraulic calibration and validation. 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 study areas. 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 DEQ, and was evaluated for potential use in the set-up, calibration, and validation of the water quality model. The existing fecal coliform loading was calculated based on current watershed conditions. Since Virginia has recently changed its bacteria standard from fecal coliform to *E. coli* the modeled fecal coliform concentrations were changed to *E. coli* concentrations using a translator.

TMDL Calculations

The TMDL represents the maximum amount of a pollutant that the stream can receive 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 to account 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 a 30-day geometric mean *E. coli* standard of 126 cfu/100 mL and the instantaneous *E. coli* standard of 235 cfu/100 mL with 0% exceedance.

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.

For the hydrologic period from January 1998 to December 2005, fecal coliform loading and instream fecal coliform concentrations were estimated for the various scenarios using the developed HSPF model of for Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River. After using the instream translator, the TMDL allocation plan was developed to meet geometric mean and instantaneous *E. coli* standards. Based on the load-allocation scenario analyses, the TMDL allocation plans that will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 mL and the instantaneous *E. coli* water quality standard of 235 cfu/100 mL are presented in **Table E-1**.

Table E-1: Allocation Plan Loads for E. coli (% reduction) for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River

Watershed	Human Sources (failed septic systems and straight pipes)	Livestock (Direct Instream Loading)	Agricultural and urban non point sources	Wildlife (Direct Instream Loading)
Dan River (VAC-L60R-01)	100%	100%	95%	48%
Blackberry Creek (VAW-L52R-02)	100%	100%	92%	0%
Byrds Branch (VAC-L62R-04)	100%	100%	95%	39%
Double Creek (VAC-L62R-03)	100%	100%	86%	0%
Fall Creek (VAC-L61R-01)	100%	100%	97%	0%
Leatherwood Creek (VAW-L56R-01)	100%	100%	97%	24%
Marrowbone Creek (VAW-L55R-01)	100%	100%	95%	9%
North Fork Mayo River (VAW-L46R-01)	100%	100%	89%	0%
Sandy Creek (VAC-L59R-01)	100%	100%	97%	13%
Sandy River (VAC-L58R-01)	100%	100%	97%	42%
Smith River (VAW-L54R-01)	100%	100%	96%	64%
Smith River (VAW-L53R-01)	100%	100%	96%	64%
South Fork Mayo River (VAW-L45R-01)	100%	100%	97.9%	0%

The summaries of the bacteria TMDL allocation plan loads for Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River are presented in **Table E-2**.

Table E-2: Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River TMDL Allocation Plan Loads for E. coli (cfu/day)

Watershed	WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
Dan River (VAC-L60R-01)	5.33E+11	2.74E+12	Implicit	3.27E+12
Blackberry Creek (VAW-L52R-02)	1.84E+08	4.01E+10	Implicit	4.03E+10
Byrds Branch (VAC-L62R-04)	1.43E+07	4.74E+09	Implicit	4.75E+09
Double Creek (VAC-L62R-03)	2.07E+08	4.47E+10	Implicit	4.49E+10
Fall Creek (VAC-L61R-01)	2.48E+08	9.38E+10	Implicit	9.40E+10
Leatherwood Creek (VAW-L56R-01)	9.55E+08	1.10E+11	Implicit	1.11E+11
Marrowbone Creek (VAW-L55R-01)	3.32E+08	6.76E+10	Implicit	6.79E+10
North Fork Mayo River (VAW-L46R-01)	6.68E+08	3.33E+11	Implicit	3.34E+11
Sandy Creek (VAC-L59R-01)	1.43E+07	8.68E+10	Implicit	8.68E+10
Sandy River (VAC-L58R-01)	2.97E+08	5.56E+11	Implicit	5.56E+11
Smith River (VAW-L54R-01)	2.86E+11	1.38E+11	Implicit	4.24E+11
Smith River (VAW-L53R-01)	2.45E+09	4.89E+11	Implicit	4.92E+11
South Fork Mayo River (VAW-L45R-01)	1.40E+09	3.35E+11	Implicit	3.37E+11

TMDL Implementation

The Commonwealth intends for this TMDL to be implemented through best management practices (BMPs) in the watershed. Implementation will occur in stages. The benefits of staged implementation are: 1) as stream monitoring continues to occur, it allows for water quality improvements to be recorded as they are being achieved; 2) it provides a measure of quality control, given the uncertainties that exist in any model; 3) it provides a mechanism for developing public support; 4) it helps to ensure the most cost effective practices are implemented initially, and 5) it allows for the evaluation of the TMDL's adequacy in achieving the water quality standard.

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. 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.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). 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.

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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 water body can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA, 2001).

The state regulatory agency for Virginia is the Department of Environmental Quality (DEQ). DEQ works in coordination with the Virginia Department of Conservation and Recreation (DCR), the Department of Mines, Minerals, and Energy (DMME), and the Virginia Department of Health (VDH) to develop and regulate a more effective TMDL process. DEQ 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. DEQ 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 DCR is to initiate non-point source pollution control programs statewide through the use of federal grant money. DMME 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 (DEQ, 2001).

As required by the Clean Water Act and WQMIRA, DEQ 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 DEQ to develop and implement TMDLs for listed waters (DEQ, 2001a). Once TMDLs have been developed, they are distributed for public comment and then submitted to the EPA for approval.

1.2 Impairment Listing

Segments of the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds were listed as impaired for bacteria on Virginia's 1996, 1998, 2002 and/or 2004 303(d) Total Maximum Daily Load Priority List and Reports (DEQ, 1996) due to violations of the state's water quality standard for fecal coliform bacteria and/or *E. coli*. The impaired segments are located in the Dan River Basin in Virginia (**Figure 1-1**). The watershed is located in the hydrologic unit (HUC) 3010103. The impaired watersheds include portions of Carroll, Floyd, Franklin, Halifax, Henry, Mecklenburg, Patrick, and Pittsylvania counties in Virginia, as well as Caswell, Forsyth, Granville, Guilford, Orange, Person, Rockingham, Stokes, and Surry counties in North Carolina.

One segment of the Dan River (VAC-L60R-01) was identified as impaired for *E. coli* on VA DEQ's 2004 305(b)/303(d) Water Quality Assessment Integrated Report. First listed as impaired in the 2002 305(b)/303(d) Water Quality Assessment Integrated Report, the impaired segment of the Dan River is 36.79 miles long and includes the Dan River from Country Line Creek to Cherry Branch near the base of the watershed. Between January 1, 1998, and December 31, 2002, 5 of 13 samples (38%) collected at the listing station (4ADAN042.80) exceeded the *E. coli* instantaneous criterion of 235 cfu/100 ml, and 3 of 13 samples (23%) collected at the listing station (4ADAN015.30) exceeded the *E. coli* instantaneous criterion of 235 cfu/100 ml.

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The total length of these 13 segments is approximately 140 miles. **Table 1-1** summarizes the details of the impaired segments and **Figure 1-1** presents their location.

Table 1-1: 2006 303(d) Impaired Segments within the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Sandy River, Smith River, and South Fork Mayo River Watersheds.

TMDL ID	Stream Name	Miles	Boundaries	Impairment	Station ID	Violation Rate
VAW-L52R-02	Blackberry Creek	14.82	Headwaters to Smith River	Bacteria	4ABRY000.05	3/20
VAC-L62R-04	Byrds Branch	2.98	Headwaters to Dan River	Fecal Coliform	4ABYR002.13	3/9
					4ABYR000.80	4/9
VAC-L60R-01	Dan River	36.79	From Country Line Creek to Cherry Branch	*E. Coli*	4ADAN042.80	5/13
					4ADAN015.30	3/13
VAC-L62R-03	Double Creek	8.28	Headwaters to Dan River	Fecal Coliform	4ADBC002.19	3/28
VAC-L61R-01	Fall Creek	2.3	From Little Fall Creek to Dan River	Fecal Coliform	4AFAL001.58	5/25
VAW-L56R-01	Leatherwood Creek	8.34	From Martinsville City intake to Smith River	Bacteria	4ALWD002.54	3/18
VAW-L55R-01	Marrowbone Creek	4.33	From Henry Co WWTP to Smith River	Bacteria	4AMRR000.02	4/29
VAW-L46R-01	North Fork Mayo River	22.46	From Laurel Branch to VA-NC state line	Bacteria	4ANMR002.60	3/25
					4ANMR020.13	3/9
VAC-L59R-01	Sandy Creek	9.17	From headwaters to Little Sandy Creek	Fecal Coliform	4ASCR007.06	5/25
VAC-L58R-01	Sandy River	7.21	From Hickory Forest Creek to Dan River	Fecal Coliform	4ASRV000.20	7/25
VAW-L53R-01	Smith River	6.95	From Reed Creek to Martinsville Dam	Bacteria	4ASRE033.19	9/59
VAW-L54R-01		13.77	From Martinsville Dam to Turkey Pen Branch	Bacteria	4ASRE021.58	6/35
					4ASRE015.43	6/35
VAW-L45R-01	South Fork Mayo River	10.86	From Spoon Creek to VA-NC state line	Bacteria	4ASMR004.14	2/16

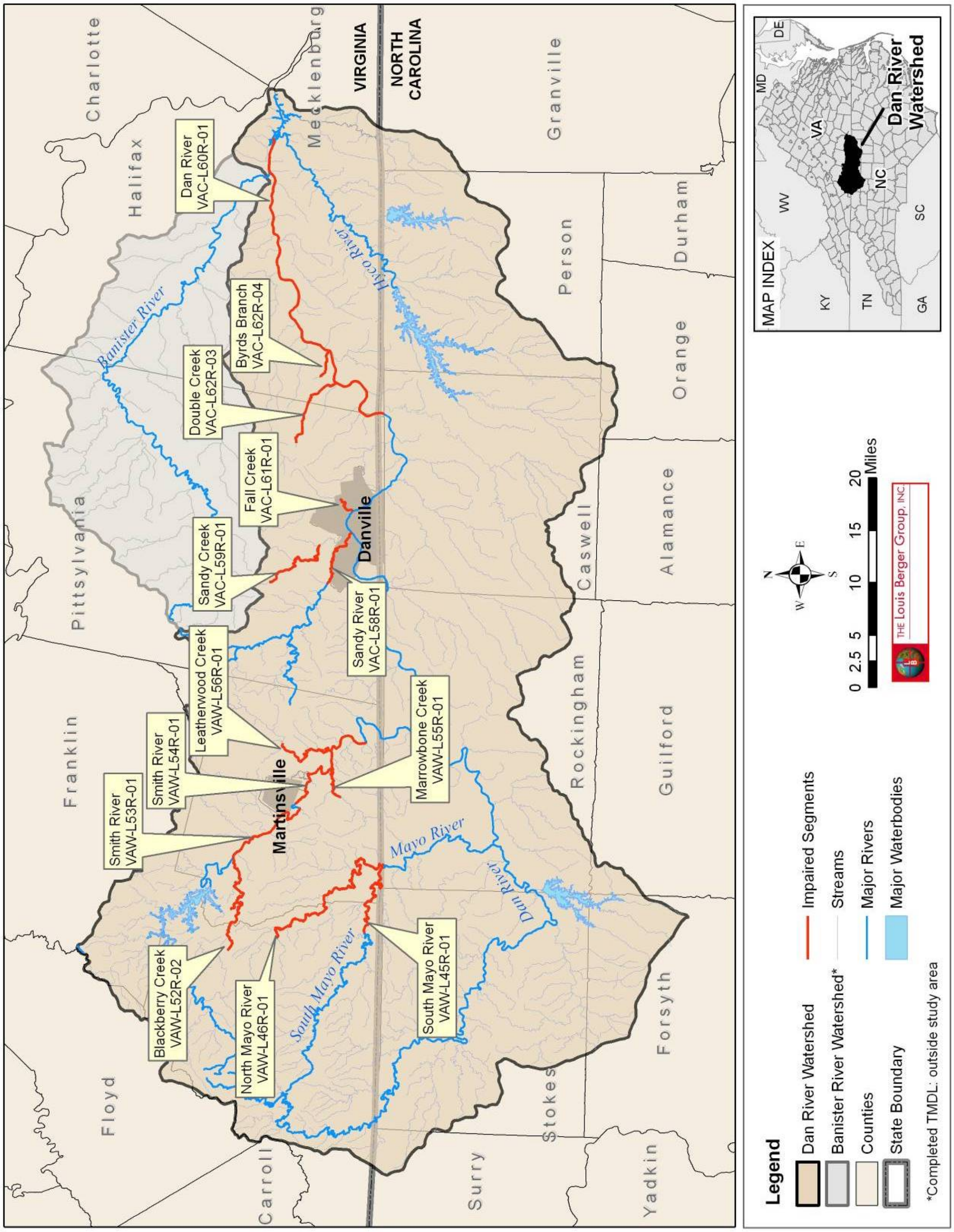

Figure 1-1: Location of Bacteria Impaired Segments of the Dan River Watershed

1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a water body 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.)."

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

Effective January 15, 2003, DEQ specified a new bacteria standard in 9 VAC 25-260-170.A, and also revised the disinfection policy in 9 VAC 25-260-170.B. These standards replaced the existing fecal coliform standard and disinfection policy 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:

> *"Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 mL of water for two or more samples taken over a calendar month nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 mL of water. This criterion shall not apply for a sampling station after the [E. coli] bacterial indicators have a minimum of 12 data points or after June 30, 2008, whichever comes first."*

"E. coli bacteria shall not exceed a geometric mean of 126 bacteria per 100 mL of water for two or more samples taken during any calendar month nor should it exceed 235 counts per 100 mL of water for a single sample maximum value. No single sample maximum for E. coli shall exceed a 75% upper one-sided confidence limit based on a site-specific log standard deviation. If site data are insufficient to establish a site-specific log standard deviation, then 0.4 shall be used as the log standard deviation in freshwater. Values shown are based on a log standard deviation of 0.4 in freshwater."

These criteria were adopted because there is a strong correlation between the concentration of *E. coli* and the incidence of gastrointestinal illness in comparison to 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.

For bacteria TMDL development after January 15, 2003, *E. coli* has become the primary applicable water quality target. However, the loading rates for watershed-based modeling are available only in terms of fecal coliform. Therefore, during the transition from fecal coliform to *E. coli* criteria, DCR, DEQ and EPA have agreed to apply a translator to in-stream fecal coliform data to determine whether reductions applied to the fecal coliform load would result in meeting in-stream *E. coli* criteria. The fecal coliform model and in-stream translator are used to calculate *E. coli* TMDLs (DEQ, 2003). The following regression based in-stream translator is used to calculate *E. coli* concentrations from fecal coliform concentrations:

$$E.\ coli\ conc.\ (cfu/100\ mL) = 2^{-0.0172} \times [fecal\ coliform\ conc.\ (cfu/100mL)]^{0.91905}$$

TMDLs are required to meet both the geometric mean and instantaneous criteria. The modeled daily fecal coliform concentrations are converted to daily *E. coli* concentrations using the in-stream translator. The TMDL development process also must account for seasonal and annual variations in precipitation, flow, land use, and pollutant contributions. Such an approach ensures that TMDLs, when implemented, do not result in violations under a wide variety of scenarios that affect fecal coliform loading.

The Dan River Bacteria TMDL includes areas that are located in Virginia and North Carolina. The Dan River flows from Virginia into North Carolina and then back into Virginia. Therefore, it is important that the both states have similar TMDL end points and the TMDL targets are achieved in both states in order to meet the bacteria standards. The North Carolina Water Quality Standard for bacteria is expressed in fecal coliform and requires that the 30-day geometric mean fecal coliform concentration does not exceed 200 cfu/100 ml. Since the Dan River Bacteria TMDL was developed based on modeling of fecal coliform contributions from all point and non-point sources in both states and in-stream targets of fecal coliform concentrations in Virginia match North Carolina's Bacteria Standard, the Water Quality Standards in both states will be met through the implementation of the Dan River Bacteria TMDL.

2.0 TMDL Endpoint Identification

2.1 Selection of TMDL Endpoint and Water Quality Targets

The 12 bacteria impaired segments within the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds are located within the boundaries of Carroll, Floyd, Franklin, Halifax, Henry, Mecklenburg, Patrick, and Pittsylvania counties in Virginia, as well as Caswell, Forsyth, Granville, Guilford, Orange, Person, Rockingham, Stokes, and Surry counties in North Carolina. These segments were initially placed on either the 1998, 2002, and/or 2004 Virginia 303(d) lists due to exceedences of the fecal coliform or E. coli standards for primary contact recreation. The impaired segments comprise a total of approximately 140 river miles.

One of the first steps in TMDL development is to determine numeric endpoints, or water quality targets, for each impaired segment. Water quality targets compare the current stream conditions to the expected restored stream conditions after TMDL load reductions are implemented. Numeric endpoints for the Bacteria TMDLs for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River TMDLs 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 violate the state numeric standards, interfere with its designated uses, or adversely affect human health and aquatic life. Therefore, the current water quality target for these four impairments, as stated in 9 VAC 25-260-170, is an *E. coli* geometric mean no greater than 126 colony-forming units (cfu) per 100 ml for two or more water quality samples taken during any calendar month, and a single sample maximum of 235 cfu per 100 ml at all times.

2.2 Critical Condition

The critical condition is considered the “worst case scenario” of environmental conditions in the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo

River, Sandy Creek, Sandy River, and Smith River. Developing TMDLs to meet the water quality targets under the critical condition will insure 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 Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River is protected during times when it is most vulnerable. Critical conditions are important because they describe the combination of factors contributing to a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards.

The Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River flow through a predominantly rural setting. The dominant land uses in the basin are forested and agricultural. Potential sources of fecal coliform include run-off from livestock grazing, manure applications, point source dischargers, and residential waste.

Fecal coliform 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 USGS flow monitoring stations located within the impaired segment. Flow data were not available at all listing stations but were available near or at the following stations: 4ADAN042.80, 4ANMR002.60, 4ASRE033.19, and 4ASRE026.27. Flow measurements for the water quality stations that are upstream of a flow station have been adjusted based on the percentage of the watershed area draining to the location of the water quality station versus the total watershed area draining to the location of the flow station.

Figure 2-1, **Figure 2-2**, and **Figure 2-3** depict fecal coliform concentrations recorded between 1997 and 2006 with the available corresponding stream flow distribution along several impaired segments. **Figure 2-1** includes fecal coliform data from one water quality station (4ADAN042.80) located slightly upstream of USGS flow station 2075500 along the Dan River in the eastern portion of the Dan River Watershed. **Figure 2-2** includes fecal coliform data from one water quality station (4ANMR002.60) located alongside the USGS flow station 2070000 along the North Fork Mayo River in the western portion of the Dan River Watershed. **Figure 2-3** includes fecal coliform data from one water quality station (4ASRE033.19) located directly upstream of the USGS flow station 2073000 along the Smith River, also in the western portion of the Dan River Watershed.

Plotting fecal coliform data along with available stream flow data (**Figure 2-1**, **Figure 2-2**, and **Figure 2-3**) revealed that the majority of exceedences tended to occur predominantly during high to moderate low flow conditions. This observation applies to data recorded on the Dan River, North Fork Mayo River, and Smith River. Several samples collected at the other stations did show exceedances of the water quality standards during dry to low flow conditions.

Figure 2-4 and **Figure 2-5** depict *E. coli* concentrations recorded between 2000 and 2006 with the available corresponding stream flow distribution along several impaired segments. **Figure 2-4** includes *E. coli* data from one water quality station (4ADAN042.80) located slightly upstream of USGS flow station 2075500 along the Dan River in the eastern portion of the Dan River Watershed. **Figure 2-5** includes *E. coli* data from two water quality stations (4ASRE033.19 and 4ASRE026.27) located on or near the USGS flow station 2073000 along the Smith River in the western portion of the Dan River Watershed.

The depiction of *E. coli* concentrations versus flow values is similar to the observations made regarding the fecal coliform data. The majority of the exceedances recorded were during moderate high flow to moderate low flow conditions (**Figure 2-4** and **Figure 2-5**).

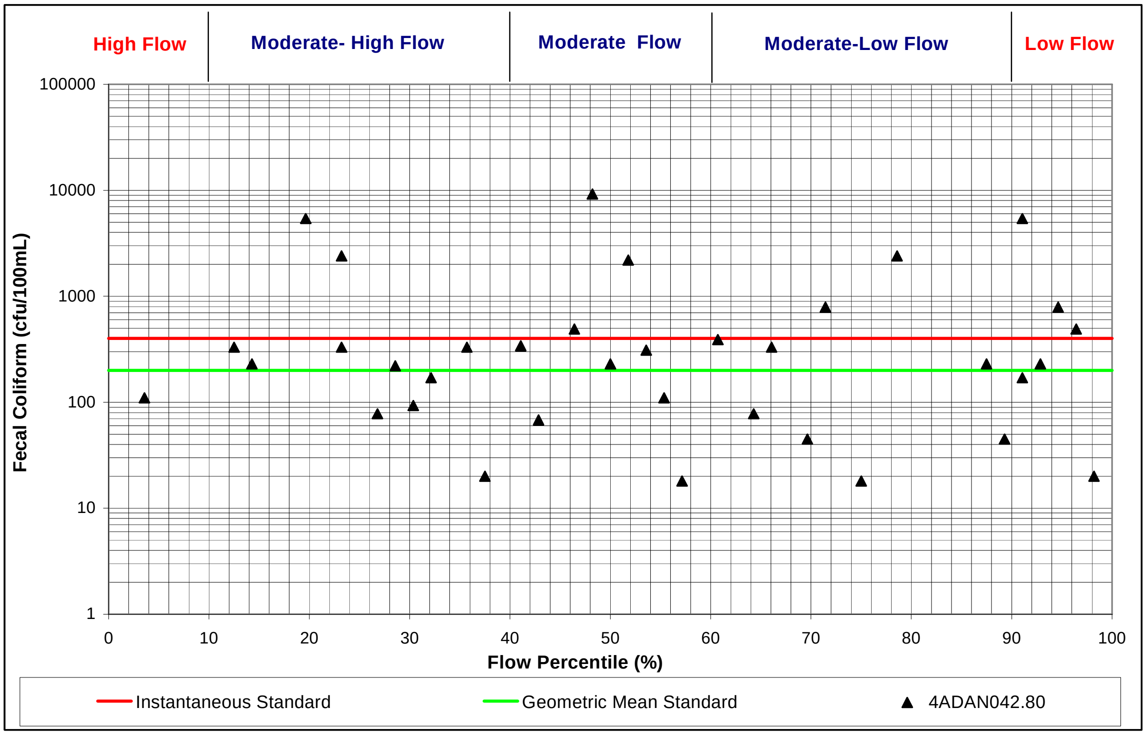

Figure 2-1: Flow Percentile and Fecal Coliform Concentrations (USGS2075500)

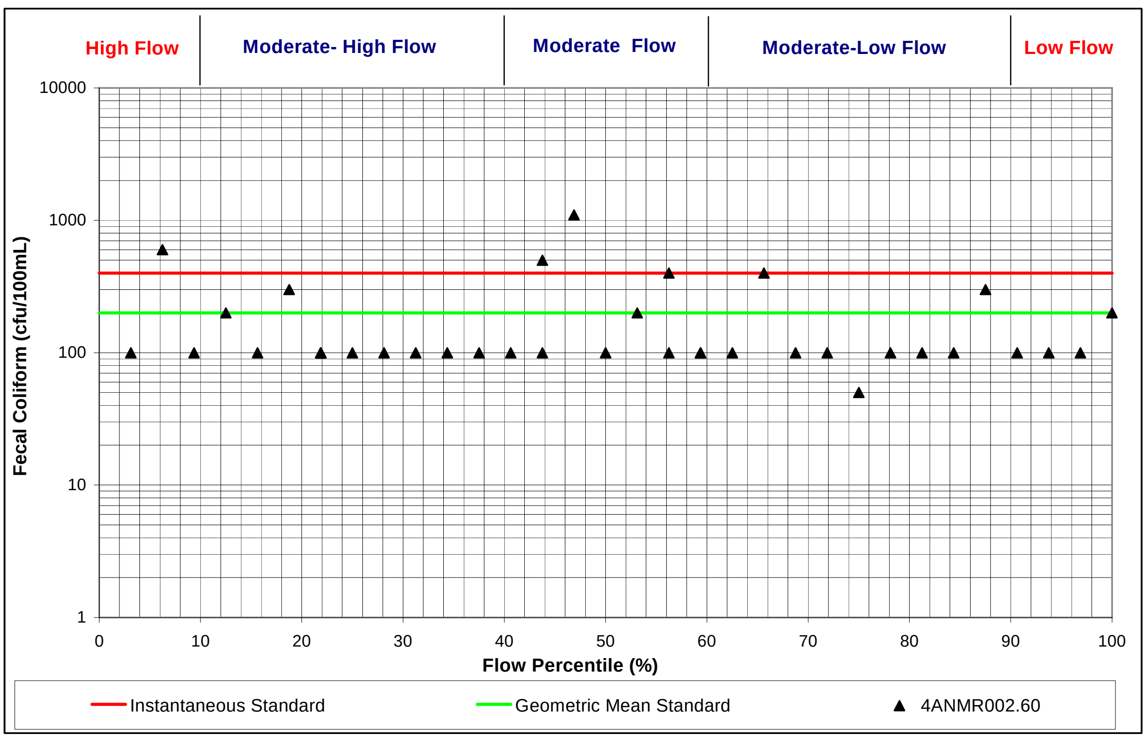

Figure 2-2: Flow Percentile and Fecal Coliform Concentrations (USGS2070000)

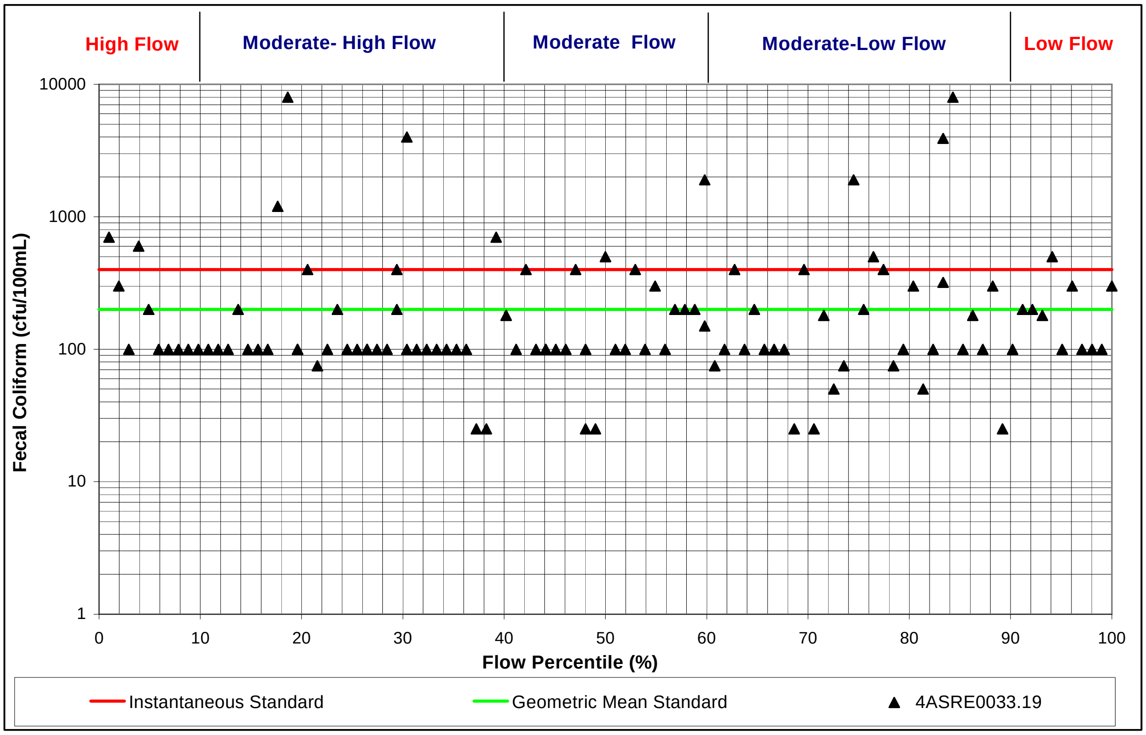

Figure 2-3: Flow Percentile and Fecal Coliform Concentrations (USGS2073000)

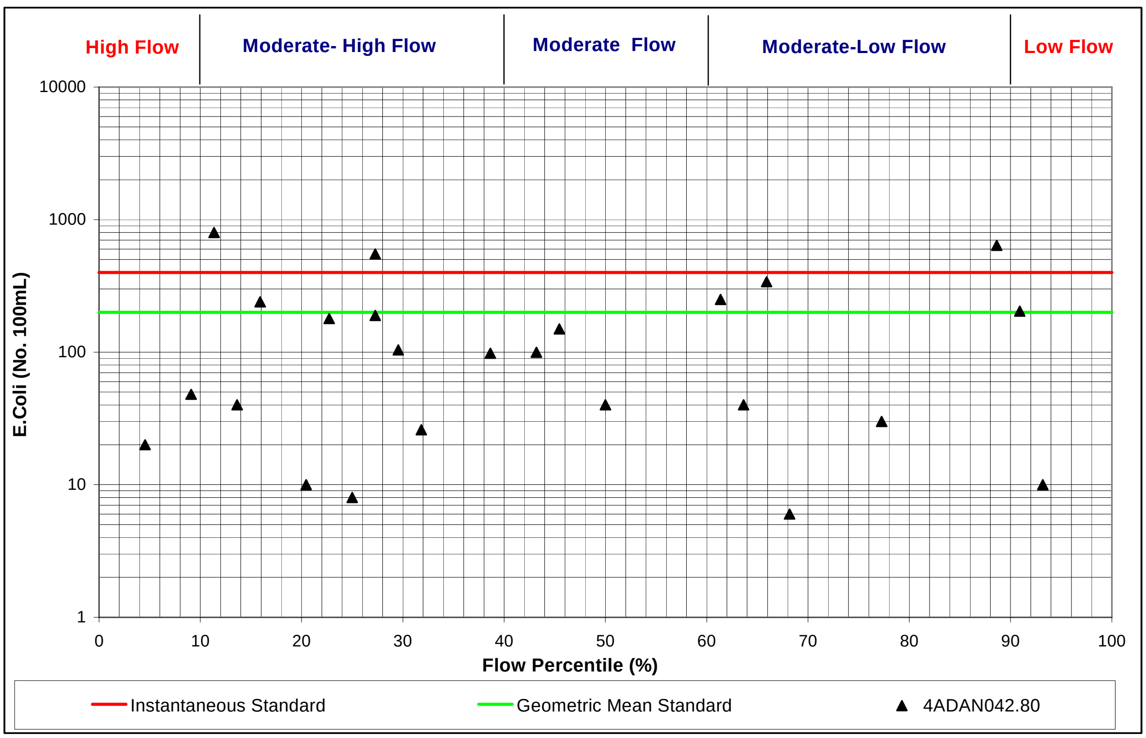

Figure 2-4: Flow Percentile and *E. coli* Concentrations (USGS2075500)

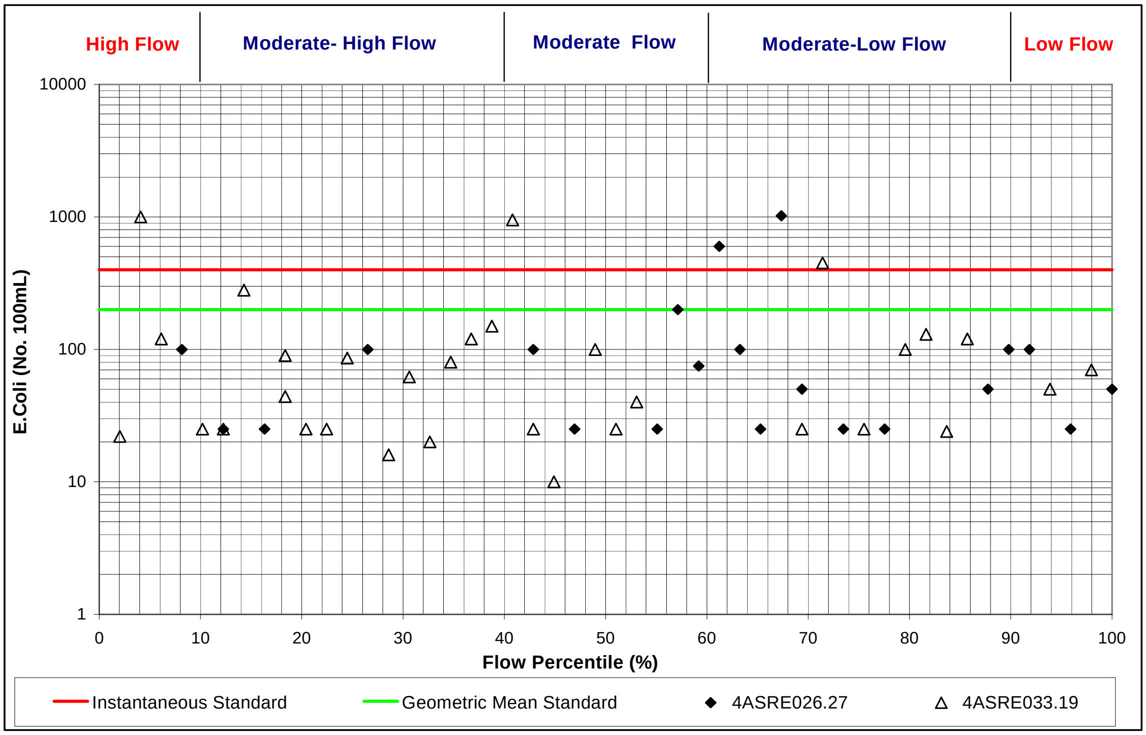

Figure 2-5: Flow Percentile and *E. coli* Concentrations (USGS2073000)

Many of the observed exceedences occurred under both moderate-high and moderate-low flow regimes, and therefore, both extremes are considered to be critical conditions. Exceedences under high-flow conditions would occur from indirect sources of bacteria, and would most likely exceed the instantaneous standard. Bacteria loads under low-flow conditions would likely occur from direct sources of bacteria, and would most likely violate the instantaneous and geometric mean standards.

These TMDLs are required to meet both the geometric mean and instantaneous bacteria standards. 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 the instantaneous and geometric mean bacteria standards.

2.3 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, allowing for the consideration of temporal variability in fecal coliform loading within the watershed.

3.0 Watershed Description and Source Assessment

This section presents the types of data available, and the information collected, for the development of the TMDLS for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, South Fork Mayo River, North Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds. The information was used to characterize each stream and its watershed, and to inventory and characterize the potential point and nonpoint sources of fecal coliform in the watershed.

3.1 Data and Information Inventory

A wide range of data and information were used in the development of this TMDL. Categories of data that were used 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 stream, such as the stream reach network and connectivity, and the stream channel depth, width, slope, and elevation

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

(4) Environmental monitoring data that describe stream flow and water quality conditions in the stream

Table 3-1 shows the various data types and the data sources used in the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, South Fork Mayo River, North Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds.

Table 3-1: Inventory of Data and Information Used in the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, South Fork Mayo River, North Fork Mayo River, Sandy River, and Smith River.

Data Category	Description	Source(s)
Watershed physiographic data	Watershed boundary	USGS, DEQ
	Land use/land cover	NLCD
	Soil data (SSURGO, STATSGO)	NRCS, BASINS
	Topographic data (USGS-30 meter DEM, USGS Quads)	USGS, DCR
Hydrographic data	Stream network and reaches (RF3)	BASINS, NHD, Field surveys
	Stream morphology	
Weather data	Hourly meteorological conditions	NCDC, Earth Info
Watershed activities/ uses data and information related to fecal coliform production	Information, data, reports, and maps that can be used to support fecal coliform source identification and loading	County governments, local groups and stakeholders
	Livestock inventory, grazing, stream access, and manure management	DCR, SWCD, NRCS
	Wildlife inventory	DGIF
	Septic systems inventory and failure rates	Local Departments of Health, Utilities, U.S. Census Bureau
	Straight pipes	Census Data, USGS Quad maps
	Best management practices (BMPs)	DCR, NRCS, local SWCDs
Point sources and direct discharge data and information	Permitted facilities locations and discharge monitoring reports (DMRs)	EPA Permit Compliance System (PCS), VPDES, DEQ
Environmental monitoring data	Ambient in-stream monitoring data	DEQ
	Stream flow data	USGS, DEQ,

Notes
BASINS: Better Assessment Science Integrating Point and Nonpoint Sources
DCR: Virginia Department of Conservation and Recreation
DEQ: Virginia Department of Environmental Quality
DGIF: Virginia Department of Game and Inland Fisheries
EPA: Environmental Protection Agency
NCDC: National Climatic Data Center
NHD: National Hydrography Dataset
NLCD: National Land Coverage Data
NRCS: Natural Resources Conservation Service
SWCD: Soil and Water Conservation District
USGS: U.S. Geological Survey
VPDES: Virginia Pollutant Discharge Elimination System

3.2 Watershed Description and Identification

The Dan River watershed is located within the borders of Carroll, Floyd, Franklin, Halifax, Henry, Mecklenburg, Patrick, and Pittsylvania counties in Virginia, as well as Caswell, Forsyth, Granville, Guilford, Orange, Person, Rockingham, Stokes, and Surry counties in North Carolina. Within the watershed's boundaries there are also the cities of Danville, Martinsville, and South Boston in Virginia. All impaired streams are located in the Dan River (USGS Cataloging Units 03010103 and 03010104). The entire Dan River watershed is approximately 2,117,103 acres. As shown in **Figure 3-1**, the major roadways that run through the watershed are Route 29 which runs from north to south through the middle of the watershed, Route 220 and Route 311 which run from north to south in the western portion of the watershed, and Route 501 which runs from north to south in the eastern portion of the watershed. Other major roads include state highways 58 and 158 which run from east to west. Interstate 40 runs from east to west directly to the south of the watershed.

Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, South Fork Mayo River, North Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds all flow into the Dan River. The impaired segments of the Dan River and Double Creek are located in Halifax and Pittsylvania counties. Byrds Branch is located in Halifax County. Sandy Creek is located in Pittsylvania County. Both the impaired segments of Sandy River and Fall Creek are located within the city of Danville. The Smith River, Leatherwood Creek, and Marrowbone Creek impaired segments are all located within Henry County. Lastly, the impaired segments of Blackberry Creek, North Fork Mayo River, and South Fork Mayo River are all located in both Henry and Patrick counties.

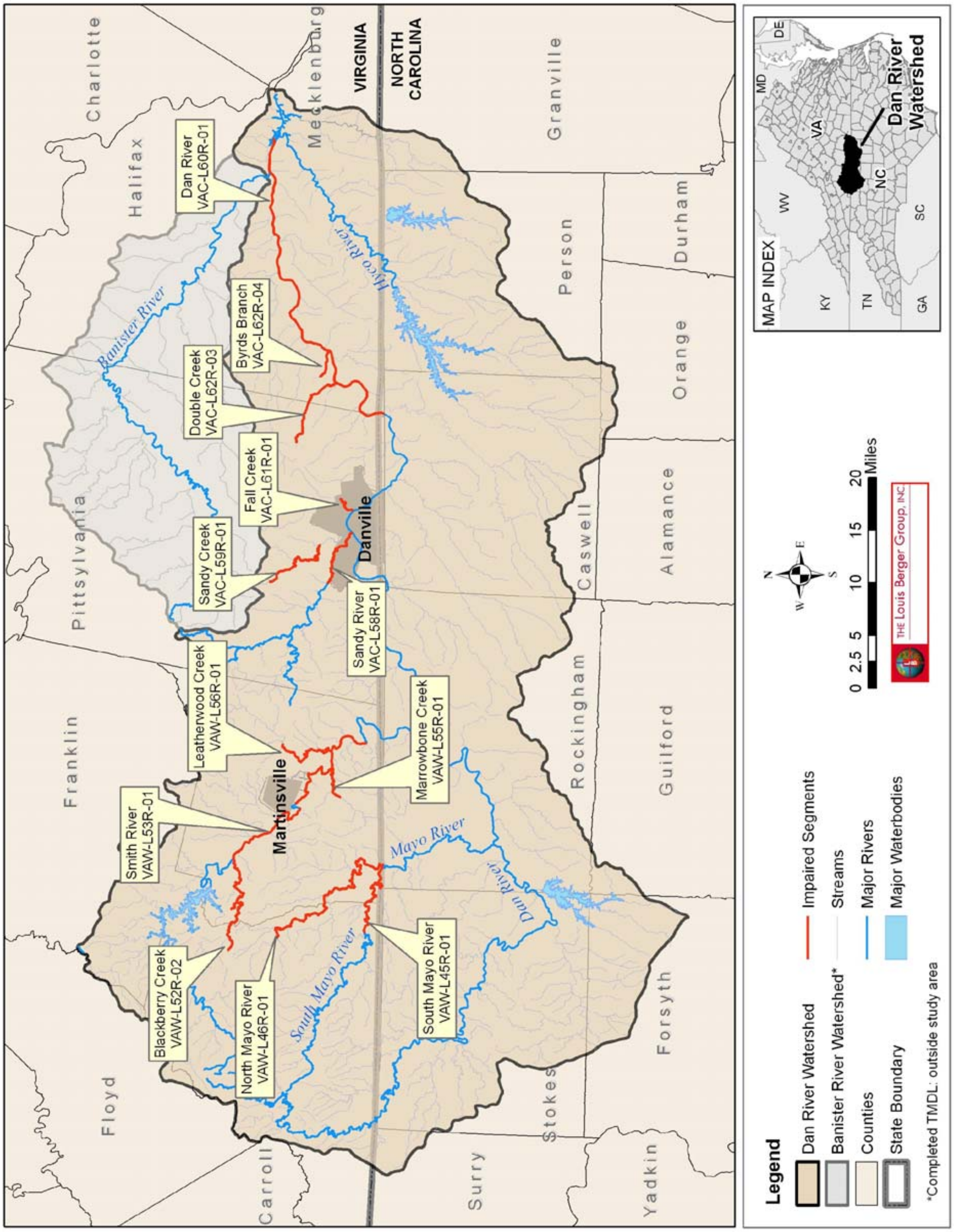

Figure 3-1: Location and Boundary of the Dan Watershed

3.2.1 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 National Map Seamless Data Distribution System maintained by the USGS Eros Data Center. Elevation within the watershed ranges from 289 to 3,576 feet (88 to 1090 meters) above mean sea level.

3.2.2 Soils

The Dan River watershed soil characterization was based on STATGO data (State Soil Geographic Database) obtained from the US Department of Agriculture's Natural Resource Conservation Service. There are 24 general soil associations located in the watershed (see **Table 3-2)**. The Madison-Cecil soils, which compose of 30% of the watershed, are very deep, well drained moderately permeable soils.

Table 3-2: Major Soil Associations Within the Dan River Watershed

Soil Name	Acres	Percent of Watershed
Appling (s8290)	3,659	<1
Georgeville (s8305)	43,860	2
Hayesville (s8267)	31,345	1
Hiwassee-Cecil (s4693)	244,200	12
Madison-Cecil (s8279)	636,363	30
Mecklenburg-Enon-Cecil (s4697)	63,475	3
Mecklenburg-Madison-Iredell-Hiwassee-Enon (s4698)	3,204	<1
Myersville-Catoctin (s8266)	61,941	3
Nason-Herndon-Helena-Georgeville-Appling (s4688)	58,317	3
Nason-Manteo (s8274)	11,806	1
Pacolet-Madison-Cecil (s4694)	281,589	13
Pinkston-Mayodan-Creedmoor (s8302)	23,194	1
Poindexter-Pacolet-Iredell (s8289)	91,088	4
Rubble land-Porters (s8280)	62,797	3
Tallapoosa-Pacolet-Madison (s4695)	80,723	4
Tatum-Georgeville (s4689)	5,301	<1
Turbeville-State (s8293)	21,633	1
Vance-Enon-Cecil-Appling (s4696)	13,439	1
Water (s8369)	6,650	<1
Wedowee-Pacolet-Louisburg-Appling (s4692)	8,690	<1
Wehadkee-Congaree-Chewacla (s8292)	13,483	1
White Store-Mayodan-Herndon-Creedmoor (s4686)	124,525	6
Wilkes-Cullen (s8291)	50,035	2
Wilkes-Pacolet (s4699)	175,786	8
Total	**2,117,103**	**100**

The hydrologic soil group linked with each soil association is also presented in **Table 3-3**. 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. However, 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 3-4**.

Table 3-3: Soil Hydrogroups within the Dan River Watershed

Hydrologic Group	Acres	Percent
A	62,797	3
B	1,541,766	73
C	414,802	20
C/D	91,088	4
Water	6,650	<1
Total	**2,117,103**	**100**

Table 3-4: 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
C/D	Combination of Hydrologic Soil Groups C and D

3.2.3 Land Use

The land use characterization for the Dan River watershed was based on land cover data from the US Geological Survey National Landcover Database (NLCD) using 2001 reference data. The distribution of land uses in the watershed, by land area and percentage, is presented in **Table 3-5**. Dominant land uses in the watershed are forest (65%) and agriculture (19%), accounting for a combined 84% of the total land area in the watershed. Brief descriptions of land use classifications are presented in **Table 3-6**. **Figure 3-2** depicts the land use distribution within the Dan River watershed.

Table 3-5: Land Use Categories within the Dan River Watershed

General Land Use Category	NLCD Land Use Types	Acres		Percent of Watershed's Land Use Area	
Water/ Wetlands	Open Water	24,420	43,321	1	2
	Woody Wetlands	18,613		1	
	Emergent Herbaceous Wetlands	288		<1	
Developed	Developed, Open Space	107,870	151,832	5	7
	Developed, Low Intensity	31,158		1	
	Developed, Medium Intensity	8,768		<1	
	Developed, High Intensity	4,036		<1	
Agriculture	Pasture/Hay	386,480	402,758	18	19
	Cultivated Crops	16,278		1	
Forest	Deciduous Forest	1,068,195	1,367,261	50	64
	Evergreen Forest	299,066		14	
Grassland / Shrub	Grassland/Herbaceous	99,437	148,451	5	7
	Scrub/Shrub	49,014		2	
Barren	Barren Land	3,480	3,480	<1	<1
Total		**2,117,102**		**100**	

Table 3-6 Descriptions of Land Use Types

Land Use Type	Description
Open Water	Areas of open water, generally with less than 25 percent or greater cover of water.
Woody Wetlands	Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Low Intensity Residential	Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
High Intensity Residential	Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.
Commercial/ Industrial/ Transportation	Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Row Crop	Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.
Deciduous Forest	Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.
Quarries/Strip Mines/Gravel Pits	Areas of extractive mining activities with significant surface expression.
Transitional	Areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.)
Urban/Recreational Grasses	Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Source: Multi-Resolution Land Characteristics Consortium NLCD (2001)

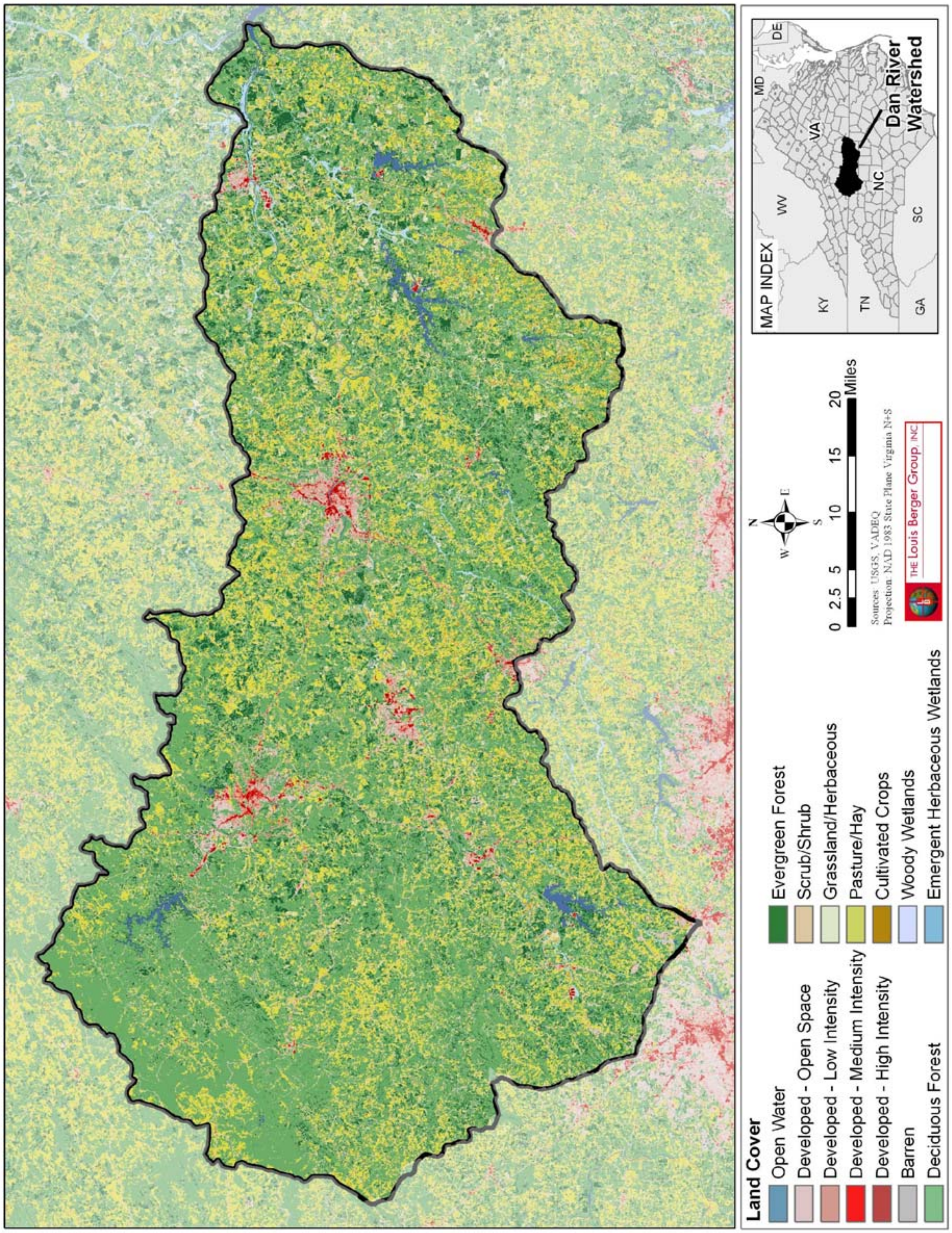

Figure 3-2: Land Use in the Dan River Watershed

3.3 Stream Flow Data

Stream flow data were available at 30 USGS stream flow-gauging stations located within the watershed. Data collected at these stations is shown in **Table 3-7.**

Table 3-7 :USGS Stream Flow Data located on the Dan River

Station ID	Station Name	Period of Daily-Mean Data		
		Start Date	End Date	# of Records
Virginia Stations				
2069700	South Mayo River Near NettleRidge, VA	10/1/1962	4/26/2007	16,331
2070000	North Mayo River Near Spencer, VA	10/1/1928	4/26/2007	28,384
2071530	Smith River at Smith River Church Near Woolwine, VA	10/1/1994	4/26/2007	4,647
2072000	Smith River Near Philpott, VA	10/1/1946	4/26/2007	22,174
2072500	Smith River at Bassett, VA	4/1/1939	4/26/2007	24,917
2073000	Smith River at Martinsville, VA	10/1/1929	4/26/2007	28,386
2073500	Leatherwood Creek Near Old Liberty, VA	10/1/1925	9/30/1934	3,287
2074500	Sandy River Near Danville, VA	10/1/1929	4/26/2007	28,386
2075000	Dan River at Danville, VA	8/1/1934	9/30/1995	22,341
2075045	Dan River at STP Near Danville	10/1/1995	4/26/2007	4,281
2075500	Dan River at Paces, VA	10/1/1950	4/26/2007	20,717
2076000	Dan River at South Boston, VA	10/1/1923	9/30/1952	10,593
2077500	Hyco River Near Denniston, VA	7/1/1929	4/26/2007	22,452
North Carolina Stations				
2068000	DanRiver Near Asbury, NC	9/1/1924	9/30/1926	760
2068500	DanRiver Near Francisco, NC	9/1/1924	4/26/2007	30,489
2069000	Dan River at Pine Hall, NC	10/1/1923	2/26/1991	2,652
2070500	Mayo River Near Price, NC	8/1/1929	4/26/2007	22,400
2071000	Dan River Near Wentworth, NC	12/1/1939	4/26/2007	26,641
2071500	Dan River at Leaksville, NC	8/1/1929	9/30/1949	7,366
2074000	Smith River at Eden, NC	10/1/1939	4/26/2007	26,658
2074218	Dan River Near Mayfield, NC	9/28/1976	11/26/1984	2,982
2075160	Moon Creek Near Yanceyville, NC	10/1/1961	9/30/1989	5,358
2077200	Hyco Creek Near Leasburg, NC	8/1/1964	4/26/2007	17,604
2077230	South Hyco Creek Near Hesters Store, NC	6/1/1964	9/30/1967	1,217
2077240	Double Creek Near Roseville, NC	6/1/1964	12/31/1982	6,252
2077250	South Hyco Creek Near Roseville, NC	10/1/1966	10/3/1980	4,436
2077300	Hyco River at McGhees Mill, NC	9/1/1964	9/30/1973	3,317
2077303	Hyco River Below Abay Dr. Near McGehees Mill, NC	10/1/1973	4/26/2007	14,251

Table 3-7 :USGS Stream Flow Data located on the Dan River

Station ID	Station Name	Period of Daily-Mean Data		
		Start Date	End Date	# of Records
2077660	Mayo Creek Near Woodsdale, NC	6/20/1975	10/3/1977	836
2077670	Mayo Creek Near Bethel Hill, NC	7/29/1977	4/26/2007	12,863

3.4 DEQ Ambient Water Quality Data

Water quality data for Virginia were obtained from Virginia DEQ, which conducted bacteria sampling at 113 water quality monitoring stations located within the watershed. Locations of these stations are summarized in **Table 3-8**. **Figure 3-3** depicts the locations of these monitoring stations.

Table 3-8: VA DEQ Water Quality Station

Station ID	Station Description	Stream Name
2000W0034A	Rt. 903 Bridge	Smith River
2000W0034B	Behind Bassett Fire Sta.	Smith River
2000W0034C	Blackberry Cr. at Rt.57A Bridge	Blackberry Creek
2000W0034D	Smith River at Rt. 1228 Bridge	Smith River
2000W0034E	American Legion Bridge	Blackberry Creek
2000W0034F	Above Rt. 698 Bridge	Blackberry Creek
2000W0034G	Blackberry Cr. Rt. 676 Bridge	Blackberry Creek
2000W0034H	Blackberry Cr. at end of Rt. 677	Blackberry Creek
2000W0034I	Blackberry Cr. at Rt. 832 Bridge	Blackberry Creek
2000W0034J	Blackberry Cr. at Rt. 687 Bridge	Blackberry Creek
2000W0034K	Sanville STP outfall	Blackberry Creek
2000W0034L	Blackberry Cr. at Microfilm Rd.	Blackberry Creek
2000W0034M	XTrib above confluence with BRY.	Blackberry Creek Trib
2000W0034O	XTrib below Westwood Lagoon	Blackberry Creek Trib
2000W0034P	XTrib immed. abv. Westwood Lagoon	Blackberry Creek Trib
2000W0034R	Blackberry Cr.along Rt. 779.	Blackberry Creek
2000W0034S	XTrib above Rt. 832 Bridge	Blackberry Creek Trib
2000W0034T	XTrib above Westwood Lagoon at Rd #1226	Blackberry Creek Trib
2000W0034U	X-trib below Westwood lagoon	Blackberry Creek Trib
2000W0034V	X-trib below Westwood lagoon	Blackberry Creek Trib
4ABAU000.94	Rt 57 Bridge	Beaver Creek
4ABAU005.34	Martinsville Reservoir station at dam	Beaver Creek
4ABAU011.17	Off Rt 922 upstream of Rt 657 crossing	Beaver Creek
4ABRY000.05	American Legion Bridge - Henry County	Blackberry Creek
4ABRY010.27	Rt 687 Bridge	Blackberry Creek
4ABRY011.44	Rt 687 Bridge (Microfilm Rd)	Blackberry Creek
4ABTC000.60	Big Toby Creek @ Rt. 691	Big Toby Creek
4ABYR000.80	Bryds Branch @ the end of Rt. 810	Byrds Branch
4ABYR002.13	Byrds Branch @ Rt. 689	Byrds Branch
4ACAN000.80	Cane Cr. @ Cedar Rd	Cane Creek
4ADAN015.30	RT. 501 Below South Boston	Dan River

Table 3-8: VA DEQ Water Quality Station

Station ID	Station Description	Stream Name
4ADAN028.90	RT. 658 at Paces	Dan River
4ADAN036.58	RT. 58 bridge E of Danville	Dan River
4ADAN042.80	RT. 62 at VA. - N.C. state line	Dan River
4ADAN052.99	Sta #10 at DGIF boat ramp below Danville	Dan River
4ADAN169.57	Rt 645 bridge - Patrick County	Dan River
4ADAN181.10	Rt 648 bridge near Kibler (Kibler Valley)	Dan River
4ADAN183.06	Off Rt 648 upstream of Roaring Cr Mout	Dan River
4ADAN187.94	Townes Reservoir at dam	Dan River
4ADAN196.09	Station #1 - arm of reservoir - Patrick	Dan River
4ADBC002.19	Double Creek, RT. 688 bridge	Double Creek
4AFAL001.58	Fall Cr @ Rt 730	Fall Creek
4AFAL005.42	Fall Cr @ Twin Arch Dr (Rt 695)	Fall Creek
4AGOB003.86	Fairy Stone Lake station at dam - Patrick	Goblin Town Creek
4AGOB005.18	Rt 623 bridge near Fairystone State Park	Goblin Town Creek
4AGOB005.46	STA #14 Rt 623 Bridge (Patrick County)	Goblin Town Creek
4AHRN004.93	Rt 695 Bridge	Horse Pasture Creek
4AHRN007.65	Off Rt 695 N of Rt 58	Horse Pasture Creek
4AJOR000.02	Rt 682 Bridge	Jordan Creek
4ALAW002.43	Lawless Creek @ Lawless Creek Rd	Lawless Creek
4ALBT003.07	Upstream of Rt 705 Crossing	Little Goblintown Creek
4ALDR002.61	RT 649 bridge (Gammons Road)	Little Dan River
4ALDR004.50	Rt 649 bridge (Old Orchard Loop)	Little Dan River
4ALSN001.04	RT. 58 bridge westbound - northern most	Lawsons Creek
4ALSN007.45	Lawsons Cr @ Rt. 708 bridge	Lawsons Creek
4ALWD002.54	Route 650 bridge - Henry County	Leatherwood Creek
4ALWD011.03	Rt 648 Bridge	Leatherwood Creek
4AMAY018.17	Rt 691 in NC at gaging station	Mayo River
4AMRR000.02	Route 642 bridge - Henry County	Marrowbone Creek
4AMRY000.82	Miry Creek @ River Rd (Rt 659)	Miry Creek
4AMTR010.33	Above confluence of Toeclout Branch	Matrimony Creek
4ANMR000.46	Rt 626 Bridge	North Fork Mayo River
4ANMR002.60	North Mayo at gage near Spenecer Rt 629	North Fork Mayo River
4APKP002.31	Pumpkin CR., RT 86	Pumpkin Creek
4APOW000.69	Powells Cr @ Rt. 751	Powells Creek
4ARBC002.21	STA #19 below conf Otter Creek with Rennet	Rennet Bag Creek
4ARBC005.44	Rt 40 bridge SW of Enditcott	Rennet Bag Creek
4AREE000.80	Route 57 bridge - Henry County	Reed Creek
4ASCR000.64	Sandy Creek @ Piedmont Drive	Sandy Creek
4ASCR007.06	Rt 746 Bridge	Sandy Creek
4ASKS002.80	Stokes Cr @ Rt. 704	Stokes Creek
4ASLC002.75	Rt. 655 bridge, Pittsylvania	Sandy River
4ASMR002.77	Downstream of Crooked Creek Confluence	South Fork Mayo River
4ASMR004.14	Rt 695 bridge	South Fork Mayo River
4ASMR016.09	Gage near Nettle Ridge, Rt 700 bridge	South Fork Mayo River
4ASMR027.44	Rt 727 brdige below Stuart Mun. & Ind. D	South Fork Mayo River
4ASMR033.23	Sta #20 Rt 787 bridge (Patrick County)	South Fork Mayo River
4ASMR033.98	Route 727 bridge, west of Stuart - Patrick	South Fork Mayo River
4ASNF007.64	Off of Rt 621	South Fork Mayo River, North

Table 3-8: VA DEQ Water Quality Station

Station ID	Station Description	Stream Name
		Fork Mayo River
4ASOO003.12	Rt 832 bridge	Spoon Creek
4ASOT000.99	Rt 622 bridge	Shooting Creek
4ASRE007.90	Rt 622 bridge, Morgan Ford Bridge	Smith River
4ASRE009.53	Above Rt 622 bridge (Morgan Ford)	Smith River
4ASRE015.43	Rt 636 bridge below Martinsville	Smith River
4ASRE019.00	Above confluence with Marrowbone Creek	Smith River
4ASRE020.75	Off Rt 702 downstream of M-ville STP	Smith River
4ASRE021.58	Rt 58 Bypass bridge, Henry County	Smith River
4ASRE022.71	Foot bridge above Martinsville STP outfall	Smith River
4ASRE026.27	Rt 58/220 bridge near gaging station	Smith River
4ASRE033.19	Rt 701 below Fieldcrest Mill	Smith River
4ASRE036.55	Rt 57 Alt Bridge, below Stanley Furniture	Smith River
4ASRE043.54	Rt 674 br above Town Creek	Smith River
4ASRE046.90	Philpott Reservoir at Buoy 2	Smith River
4ASRE048.98	#2A, #2B, #2C Goose Pointtop, Middle, B	Smith River
4ASRE052.31	#3A, #3B, #3C, Horseshoe Point - Top, Middle	Smith River
4ASRE056.06	#4A, #4B, #4C, Union Bridge - Top, Middle	Smith River
4ASRE075.69	Rt 708 bridge	Smith River
4ASRV000.20	Route 58 bridge, Danville	Sandy River
4ASRV007.46	Gage near Danville RT 863 bridge	Sandy River
4ASRV010.68	Sandy River @ Stony Mill Rd	Sandy River
4ASRV012.19	At the end of Rt 950 (off Rt 852)	Sandy River
4ASRV018.79	Sandy River @ Hinesville Rd (Rt 845)	Sandy River
4ASRV022.99	Sandy River @ Wyatt Farm Road RT 612	Sandy River
4ASRV025.40	Sandy River @ Mapleton Rd	Sandy River
4ASSP002.44	RT 841 Whispering Pines Road	Sandy River South Prong
4ASUT000.89	Sugartree @ Inman Rd	Sugartree Creek
4ASWA002.97	Stewart Creek @ Rt 882	Stewart Creek
4ATRD000.04	Tanyard Creek, Rt 855 in Soap Stone	Tanyard Creek
4ATRD000.35	Tanyard Br, upstream of rt 855 Martin Dr	Tanyard Creek
4AWFE001.57	Wolfe Creek N of 58 W of County Line	Wolf Creek
4AXME001.19	Carlton Farm on Sunshine Dr.	Dan River, UT
4AXMU001.98	Off Rt 58 near Burnt Chimneys	Mill Creek, UT
4AXMX003.62	Off Reed Creek Dr (Hodges Prop)	Reed Creek, UT

Water quality data for North Carolina were obtained from EPA STORET, which included bacteria sampling records at 20 water quality monitoring stations located within the watershed containing records from 1990 to present. Locations of these stations are summarized in **Table 3-9**. **Figure 3-3** depicts the locations of these monitoring stations.

Table 3-9: NC STORET Water Quality Station

Station ID	Station Description	Stream Name
N0150000	Dan River at HWY 704 NR Francisco	Dan River
N1400000	Mayo River at SR 1358 NR Price	Mayo River
N2300000	Dan River at SR 2150 NR Wentworth	Dan River
N2430000	Smith River at SR 1714 NR Eden	Smith River
N2450000	Smith River at HWY 14 at Eden	Smith River
N3000000	Dam River at SR 1761 NR Mayfield	Dan River
N3500000	Dan River at NC 57 at VA line at Milton	Dan River
N4110000	Hyco Creek at US 158 NR Leasburg	Hyco Creek
N4120010	Hyco Lake at mouth Hyco Creek near Concord NC	Hyco Lake
N4160000	Hyco Lake DNS HWY 57 NR Concord	Hyco Lake
N4160010	Hyco Lake below NC HWY 57 near Concord NC	Hyco Lake
N4170000	Hyco Lake at Power Plant NR Ceffo	Hyco Lake
N4170010	Hyco Lake at Power Plant at Ceffo NC	Hyco Lake
N4180000	Hyco Lake at Main Dam NR McGhees Mill	Hyco Lake
N4180010	Hyco Lake at Main Dam NR McGhees Mill NC	Hyco Lake
N4250000	Hyco River Below Afterbay Dam NR McGhees Mill	Hyco River
N4400000	Marlowe Creek at SR 1322 NR Woodsdale	Marlowe Creek
N4510000	Hyco River at US 501 NR Denniston VA	Hyco River
N4515000	Mayo Creek at SR 1547 NR Allensville	Mayo Creek
N4590000	Mayo Creek at SR 1501 NR Bethel Hill	Mayo Creek

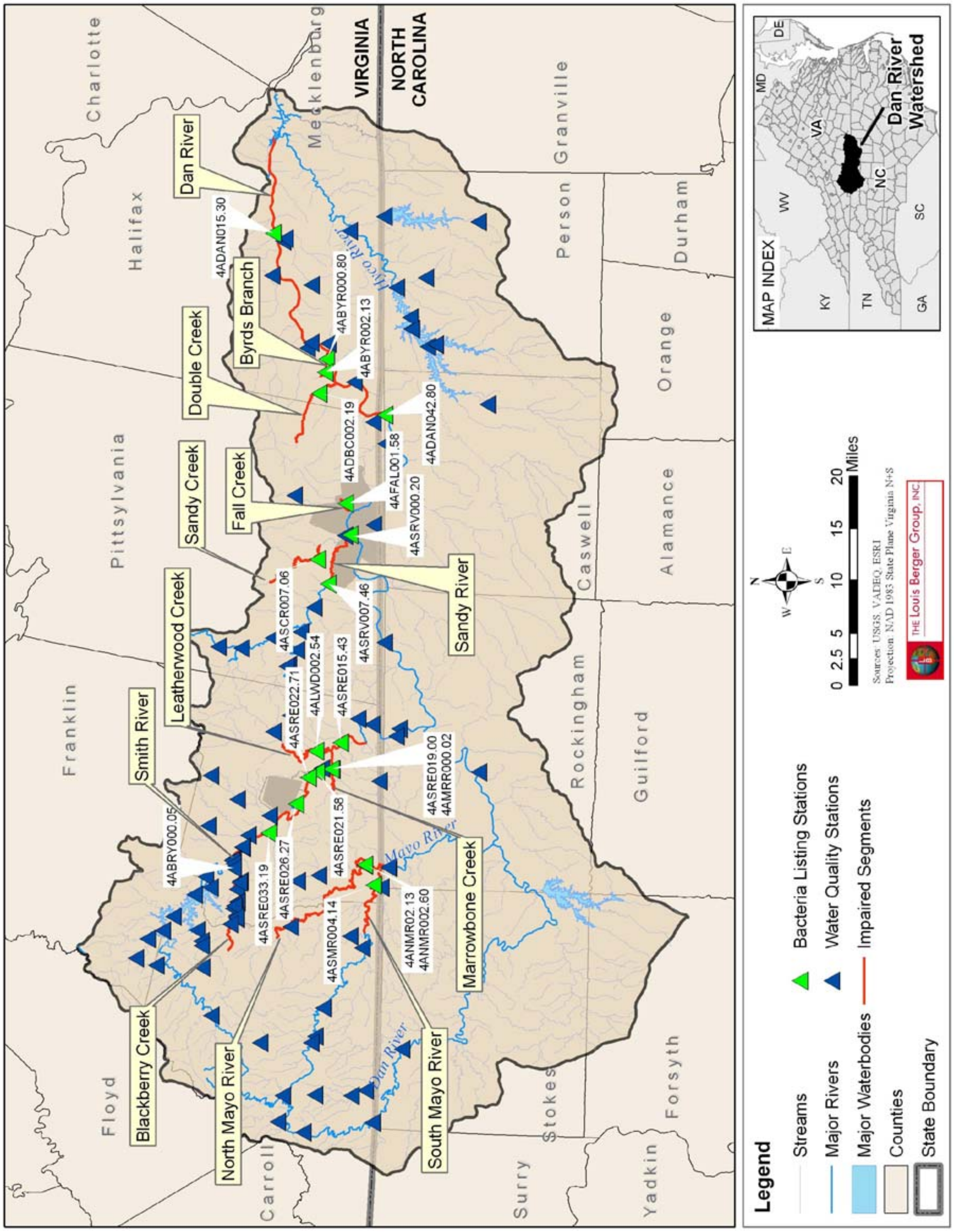

Figure 3-3: Dan River Watershed Water Quality Monitoring Stations

Virginia DEQ stations were sampled between 1990 and 2007 for fecal coliform bacteria. **Table 3-10** lists the water quality sampling period of record, the number of samples, the minimum, maximum and average concentrations observed, and the number and percentage of samples violating the water quality standards collected between 1990 and 2007. The stations formatted in bold text are the DEQ listing stations for the bacteria impaired segments. Analysis of the water quality data indicated that exceedences of the fecal coliform standard ranged between 10 and 46 percent for the instantaneous maximum criterion of 400 cfu/100 ml and between 0 and 11 percent for the geometric mean criterion of 200 cfu/100 ml.

Table 3-10: Fecal Coliform Data Collected within the Dan River Watershed

Station ID	Sample Date		Sample Value (cfu/100ml)				Exceedences			
							Instantaneous		Geometric Mean	
	First	Last	No. of Samples	Min	Max	Ave	No.	%	No.	%
4ABRY000.05	**2/12/1992**	**12/19/2006**	**56**	**25**	**8,000**	**904**	**14**	**25%**	**-**	**-**
4ABYR000.80	**3/26/1998**	**6/28/2000**	**9**	**18**	**5,400**	**1,073**	**4**	**44%**	**-**	**-**
4ABYR002.13	**12/18/1997**	**6/28/2000**	**11**	**18**	**2,400**	**440**	**4**	**36%**	**1**	**9%**
4ADBC002.19	**7/25/1994**	**6/5/2003**	**45**	**20**	**16,000**	**903**	**10**	**22%**	**-**	**-**
4AFAL001.58	**9/20/1993**	**6/12/2003**	**46**	**100**	**7,300**	**663**	**14**	**30%**	**-**	**-**
4ALWD002.54	**3/16/1992**	**6/12/2001**	**42**	**100**	**6,200**	**617**	**10**	**24%**	**-**	**-**
4AMRR000.02	**2/12/1992**	**6/4/2003**	**54**	**100**	**8,000**	**981**	**12**	**22%**	**-**	**-**
4ANMR002.60	**4/7/1992**	**2/21/2007**	**49**	**50**	**8,000**	**530**	**7**	**14%**	**-**	**-**
4ASMR004.14	**11/26/1996**	**5/14/2001**	**21**	**100**	**6,800**	**476**	**2**	**10%**	**-**	**-**
4ASRE015.43	**7/27/1998**	**12/14/2006**	**44**	**25**	**1,300**	**251**	**8**	**18%**	**1**	**2%**
4ASRE019.00	8/16/2005	12/14/2006	9	25	1,200	289	2	22%	1	11%
4ASRE021.58	**7/27/1998**	**12/14/2006**	**44**	**25**	**8,000**	**697**	**9**	**20%**	**-**	**-**
4ASRE022.71	2/12/1992	6/12/2001	110	100	8,000	544	26	24%	-	-
4ASRE033.19	**2/12/1992**	**2/21/2007**	**155**	**25**	**8,000**	**531**	**22**	**14%**	**2**	**1%**
4ADAN015.30	1/8/1990	12/28/2006	165	0	16,000	1,417	52	32%	0	0%
4ADAN042.80	7/25/1994	2/26/2001	78	18	16,000	2,445	36	46%	0	0%
4ASCR007.06	**8/22/1994**	**6/12/2003**	**42**	**100**	**8,000**	**805**	**12**	**29%**	**0**	**0%**
4ASRV000.20	**4/30/1990**	**6/12/2003**	**58**	**100**	**8,000**	**719**	**18**	**31%**	**0**	**0%**

[1] Instantaneous maximum fecal coliform bacteria concentration of 400 cfu/100 ml.
[2] Geometric mean fecal coliform bacteria concentration of 200 cfu/100 ml, calculated only when two or more samples are collected within a calendar month.
Note: Rows in **bold** are listing stations for the bacteria impairment segments.

Sixteen stations within the watershed were sampled between 2000 and 2007 for *E. coli* bacteria. **Table 3-11** lists the water quality sampling period of record, the number of samples, the minimum, maximum and average concentrations observed, and the number and percentage of samples violating the water quality standards collected between 2000 and 2007. The stations formatted in bold text are the DEQ listing stations for bacteria. *E. coli* exceedences of 235 cfu/ 100ml of the instantaneous maximum ranged between 9 and 44 percent and between 0 and 11 percent for the geometric mean criterion of 126 cfu/ 100ml.

Table 3-11: *E. Coli* Data Collected within the Dan River Watershed

Station ID	Sample Date		Sample Value (cfu/100ml)				Exceedences			
							Instantaneous		Geometric Mean	
	First	Last	No. of Samples	Min	Max	Ave	No.	%	No.	%
4ABRY000.05	8/9/2005	12/19/2006	19	2	1,200	239	7	37%	2	11%
4ABYR002.13	7/13/2004	6/29/2005	12	25	2,000	299	3	25%	-	-
4ADBC002.19	7/20/2004	11/13/2006	28	12	360	113	4	14%	-	-
4AFAL001.58	1/18/2006	11/13/2006	22	14	840	240	6	27%	-	-
4ALWD002.54	8/21/2003	12/14/2006	30	25	1,600	201	8	27%	2	7%
4AMRR000.02	1/19/2006	2/21/2007	11	50	1,410	269	3	27%	-	-
4ANMR002.60	1/19/2006	2/21/2007	11	18	1,100	243	3	27%	-	-
4ASMR004.14	8/9/2005	12/19/2006	16	25	700	180	4	25%	-	-
4ASRE019.00	8/16/2005	12/14/2006	19	25	1,060	210	6	32%	2	11%
4ASRE021.58	8/16/2005	12/14/2006	9	25	1,400	336	4	44%	-	-
4ASRE026.27	8/21/2003	12/19/2006	21	25	1,020	135	2	10%	-	-
4ASRE033.19	8/21/2003	2/21/2007	32	10	1,000	135	4	13%	1	3%
4ADAN015.30	**1/19/2000**	**12/28/2006**	**60**	**10**	**2,000**	**214**	**11**	**18%**	**3**	**5%**
4ADAN042.80	**1/19/2000**	**11/13/2006**	**35**	**6**	**800**	**158**	**7**	**20%**	**0**	**0%**
4ASCR007.06	1/18/2006	11/13/2006	22	24	20,000	1,996	6	27%	0	0%
4ASRV000.20	1/18/2006	11/13/2006	22	6	250	108	2	9%	0	0%

[1] Instantaneous maximum *E.coli* bacteria concentration of 235/100 ml
[2] Geometric mean fecal *E.coli* bacteria concentration of 126/100 ml, of water for two or more samples taken during any calendar month
Note: Rows in **bold** are listing stations for the bacteria impairment segments.

3.4.1 DEQ Bacteria Source Data

As part of the TMDL development, Bacteria Source Tracking (BST) sampling was conducted at 18 locations throughout the watershed as part of the TMDL development. The objective of the BST study was to identify the sources of fecal coliform in the listed segments of the Dan River Watershed. After identifying these sources, this information was used in the model set-up, and in the distribution of fecal coliform loadings among the various sources.

There are various methodologies used to perform BST, which fall into three major categories: molecular, biochemical and chemical. Molecular (genotype) methods are referred to as "DNA fingerprinting," and are based on the unique genetic makeup of different strains, or subspecies, of fecal coliform bacteria. Biochemical (phenotype) methods are based on detecting biochemical substances produced by bacteria. The type and quantity of these substances are measured to identify the bacteria source. Chemical methods are based on testing for chemical compounds that are associated with human wastewaters, and are restricted to determining if sources of pollution are human or non-human.

For the Dan River Watershed TMDLs, the Antibiotic Resistance Analysis (ARA) method of BST was used. ARA has been the most widely used and published BST method to date and has been employed in Virginia, Florida, Kansas, Oregon, South Carolina, Tennessee, and Texas. Advantages of ARA include low cost per sample and fast turnaround times for analyzing samples.

BST was conducted monthly from January 2006 to December 2006 at 18 stations throughout the watershed. Sampling results indicate that bacteria from human, livestock, wildlife, and pet sources are all present in the Dan River. The station IDs and locations of each BST station are presented in **Table 3-12**. **Figure 3-4** depicts the locations of the monitoring stations in the Dan River Watershed.

Table 3-12: VA DEQ Water Quality Station

Station ID	Station Description	Stream Name
4ASCR007.06	Rt 746 Bridge	Sandy Creek
4ASRV000.20	Rt 58 bridge, Danville	Sandy River
4ABYR000.80	Byrds Branch @ the end of Rt. 810	Byrds Branch
4ADAN015.30	Dan River at Rt 501	Dan River
4ADAN042.80	Dan River at Hwy 62	Dan River
4ADBC002.19	Rt 688 bridge	Double Creek
4AFAL001.58	Fall Cr @ Rt 730	Fall Creek
4AMRY000.82	Miry Creek @ River Rd (Rt 659)	Miry Creek
4ABRY000.05	American Legion Bridge - Henry County	Blackberry Creek
4ABRY010.27	Rt 687 Bridge	Blackberry Creek
4ABRY011.44	Rt 687 Bridge (Microfilm Rd)	Blackberry Creek
4ALWD002.54	Rt 650 bridge - Henry County	Leatherwood Creek
4AMRR000.02	Rt 642 bridge - Henry County	Marrowbone Creek
4ANMR002.60	North Mayo at gage near Spencer Rt 629	North Fork Mayo River
4ASMR004.14	Rt 695 bridge	South Fork Mayo River
4ASRE015.43	Rt 636 bridge below Martinsville	Smith River
4ASRE019.00	Above confluence with Marrowbone Creek	Smith River
4ASRE033.19	Rt 701 below Fieldcrest Mill	Smith River

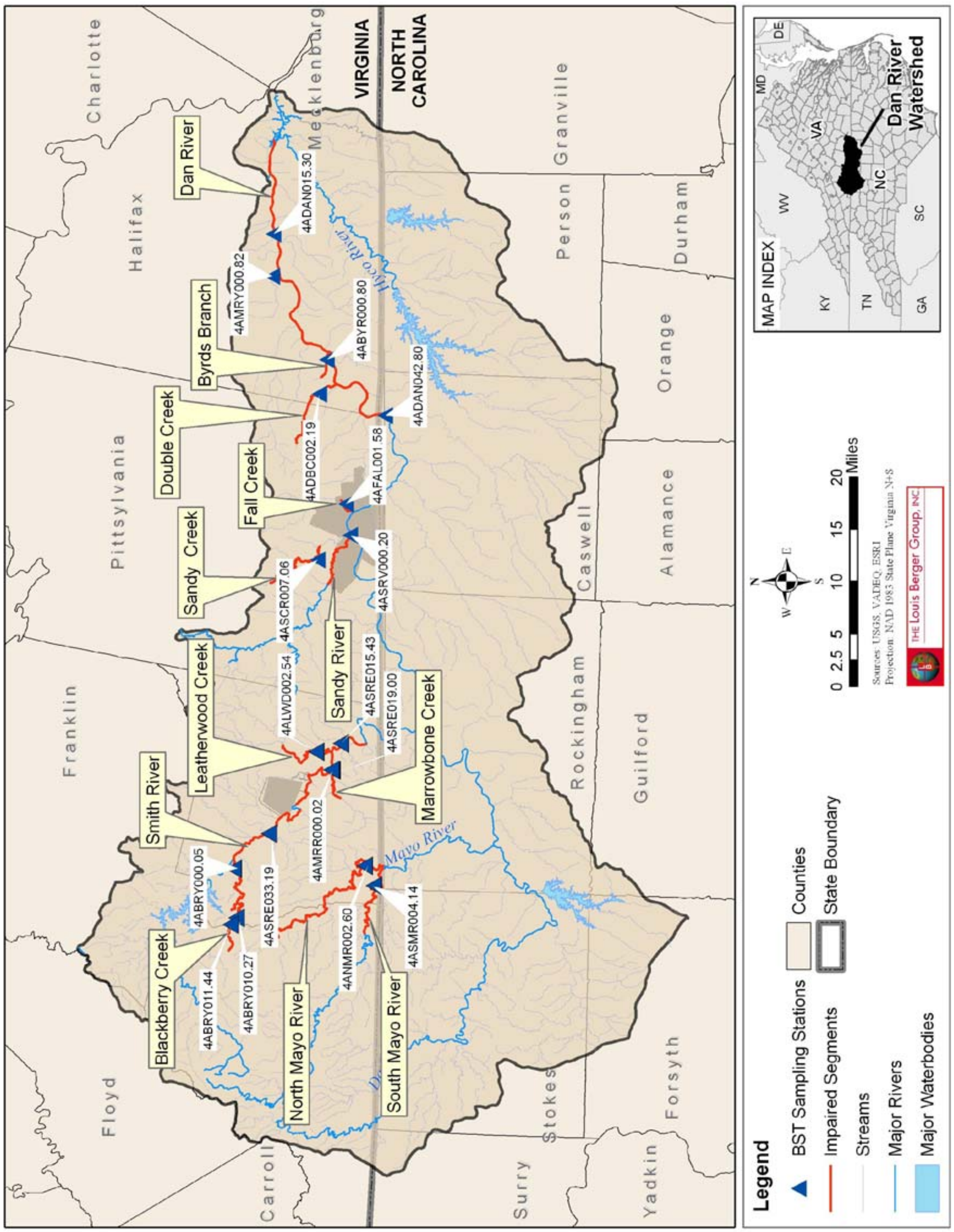

Figure 3-4: BST Monitoring Stations in the Dan River Watershed

Four categories of fecal bacteria sources were considered: wildlife, human, livestock and pet. Results from 12 sampling events at each station, are presented in **Table 3-13** and results are depicted in **Figures 3-5** through **3-22**. The load weighted average is given to account for the varying *E. coli* concentrations in each sample. *E. coli* concentrations exceeded the instantaneous maximum *E. coli* bacteria criterion of 235 cfu/100 ml 30 times in the 96 samples collected at all 8 stations. In terms of percentages, the instantaneous *E. coli* standard was violated anywhere from 8 to 67 percent of the time.

Table 3-13: BST Data Collected in 2006 within the Dan River Watershed

Station ID	Date of Sample	E.Coli cfu/100ml	Wildlife	Human	Livestock	Pet
4ASCR007.06 4 out of 12 samples (33%) exceed 235 cfu/100ml	1/18/06	120	51%	12%	12%	25%
	2/15/06	24	38%	0%	8%	54%
	3/20/06	58	62%	0%	38%	0%
	4/18/06	92	25%	0%	4%	71%
	5/15/06	213	15%	0%	47%	38%
	6/12/06	380	90%	5%	5%	0%
	7/31/06	86	94%	0%	0%	6%
	8/21/06	160	92%	0%	4%	4%
	9/25/06	910	33%	59%	0%	8%
	10/18/06	20,000	38%	8%	0%	54%
	11/13/06	260	73%	0%	18%	9%
	12/18/06	120	22%	4%	65%	9%
	Load Weighted Average		**38%**	**8%**	**0%**	**54%**
4ASRV000.20 1 out of 12 samples (8%) exceed 235 cfu/100ml	1/18/06	175	21%	33%	8%	38%
	2/15/06	6	100%	0%	0%	0%
	3/20/06	18	67%	0%	33%	0%
	4/18/06	66	33%	4%	4%	59%
	5/15/06	118	12%	8%	55%	25%
	6/12/06	250	96%	0%	0%	4%
	7/31/06	52	83%	0%	0%	17%
	8/21/06	120	71%	4%	17%	8%
	9/25/06	210	96%	0%	4%	0%
	10/18/06	122	43%	12%	12%	33%
	11/13/06	62	87%	0%	9%	4%
	12/18/06	18	90%	10%	0%	0%
	Load Weighted Average		**63%**	**8%**	**12%**	**17%**
4ABYR000.80 8 out of 12 samples (67%) exceed 235 cfu/100ml	1/18/06	560	21%	33%	38%	8%
	2/15/06	72	0%	33%	67%	0%
	3/20/06	180	38%	29%	29%	4%
	4/18/06	177	0%	43%	47%	10%
	5/15/06	480	13%	7%	80%	0%
	6/12/06	710	21%	21%	14%	44%

Table 3-13: BST Data Collected in 2006 within the Dan River Watershed

Station ID	Date of Sample	E.Coli cfu/100ml	Wildlife	Human	Livestock	Pet
	7/31/06	700	46%	17%	8%	29%
	8/21/06	430	10%	5%	75%	10%
	9/25/06	580	8%	0%	46%	46%
	10/18/06	250	12%	25%	21%	42%
	11/13/06	300	32%	9%	36%	23%
	12/18/06	80	20%	35%	20%	25%
	Load Weighted Average		**22%**	**17%**	**37%**	**24%**
4ADAN015.30 1 out of 12 samples (8%) exceed 235 cfu/100ml	1/18/06	180	25%	12%	55%	8%
	2/15/06	4	25%	50%	25%	0%
	3/20/06	12	29%	57%	14%	0%
	4/18/06	34	31%	6%	51%	12%
	5/15/06	106	0%	0%	100%	0%
	6/12/06	80	32%	41%	18%	9%
	7/31/06	146	77%	17%	0%	6%
	8/21/06	34	0%	0%	60%	40%
	9/25/06	112	12%	17%	42%	29%
	10/18/06	118	12%	17%	4%	67%
	11/13/06	1,020	17%	33%	33%	17%
	12/18/06	36	43%	36%	21%	0%
	Load Weighted Average		**22%**	**27%**	**33%**	**18%**
4ADAN042.80 2 out of 12 samples (17%) exceed 235 cfu/100ml	1/18/06	204	17%	21%	25%	37%
	2/15/06	6	67%	33%	0%	0%
	3/20/06	8	80%	0%	0%	20%
	4/18/06	26	0%	0%	100%	0%
	5/15/06	189	29%	4%	67%	0%
	6/12/06	179	35%	4%	22%	39%
	7/31/06	104	29%	0%	64%	7%
	8/21/06	48	0%	0%	100%	0%
	9/25/06	550	4%	29%	29%	38%
	10/18/06	98	0%	0%	100%	0%
	11/13/06	340	0%	39%	48%	13%
	12/18/06	12	38%	25%	12%	25%
	Load Weighted Average		**12%**	**21%**	**43%**	**24%**
4ADBC002.19 2 out of 12 samples (17%) exceed 235 cfu/100ml	1/18/06	126	4%	17%	33%	46%
	2/15/06	20	0%	40%	60%	0%
	3/20/06	12	53%	40%	7%	0%
	4/18/06	64	24%	18%	58%	0%
	5/15/06	122	12%	38%	50%	0%
	6/12/06	330	29%	38%	33%	0%
	7/31/06	92	12%	0%	33%	55%
	8/21/06	92	8%	21%	63%	8%
	9/25/06	360	8%	12%	29%	51%
	10/18/06	110	8%	0%	92%	0%
	11/13/06	74	50%	7%	29%	14%
	12/18/06	26	50%	29%	21%	0%
	Load Weighted Average		**16%**	**19%**	**40%**	**24%**

Table 3-13: BST Data Collected in 2006 within the Dan River Watershed

Station ID	Date of Sample	E.Coli cfu/100ml	Wildlife	Human	Livestock	Pet
4AFAL001.58 3 out of 12 samples (25%) exceed 235 cfu/100ml	1/18/06	185	25%	12%	46%	17%
	2/15/06	16	0%	33%	67%	0%
	3/20/06	14	50%	50%	0%	0%
	4/18/06	84	21%	12%	29%	38%
	5/15/06	540	4%	4%	92%	0%
	6/12/06	840	29%	21%	12%	38%
	7/31/06	160	53%	0%	26%	21%
	8/21/06	138	12%	12%	72%	4%
	9/25/06	190	29%	17%	4%	50%
	10/18/06	200	46%	4%	50%	0%
	11/13/06	270	4%	88%	4%	4%
	12/18/06	36	38%	50%	12%	0%
	Load Weighted Average		**22%**	**21%**	**37%**	**20%**
4AMRY000.82 7 out of 12 samples (58%) exceed 235 cfu/100ml	2/15/06	92	35%	26%	35%	4%
	3/20/06	280	21%	21%	12%	46%
	4/18/06	94	0%	26%	57%	17%
	5/15/06	510	9%	17%	74%	0%
	6/12/06	260	0%	43%	10%	47%
	7/31/06	130	12%	8%	25%	55%
	8/21/06	80	12%	8%	47%	33%
	9/25/06	250	16%	42%	42%	0%
	10/18/06	370	8%	17%	12%	63%
	11/13/06	980	0%	88%	0%	12%
	12/18/06	177	29%	25%	38%	8%
	10/25/06	306	21%	42%	25%	12%
	Load Weighted Average		**10%**	**43%**	**25%**	**22%**
4ABRY000.05 4 out of 11 samples (36%) exceed 235 cfu/100ml	1/19/06	22	93%	0%	0%	7%
	3/28/06	24	50%	0%	50%	0%
	4/18/06	175	4%	41%	17%	38%
	5/17/06	154	5%	57%	14%	24%
	6/21/06	280	47%	32%	0%	21%
	7/26/06	440	79%	0%	21%	0%
	8/14/06	260	64%	0%	27%	9%
	9/25/06	550	63%	12%	0%	25%
	10/31/06	66	52%	9%	26%	13%
	11/29/06	64	67%	4%	25%	4%
	12/18/06	42	0%	6%	17%	77%
	Load Weighted Average		**54%**	**15%**	**13%**	**18%**
4ABRY010.27 4 out of 11 samples (36%) exceed 235 cfu/100ml	1/19/06	4	0%	0%	50%	50%
	3/28/06	28	66%	0%	27%	7%
	4/18/06	191	75%	0%	0%	25%
	5/17/06	36	21%	72%	7%	0%
	6/21/06	410	92%	0%	8%	0%
	7/26/06	1100	72%	4%	12%	12%
	8/14/06	320	61%	5%	5%	29%
	9/25/06	350	88%	4%	4%	4%

Table 3-13: BST Data Collected in 2006 within the Dan River Watershed

Station ID	Date of Sample	E.Coli cfu/100ml	Wildlife	Human	Livestock	Pet
	10/31/06	50	85%	0%	15%	0%
	11/29/06	190	67%	4%	25%	4%
	12/18/06	114	29%	4%	25%	42%
	Load Weighted Average		**74%**	**4%**	**10%**	**12%**
4ABRY011.44 6 out of 12 samples (50%) exceed 235 cfu/100ml	1/19/06	6	50%	50%	0%	0%
	2/14/06	2	0%	0%	0%	100%
	3/28/06	1500	88%	0%	12%	0%
	4/18/06	244	0%	0%	0%	100%
	5/17/06	174	0%	75%	0%	25%
	6/21/06	1660	55%	8%	29%	8%
	7/26/06	2000	67%	0%	33%	0%
	8/14/06	830	82%	0%	9%	9%
	9/25/06	350	83%	0%	0%	17%
	10/31/06	58	26%	5%	53%	16%
	11/29/06	128	50%	0%	41%	9%
	12/18/06	210	0%	33%	17%	50%
	Load Weighted Average		**68%**	**4%**	**22%**	**6%**
4ALWD002.54 4 out of 12 samples (33%) exceed 235 cfu/100ml	1/19/06	251	59%	12%	0%	29%
	2/14/06	176	58%	17%	8%	17%
	3/28/06	100	76%	4%	12%	8%
	4/18/06	56	69%	0%	6%	25%
	5/17/06	122	0%	0%	0%	100%
	6/21/06	310	55%	9%	0%	36%
	7/26/06	152	58%	5%	32%	5%
	8/14/06	470	5%	5%	43%	47%
	9/25/06	530	84%	8%	0%	8%
	10/31/06	200	48%	5%	33%	14%
	11/29/06	230	52%	38%	0%	10%
	12/18/06	108	0%	18%	50%	32%
	Load Weighted Average		**51%**	**11%**	**15%**	**23%**
4AMRR000.02 3 out of 12 samples (25%) exceed 235 cfu/100ml	1/19/06	124	17%	17%	30%	36%
	2/14/06	52	38%	20%	4%	38%
	3/28/06	108	63%	8%	29%	0%
	4/18/06	82	5%	0%	63%	32%
	5/17/06	230	10%	19%	0%	71%
	6/21/06	220	42%	0%	4%	54%
	7/26/06	330	38%	8%	42%	12%
	8/14/06	270	22%	9%	43%	26%
	9/25/06	1410	84%	12%	4%	0%
	10/31/06	86	64%	12%	12%	12%
	11/29/06	176	12%	17%	59%	12%
	12/18/06	80	67%	4%	25%	4%
	Load Weighted Average		**55%**	**11%**	**18%**	**16%**
4ANMR002.60 4 out of 12 samples (33%) exceed 235	1/19/06	122	38%	12%	21%	29%
	2/14/06	18	20%	0%	0%	80%
	3/28/06	102	0%	21%	4%	75%

Table 3-13: BST Data Collected in 2006 within the Dan River Watershed						
Station ID	**Date of Sample**	**E.Coli cfu/100ml**	**Wildlife**	**Human**	**Livestock**	**Pet**
cfu/100ml	4/18/06	62	70%	9%	4%	17%
	5/17/06	158	22%	47%	9%	22%
	6/21/06	280	75%	0%	0%	25%
	7/26/06	1100	20%	40%	20%	20%
	8/14/06	118	28%	0%	36%	36%
	9/25/06	510	92%	0%	8%	0%
	10/31/06	170	23%	5%	72%	0%
	11/29/06	290	13%	13%	65%	9%
	12/18/06	42	4%	66%	0%	30%
	Load Weighted Average		**47%**	**13%**	**23%**	**17%**
4ASMR004.14 2 out of 11 samples (18%) exceed 235 cfu/100ml	1/19/06	84	42%	21%	8%	29%
	3/28/06	22	63%	12%	0%	25%
	4/18/06	66	0%	12%	8%	80%
	5/17/06	50	10%	55%	5%	30%
	6/21/06	66	12%	84%	0%	4%
	7/26/06	350	0%	29%	38%	33%
	8/14/06	56	50%	18%	0%	32%
	9/25/06	470	83%	0%	17%	0%
	10/31/06	118	50%	0%	45%	5%
	11/29/06	40	50%	5%	40%	5%
	12/18/06	18	0%	73%	0%	27%
	Load Weighted Average		**43%**	**17%**	**22%**	**18%**
4ASRE015.43 2 out of 12 samples (17%) exceed 235 cfu/100ml	1/19/06	78	30%	13%	27%	30%
	2/14/06	94	55%	8%	8%	29%
	3/28/06	36	80%	7%	13%	0%
	4/18/06	92	49%	4%	4%	43%
	5/17/06	104	27%	9%	0%	64%
	6/21/06	102	38%	8%	8%	46%
	7/26/06	990	71%	0%	29%	0%
	8/14/06	32	36%	0%	36%	28%
	9/25/06	250	86%	14%	0%	0%
	10/31/06	106	73%	9%	9%	9%
	11/29/06	138	15%	25%	25%	35%
	12/18/06	36	67%	0%	33%	0%
	Load Weighted Average		**63%**	**5%**	**20%**	**11%**
4ASRE019.00 3 out of 12 samples (25%) exceed 235 cfu/100ml	1/19/06	68	21%	8%	29%	42%
	2/14/06	14	56%	33%	11%	0%
	3/28/06	46	36%	0%	14%	50%
	4/18/06	60	44%	6%	6%	44%
	5/17/06	470	0%	11%	11%	78%
	6/21/06	92	40%	25%	15%	20%
	7/26/06	1060	71%	4%	25%	0%
	8/16/06	64	7%	60%	0%	33%
	9/25/06	410	92%	4%	0%	4%
	10/31/06	84	54%	0%	42%	4%
	11/29/06	68	45%	25%	10%	20%

Table 3-13: BST Data Collected in 2006 within the Dan River Watershed

Station ID	Date of Sample	E.Coli cfu/100ml	Wildlife	Human	Livestock	Pet
	12/18/06	16	78%	0%	11%	11%
	Load Weighted Average		**62%**	**7%**	**18%**	**13%**
4ASRE033.19 2 out of 12 samples (17%) exceed 235 cfu/100ml	1/19/06	24	72%	0%	7%	21%
	2/14/06	20	24%	38%	0%	38%
	3/28/06	16	46%	8%	15%	31%
	4/18/06	90	75%	0%	4%	21%
	5/17/06	22	0%	0%	0%	100%
	6/21/06	62	38%	38%	6%	18%
	7/26/06	450	75%	0%	17%	8%
	8/14/06	86	29%	8%	34%	29%
	9/25/06	950	79%	0%	4%	17%
	10/31/06	44	29%	7%	14%	50%
	11/29/06	30	39%	0%	28%	33%
	12/18/06	2	50%	0%	0%	50%
	Load Weighted Average		**72%**	**2%**	**10%**	**17%**

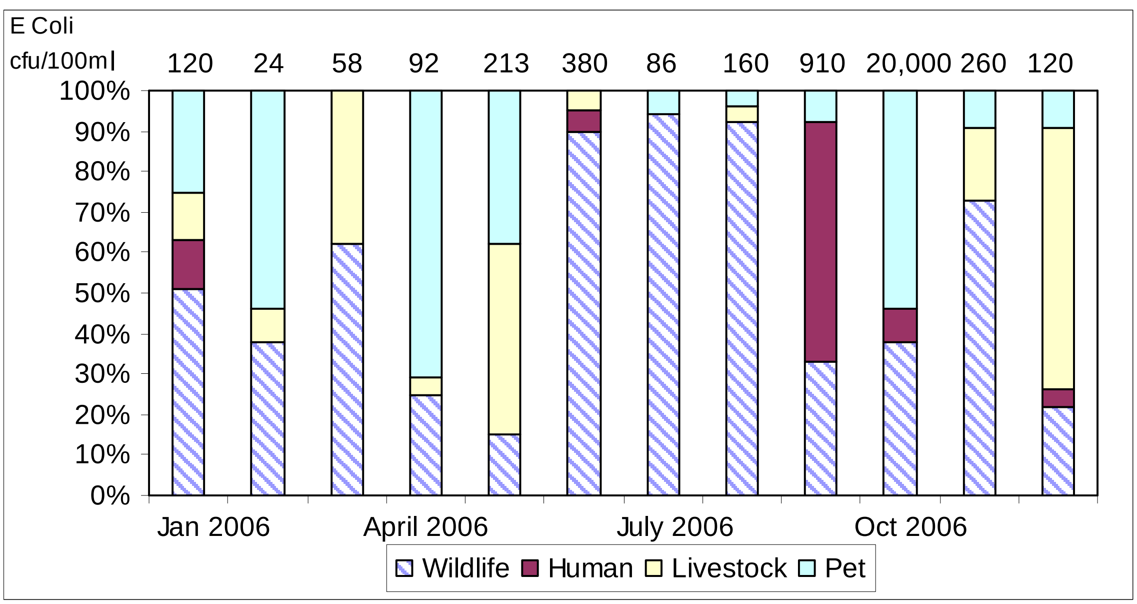

Figure 3-5: BST Source Distributions at 4ASCR007.06

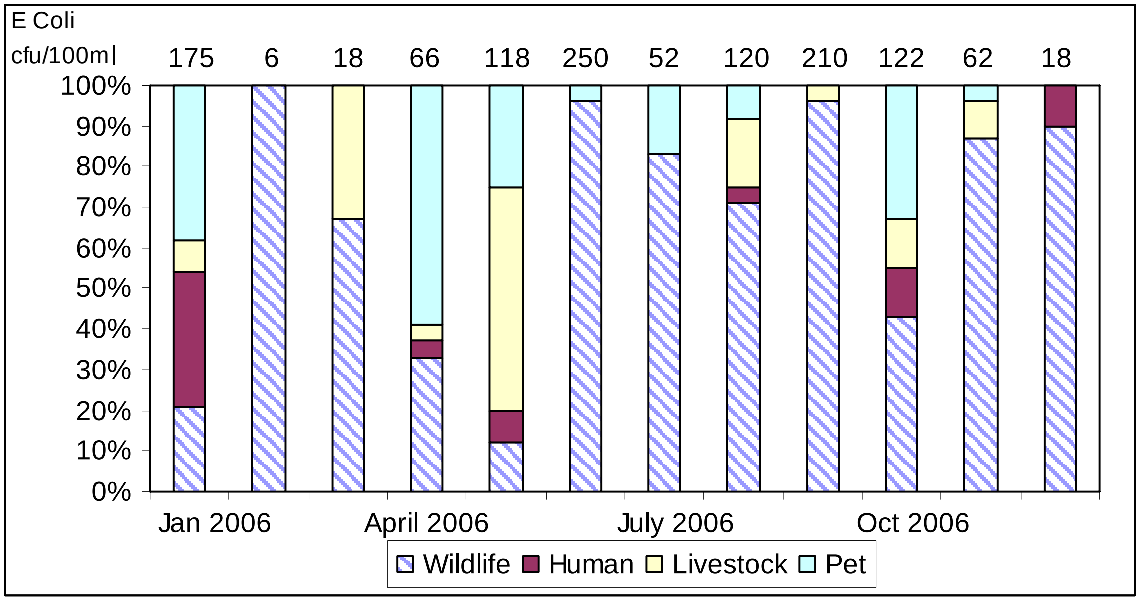

Figure 3-6: BST Source Distributions at 4ASRV000.20

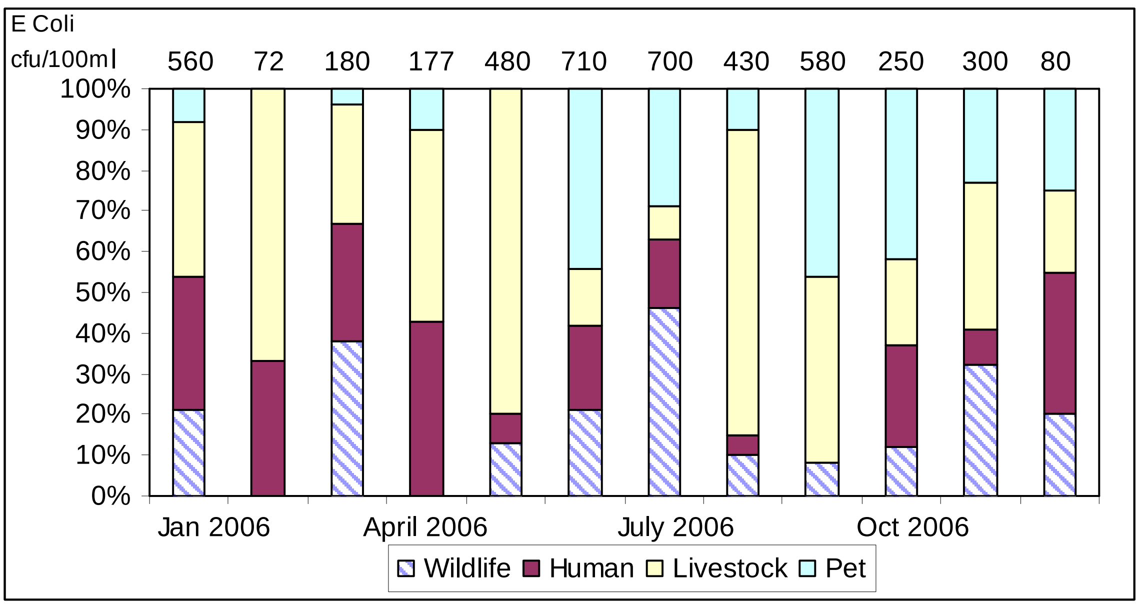

Figure 3-7: BST Source Distributions at 4ABYR000.80

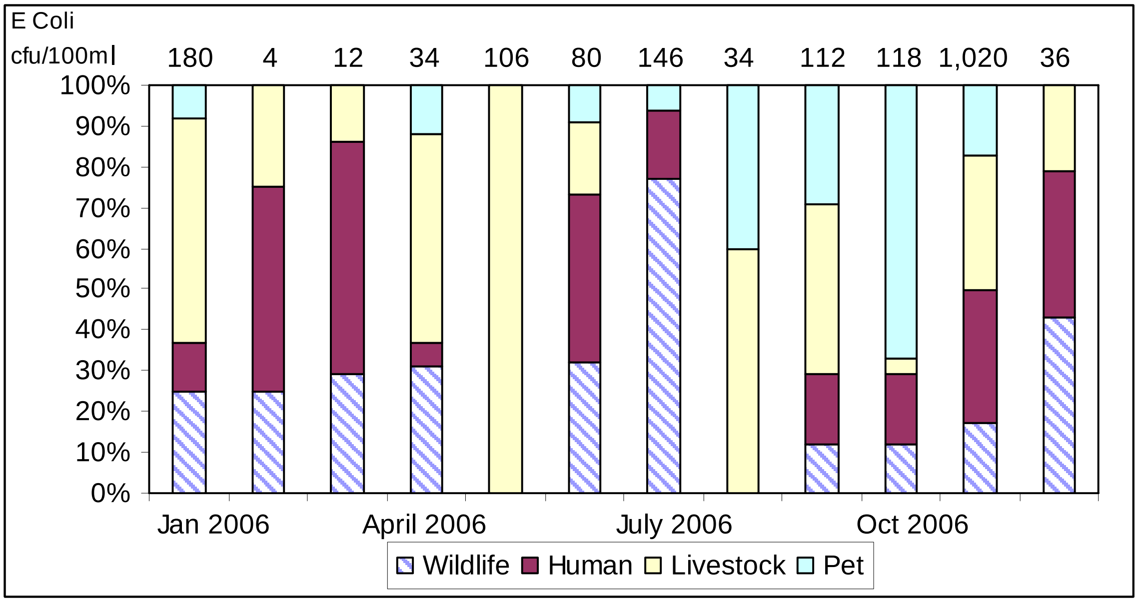

Figure 3-8: BST Source Distributions at 4ADAN015.30

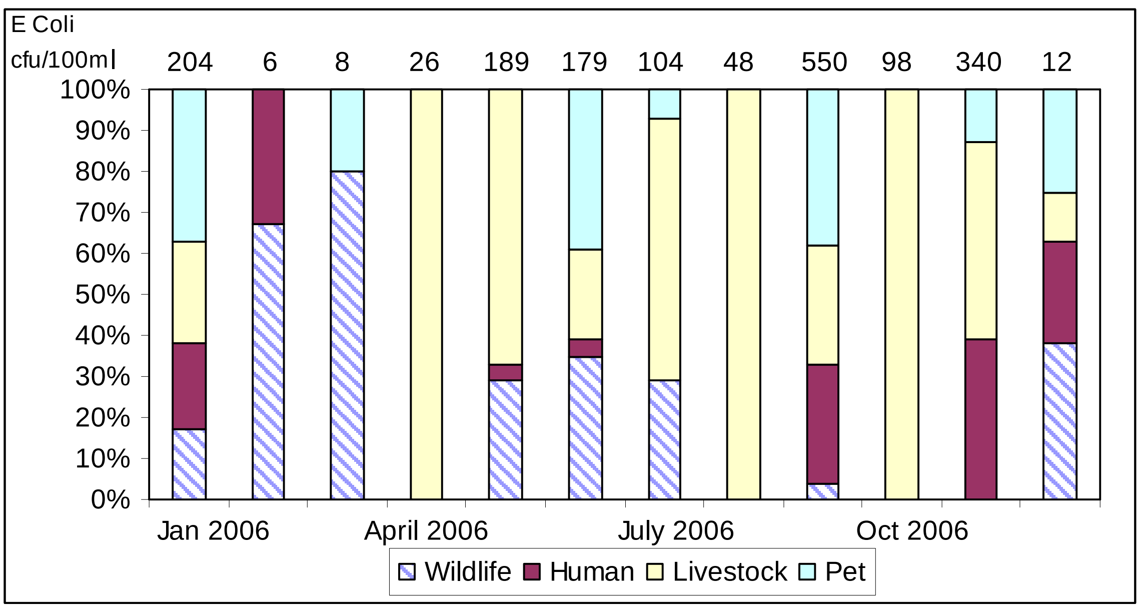

Figure 3-9: BST Source Distributions at 4ADAN042.80

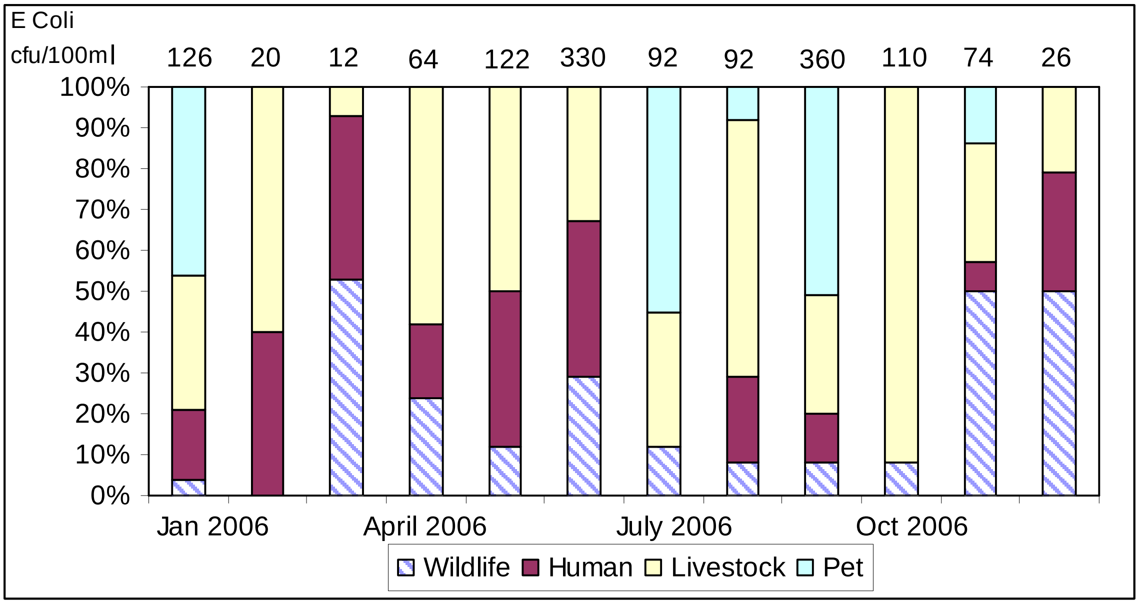

Figure 3-10: BST Source Distributions at 4ADBC002.19

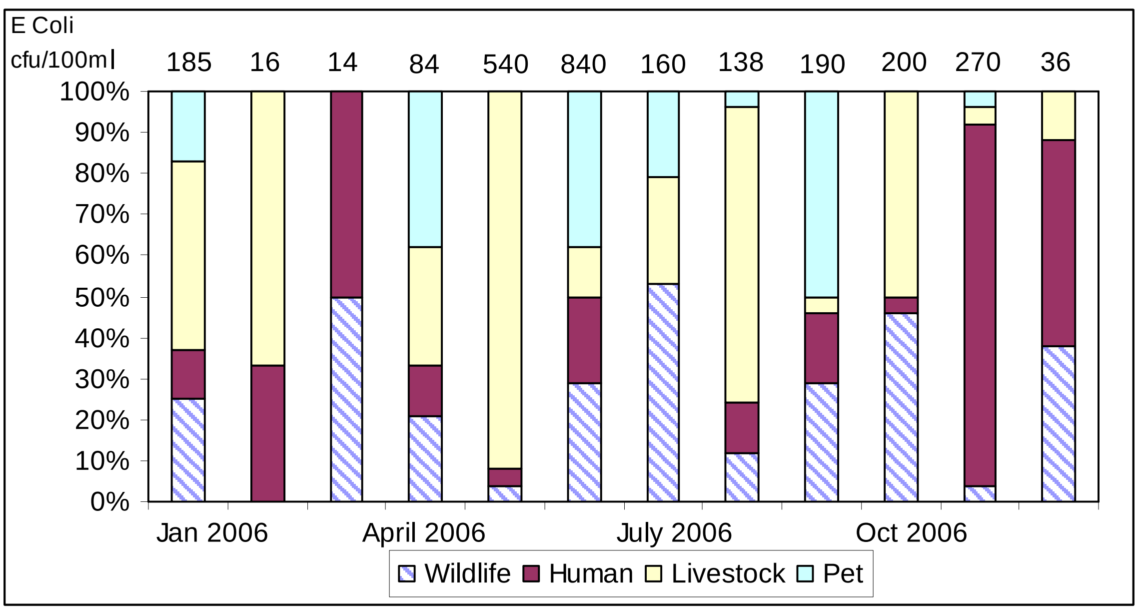

Figure 3-11: BST Source Distributions at 4AFAL001.58

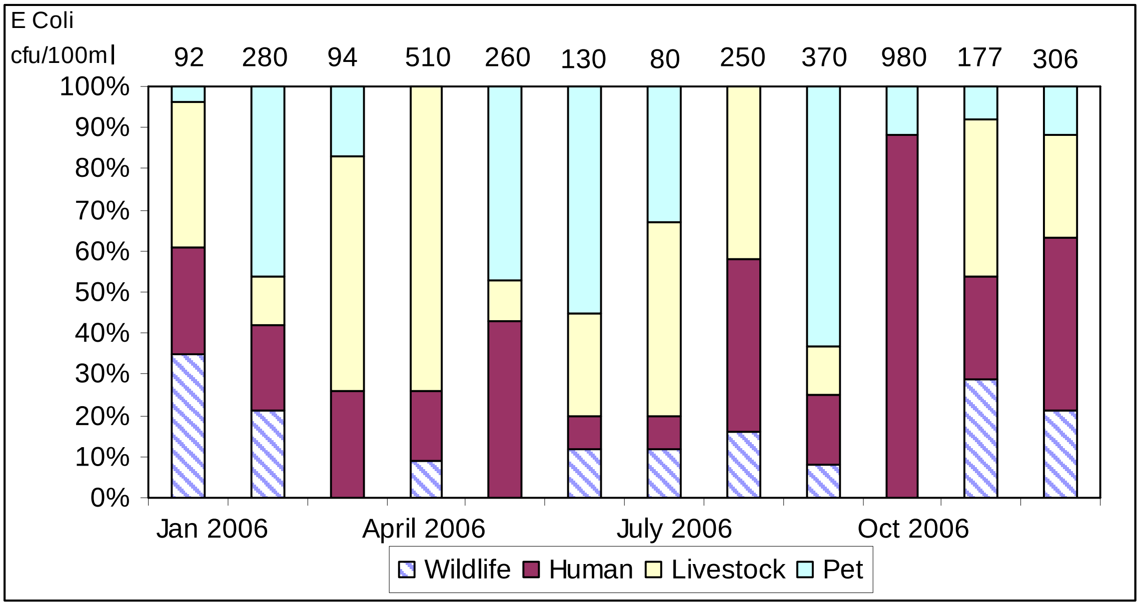

Figure 3-12: BST Source Distributions at 4AMRY000.82

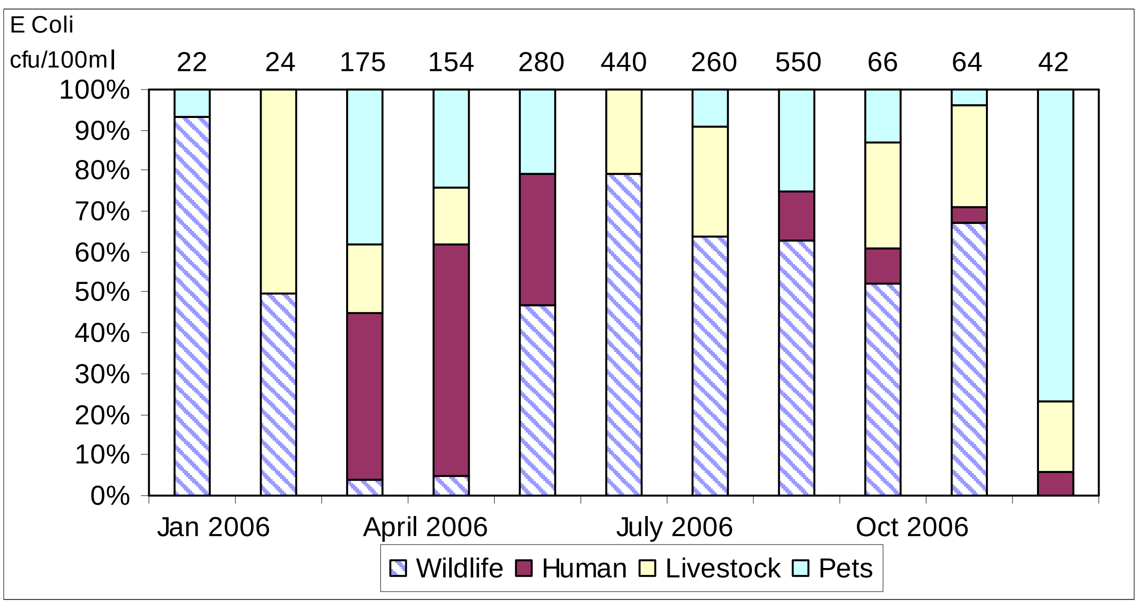

Figure 3-13: BST Source Distributions at 4ABRY000.05

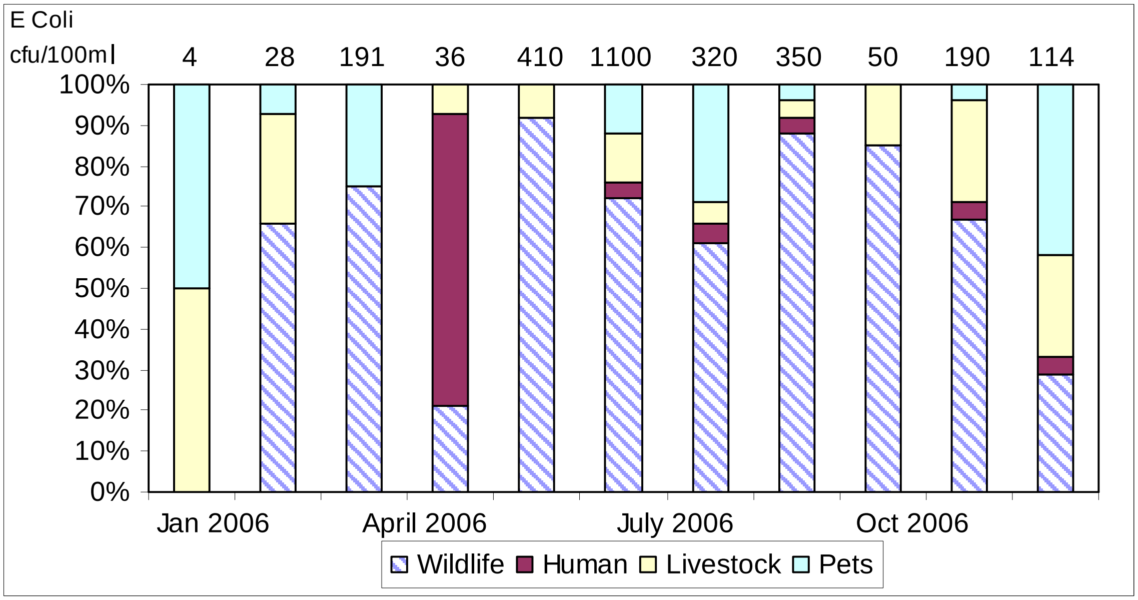

Figure 3-14: BST Source Distributions at 4ABRY010.27

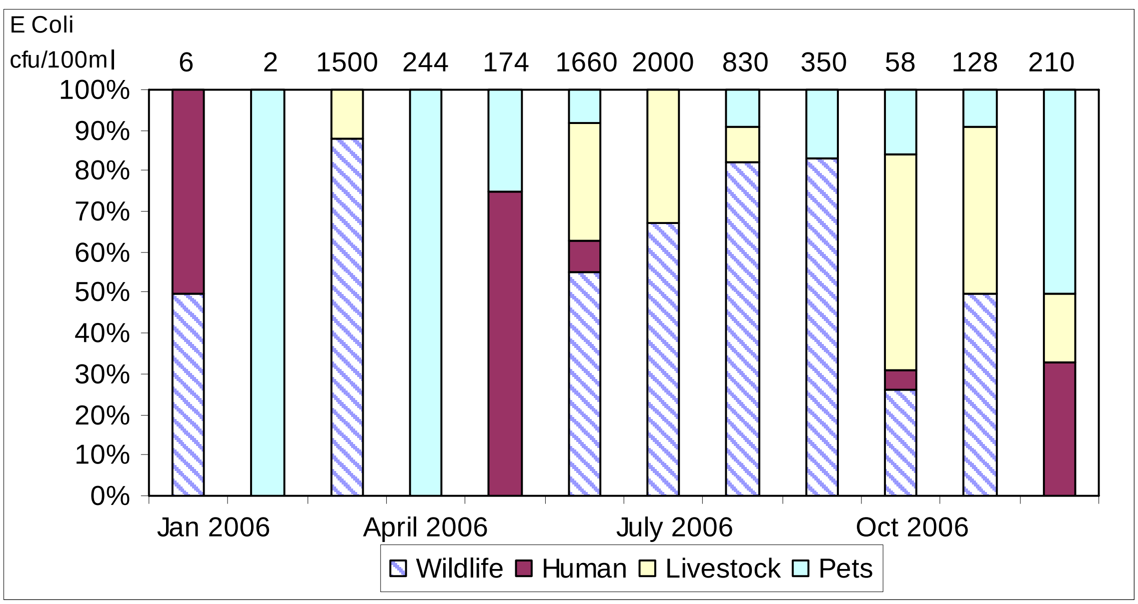

Figure 3-15: BST Source Distributions at 4ABRY011.44

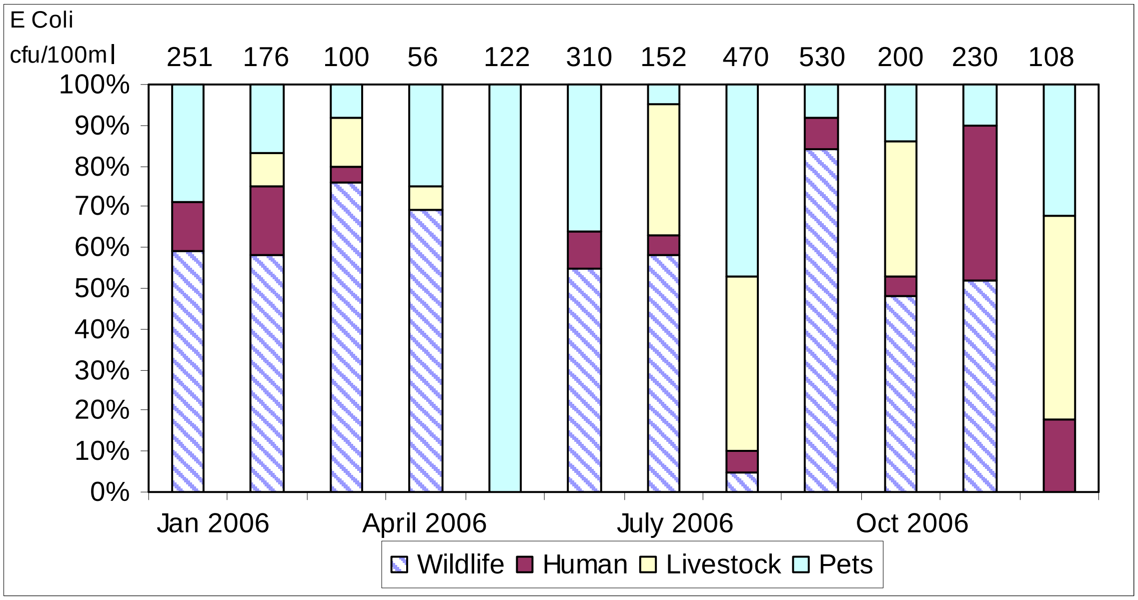

Figure 3-16: BST Source Distributions at 4ALWD002.54

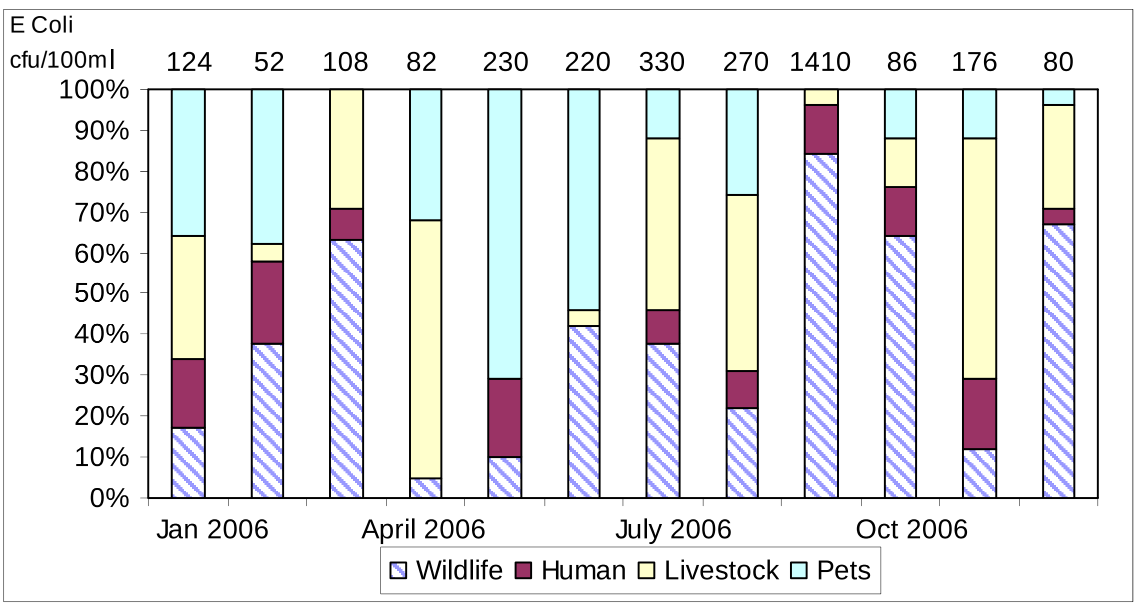

Figure 3-17: BST Source Distributions at 4AMRR000.02

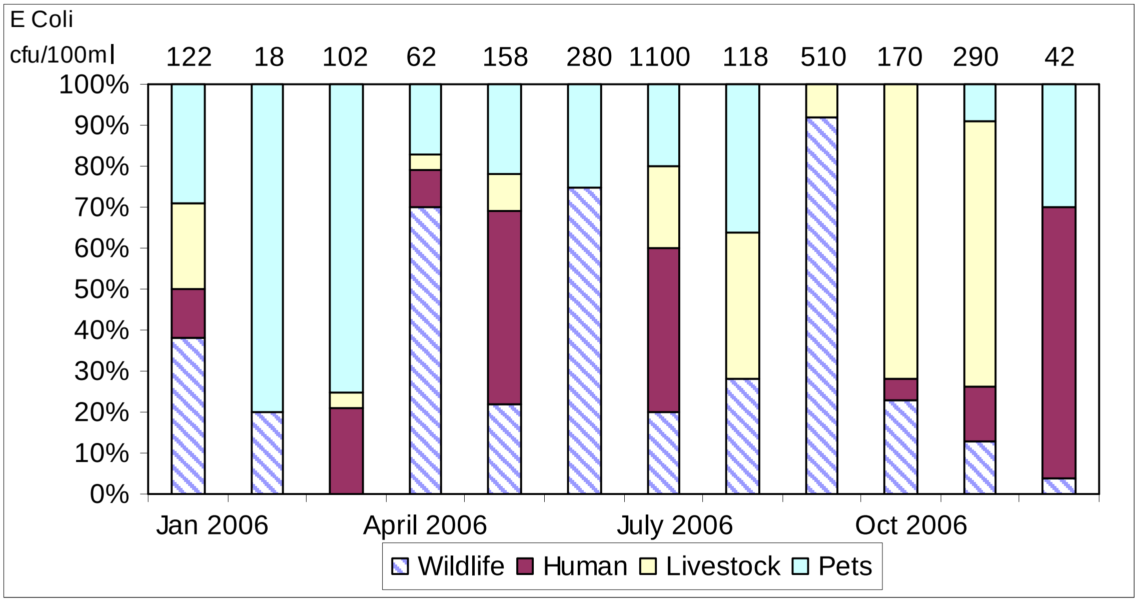

Figure 3-18: BST Source Distributions at 4ANMR002.60

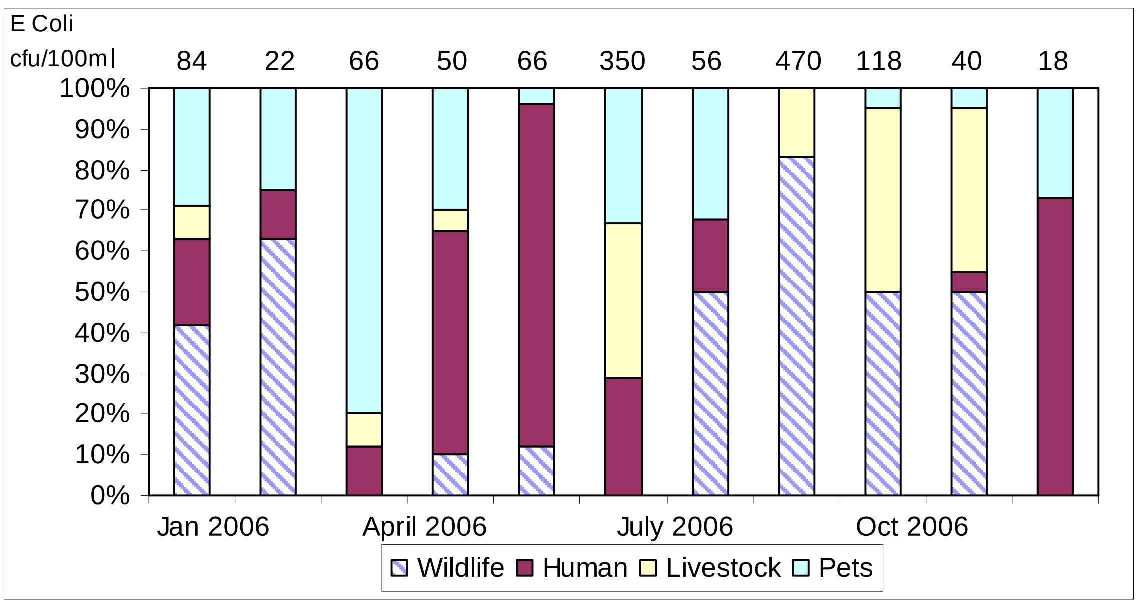

Figure 3-19: BST Source Distributions at 4ASMR004.14

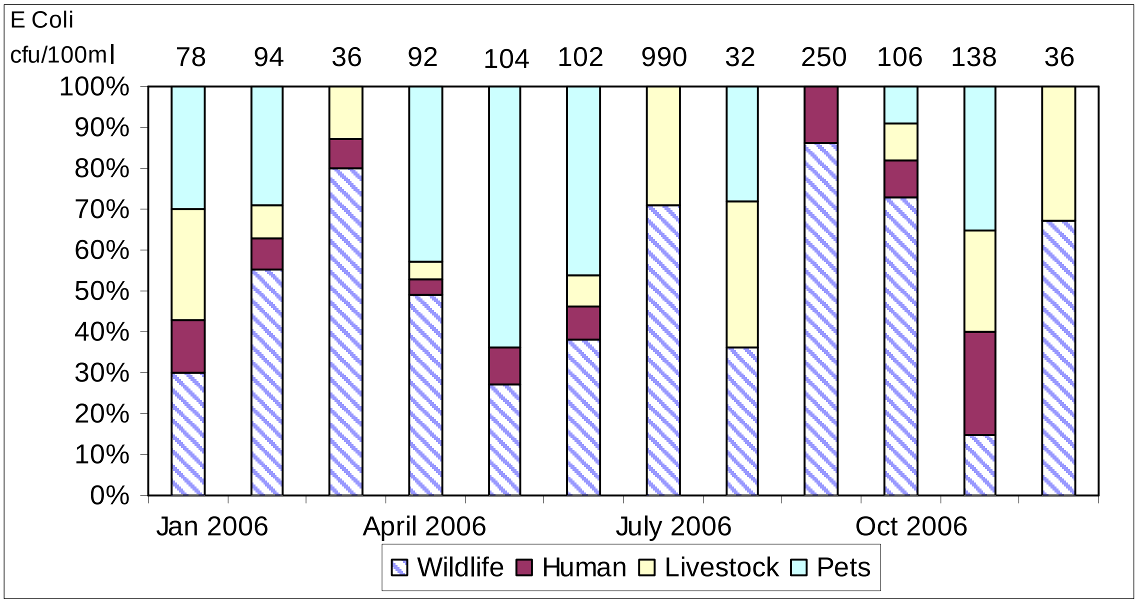

Figure 3-20: BST Source Distributions at 4ASRE015.43

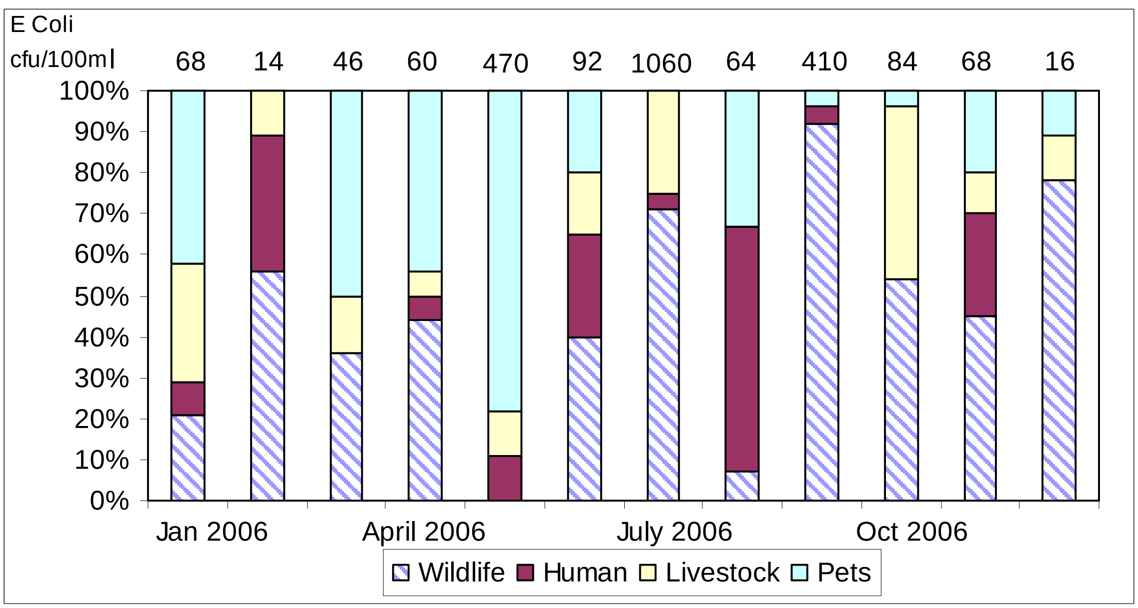

Figure 3-21: BST Source Distributions at 4ASRE019.00

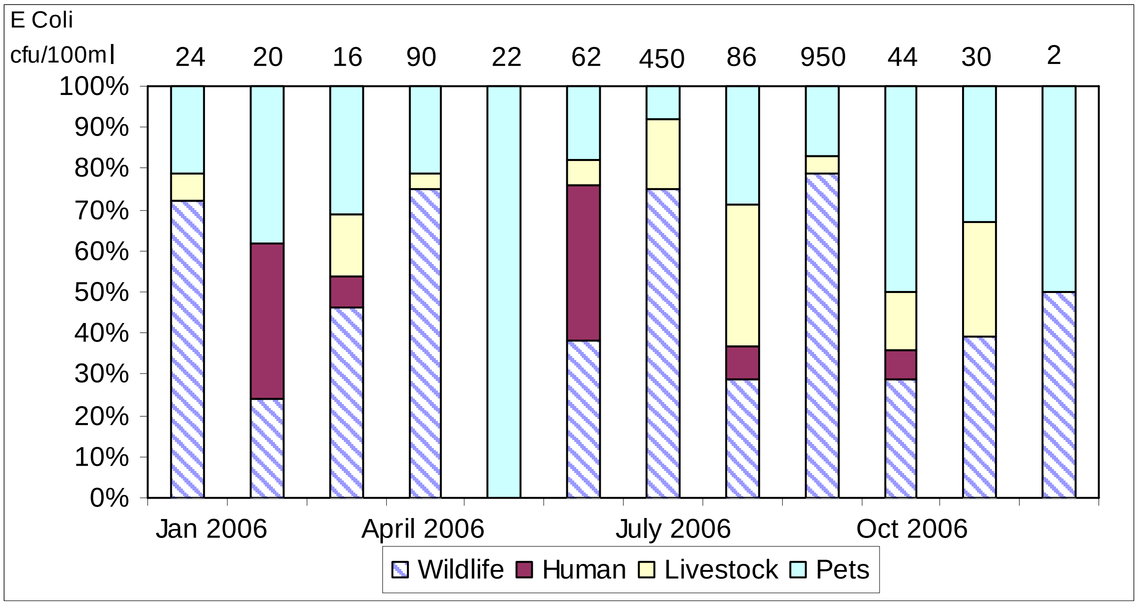

Figure 3-22: BST Source Distributions at 4ASRE033.19

3.5 Fecal Coliform Source Assessment

This section focuses on characterizing the sources that potentially contribute to the fecal coliform loading in the Dan River watershed. These sources include permitted facilities, sanitary sewer systems and septic systems, livestock, wildlife, pets, and land application of manure and biosolids. Chapter 4 includes a detailed presentation of how these sources are incorporated and represented in the model.

3.5.1 Permitted Facilities

Virginia Permitted Discharge Facilities

Data obtained from the DEQ's South Central and West Central Regional Offices indicate that there are 24 individually permitted facilities currently active or under application within in the Dan River Watershed in Virginia. The permit number, design flow, and status for each permit are presented in **Table 3-14** and shown in **Figure 3-11**.

The available flow data for the permitted facilities was retrieved and analyzed. Average flows for the permitted facilities were used in the HSPF model set-up and calibration.

The waste water treatment plants use chlorine for disinfection, and so use total residual chlorine as a surrogate for bacteria limits. Compliance with the chlorine contact requirements has been shown to translate to compliance with the bacteria criteria, and *E. coli* limitations are therefore not required.

Table 3-14: Individual Permitted Facilities within the Dan River Watershed, Virginia

Permit No	Facility Name	Receiving Stream	Status	Size	Category	Design Flow (GPD)
VA0052841	Colonial Pipeline Co - Witt Station	Fall Creek, UT	Active	Minor	Industrial	0.0059
VA0001627	Corning Inc - Danville	Rutledge Creek	Active	Minor	Industrial	0.692
VA0074586	Country Oaks LLC STP	Sandy Creek	Active	Minor	Municipal	0.03
VA0060593	Danville City - Northside	Dan River	Application	Major	Municipal	24
VA0001201	Goodyear Tire & Rubber Co - Danville	Hogans Creek, UT1	Active	Minor	Industrial	0.13
VA0022705	Halifax County Schools Cluster Springs Elem	Stokes Creek/U.T.	Active	Minor	Municipal	0.0051
VA0027685	Pittsylvania Co - Dan River High School	Little Fall Creek, UT	Active	Minor	Municipal	0.0104
VA0027693	Pittsylvania Co - Tunstall High School	Stewart Creek, UT	Active	Minor	Municipal	0.012
VA0089893	South Boston WTP	Poplar Creek	Active	Minor	Industrial	0.04
VA0020362	South Boston WWTP	Dan River	Active	Major	Municipal	2
VA0001554	Hanesbrands Incorporated	Smith River	Active	Major	Industrial	0.3881
VA0021989	Virginia Glass Products Corp	Machine Branch, UT	Active	Minor	Industrial	0.008
VA0023558	DOC - Patrick Henry Correctional Unit 28	Jennings Creek, UT	Active	Minor	Municipal	0.028
VA0025305	Martinsville City Sewage Treatment Plant	Smith River	Active	Major	Municipal	8
VA0029858	Carver Estates - Sewage Treatment Plant	Grassy Creek	Active	Minor	Municipal	0.06
VA0030660	DCR - Fairy Stone State Park	Hale Creek	Active	Minor	Industrial	0.0005
VA0058441	Upper Smith River Water Filtration Plant	Smith River, UT	Active	Minor	Industrial	0.096
VA0060445	Henry County Public SA - Piedmont Estates Lagoon	Mill Creek	Active	Minor	Municipal	0.04
VA0069345	Henry County PSA - Lower Smith River STP	Smith River	Active	Major	Municipal	4
VA0072354	CPFilms Inc - Plant 1	Smith River	Active	Minor	Industrial	4.2
VA0086665	Bassett Mirror Company Incorporated	Town Creek	Active	Minor	Industrial	0.0035
VA0090174	Green Acres Mobile Home Park	Tanyard Branch	Active	Minor	Municipal	0.01
VA0090280	Henry County Public SA - Greenbriar Lagoon STP	Grassy Creek	Active	Minor	Municipal	0.032
VA0090310	Philpott Dam Hydroelectric Plant	Smith River	Active	Minor	Industrial	0.0638

There are also general permits issued within the watershed. The active and application general permits are shown in **Table 3-15**. The flow from all permitted dischargers will be considered in model setup and calibration.

Table 3-15: Active and Application General Permits within the Dan River Watershed, Virginia

Permit No	Facility	Receiving Stream	Discharge (GPD)	Classification
VAG402049	Business	Little Reed Creek	150	NA
VAG402049	Business	Little Reed Creek	850	NA
VAG402052	Residence	McGuff Creek Tributary	450	Application
VAG402053	Residence	Rocky Branch	450	Application
VAG402105	Post Office	Town Creek or UT to Town Creek	450	NA
VAG404018	Residence	Dan River	1000	Application
VAG404039	Residence	Poplar Creek	1000	Application
VAG404043	Residence	Poplar Creek	1000	Application
VAG404067	Residence	Poplar Creek	1000	Application
VAG404095	Residence	Poplar Creek	1000	Application
VAG404104	Residence	Stokes Creek UT	450	Active
VAG404108	Residence	Poplar Creek	1000	Application
VAG404112	Residence	Dan River UT	1000	Application
VAG404119	Residence	Lawsons Creek UT	1000	Application
VAG404121	Residence	Dan River UT	450	Application
VAG404123	Residence	Poplar Creek	1000	Application
VAG404127	Business	Dan River UT	300	Active
VAG404138	Residence	Stokes Creek UT	900	Active
VAG404160	Residence	Dan River	300	Application
VAG404163	Residence	Dan River UT	300	Application
VAG404173	Residence	Dan River/UT	450	Application
VAG404195	Residence	Birch Creek UT	450	Active
VAG407197	Residence	Dry Ditch to Lawson's Creek	450	Active
VAG407218	Residence	Stokes Creek	300	Application
VAG407219	Residence	dry ditch	300	Application
VAG407220	Airport	UT to Dan River	100	Application
VAG407223	Residence	UT to Stokes Creek	450	Active
VAG407240	Residence	UT to Barley Branch	450	Active
VAG407244	Residence	UT to Barley Branch	450	Active
VAG407245	Residence	UT to Tanyard Branch	450	Active
VAG407246	Residence	UT to Tanyard Branch	450	Active
VAG407247	Residence	Tanyard Branch	450	Active
VPG100008	Hog Farm	Sandy Creek	NA	Active
VPG100019	Dairy Farm	NA	NA	NA
VPG100029	Hog Farm	Dan River/UT	NA	Active
VPG100049	Hog Farm	Long Branch	NA	Active
VPG100056	Hog Farm	Perrin Creek/UT	NA	Active
VPG100139	Dairy Farm	Sandy Creek/U.T.	NA	Active
VPG100152	Hog Farm	Miry Creek	NA	Active
VPG120007	Dairy Farm	NA	NA	NA

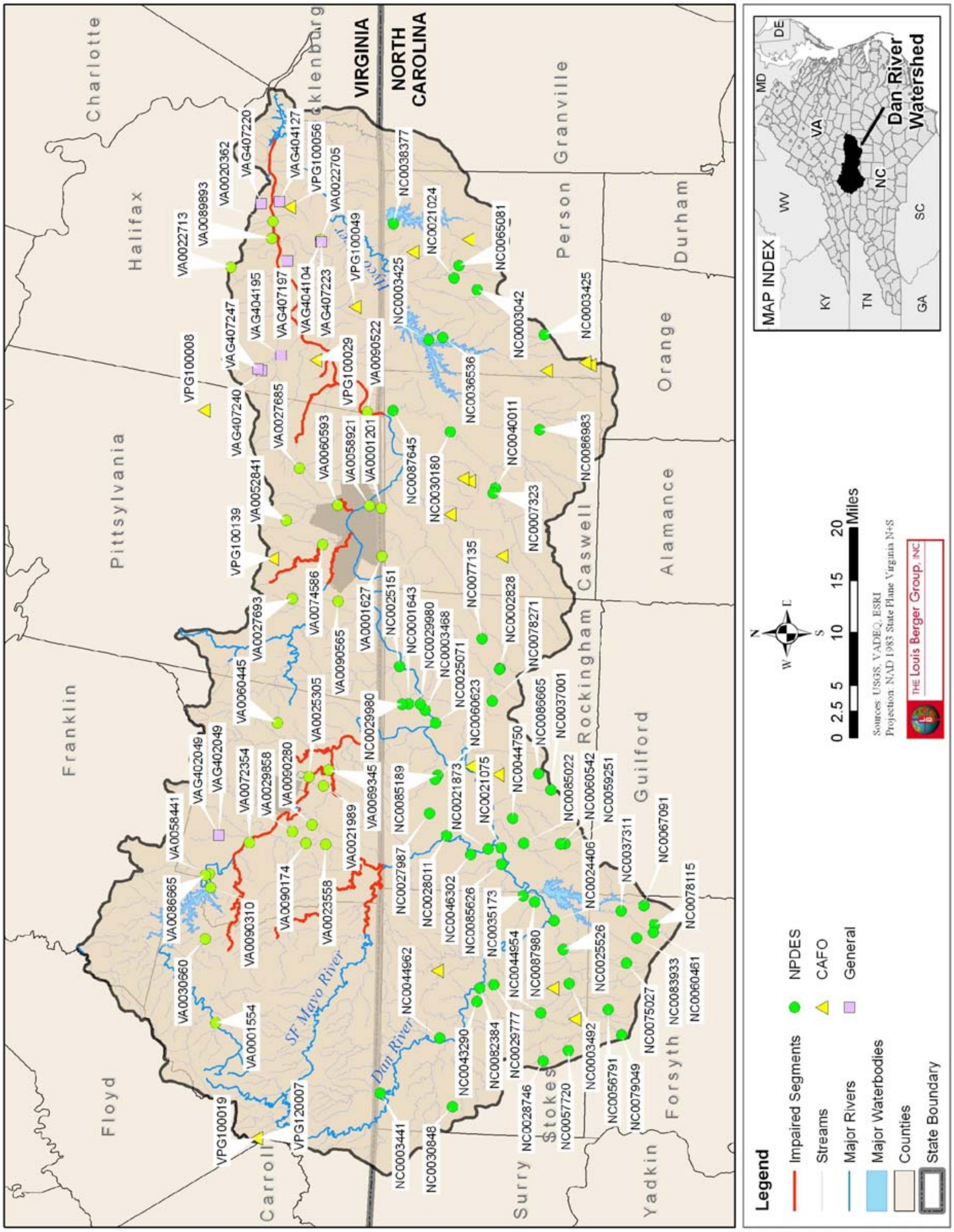

Figure 3-23: Location of Permitted Facilities in the Dan River Watershed

North Carolina Permitted Discharge Facilities

Data obtained from the North Carolina Department of Environment and Natural Resources indicate that there are 57 individually permitted facilities within in the Dan River Watershed within North Carolina. Within the information downloaded, it was not specified whether these sites are active, application, or historical. The permit number, design flow, and status for each permit are presented in **Table 3-16.**

Table 3-16: Individual Permitted Facilities within the Dan River Watershed, North Carolina

Permit No	Facility Name	Receiving Stream	Size	Category
NC0001643	New Street Mill	Dan River	Major	Industrial
NC0002828	Diakon Molding	Lick Fork Creek	Minor	Industrial
NC0003042	Roxboro WTP	Marlowe Creek	Minor	Municipal
NC0003425	Roxboro Steam Electric Power Plant	Hyco River	Major	Industrial
NC0003425	Roxboro Steam Electric Power Plant	South Hyco Creek	Major	Industrial
NC0003441	JPS Elastomerics Corp-Caro Plt	Little Dan River	Minor	Industrial
NC0003468	Dan River Steam Station	Dan River	Major	Industrial
NC0003492	R J Reynolds Tobacco Co - Brook Cove	Voss Creek	Minor	Industrial
NC0007323	Yanceyville WTP	Fullers Creek	Minor	Municipal
NC0021024	City of Roxboro WWTP	Marlowe Creek	Major	Municipal
NC0021075	Madison WWTP	Dan River	Minor	Municipal
NC0021873	Mayodan WWTP	Mayo River	Major	Municipal
NC0024406	Belews Creek Steam Station	West Belews Creek	Major	Industrial
NC0025071	Mebane Bridge WWTP	Dan River	Major	Municipal
NC0025151	Dry Creek WWTP	Dan River	Minor	Municipal
NC0025526	Walnut Cove WWTP	Town Fork Creek	Minor	Municipal
NC0027987	Stoneville Quarry	Buffalo Creek	Minor	Industrial
NC0028011	Stoneville WWTP	Mayo River	Minor	Municipal
NC0028746	Briarwood Subdivision WWTP	Brushy Fork Creek	Minor	Domestic
NC0029777	Stokes Correctional Center WWTP	Flat Shoals Creek	Minor	Domestic
NC0029980	Miller Brewing Company	Dan River	Major	Industrial
NC0029980	Miller Brewing Company	Dry Creek	Major	Industrial
NC0030180	Blanch Youth Center WWTP	Country Line Creek	Minor	Domestic
NC0030848	Jefferson Landing WWTP	Dog Creek	Minor	Domestic
NC0035173	Kobewireland Copper Products Inc	Dan River	Minor	Industrial
NC0036536	Woodland Elementary School	South Hyco Creek	Minor	Domestic
NC0037001	Bethany Elementary School	Huffines Mill Creek	Minor	Domestic
NC0037311	Creekside Manor Rest Home	Belews Creek	Minor	Domestic
NC0038377	Mayo Steam Electric Plant	Mayo Creek	Major	Industrial
NC0040011	Yanceyville WWTP	Country Line Creek	Minor	Municipal
NC0043290	Danbury WTP	Scott Creek	Minor	Municipal
NC0044750	Britthaven Of Madison	Hogans Creek	Minor	Industrial
NC0044954	South Stokes High School	Little Neatman Creek	Minor	Domestic
NC0044962	North Stokes High School	Dan River	Minor	Domestic
NC0046302	Mayodan WTP	Mayo River	Minor	Municipal
NC0056791	Horizons Residential Care Ctr	Buffalo Creek	Minor	Domestic
NC0057720	Twin Lakes Mobile Home Park	Timmons Creek	Minor	Domestic

Table 3-16: Individual Permitted Facilities within the Dan River Watershed, North Carolina				
Permit No	**Facility Name**	**Receiving Stream**	**Size**	**Category**
NC0059251	Quail Acres Mobile Home Park	Hogans Creek	Minor	Domestic
NC0060461	Abington WWTP	Belews Creek	Minor	Domestic
NC0060542	Gold Hill Mobile Home Park	Hogans Creek	Minor	Domestic
NC0060623	Stone Highway Mobile Home Park	Buffalo Creek	Minor	Domestic
NC0065081	Roxboro Cogen plant	Mitchell Creek	Minor	Industrial
NC0067091	Mikkola Downs WWTP	East Belews Creek	Minor	Domestic
NC0075027	Cains Way Mobile Home Park	Ader Creek	Minor	Domestic
NC0077135	Hidden Valley WWTP	Lick Fork Creek	Minor	Domestic
NC0078115	Greystone Subdivision WWTP	Belews Creek	Minor	Domestic
NC0078271	Betsy Jeff Penn 4H Education	Carroll Creek	Minor	Domestic
NC0079049	R.H. Johnson Construction WWTP	Rough Fork	Minor	Domestic
NC0082384	Danbury WWTP	Dan River	Minor	Municipal
NC0083933	Salem Quarters WWTP	Belews Creek	Minor	Domestic
NC0085022	220 Mobile Home Park	Hogans Creek	Minor	Municipal
NC0085189	Jose's Restaurant-Sand Filter	Buffalo Creek	Minor	Domestic
NC0085626	Madison WTP	Big Beaver Island Creek	Minor	Municipal
NC0086665	Rockingham Power LLC/Dynegy	Jacobs Creek	Minor	Industrial
NC0086983	South Elementary WTP	Hyco Creek	Minor	Municipal
NC0087645	Milton WWTP	Country Line Creek	Minor	Municipal
NC0087980	Pine Hall Elementary School WWTP	Eurins Creek	Minor	Domestic

Data obtained from the North Carolina Department of Environment and Natural Resources indicate that there are 14 animal operation permit facilities in the North Carolina portion of the watershed. **Table 3-17** provides a summary of these sites.

Table 3-17: North Carolina Animal Operation Permit Facilities			
Farm Name	**Facility**	**Design Flow (GPD)**	**County**
Alvis Hodges Farm	Hog Farm	1300	Caswell
John Shumaker Dairy Farm, Inc.	Dairy Farm	200	Caswell
Stepstone Holsteins	Dairy Farm	200	Caswell
Stilwell Farm	Hog Farm	90	Caswell
R&R Farms	Hog Farm	50	Person
Cross Creek Dairy	Dairy Farm	200	Person
Phillip Whitfield Swine Farm	Hog Farm	100	Person
Thomas Farms Pork Inc.	Hog Farm	260	Person
The Hill of Berrys	Hog Farm	90	Person
Massey Creek Farms	Hog Farm	1205	Rockingham
Eagle Falls Hog Farm	Hog Farm	1800	Rockingham
Mark Bray Farm	Beef Cattle Farm	325	Stokes
Shorehill Farm	Dairy Farm	125	Stokes
Edsel Bennett Feeder Pig Farm	Hog Farm	800	Stokes

In addition to the individual and general permits presented above, Municipal Separate Storm Sewer (MS4) permits have been issued to cities, counties, and other facilities within the bacteria impaired Dan River Watershed. **Table 3-18** lists all the MS4 permit holders and the area covered by each MS4 locality. The MS4 City area was calculated using the US Census Urban Areas and subtracting the acreages for the VDOT road areas. VDOT road areas were estimated using the roads length within the urban areas and assuming a 25 foot-road-width. Combined, these MS4 permits cover approximately 1.3 percent of the Dan River bacteria impaired watershed. **Figure 3-12** presents the major MS4 areas located within the Dan River bacteria impaired Watershed.

Table 3-18: MS4 Permits within the Dan River Watershed

Permit Number	MS4 Permit Holder	Permit Acreage	MS4 Locality	Locality Acreage
VAR040018	City of Danville	27,112	City of Danville	28,123
VAR040003	VDOT Danville Urban Area	1,011		
Total				**28,123**

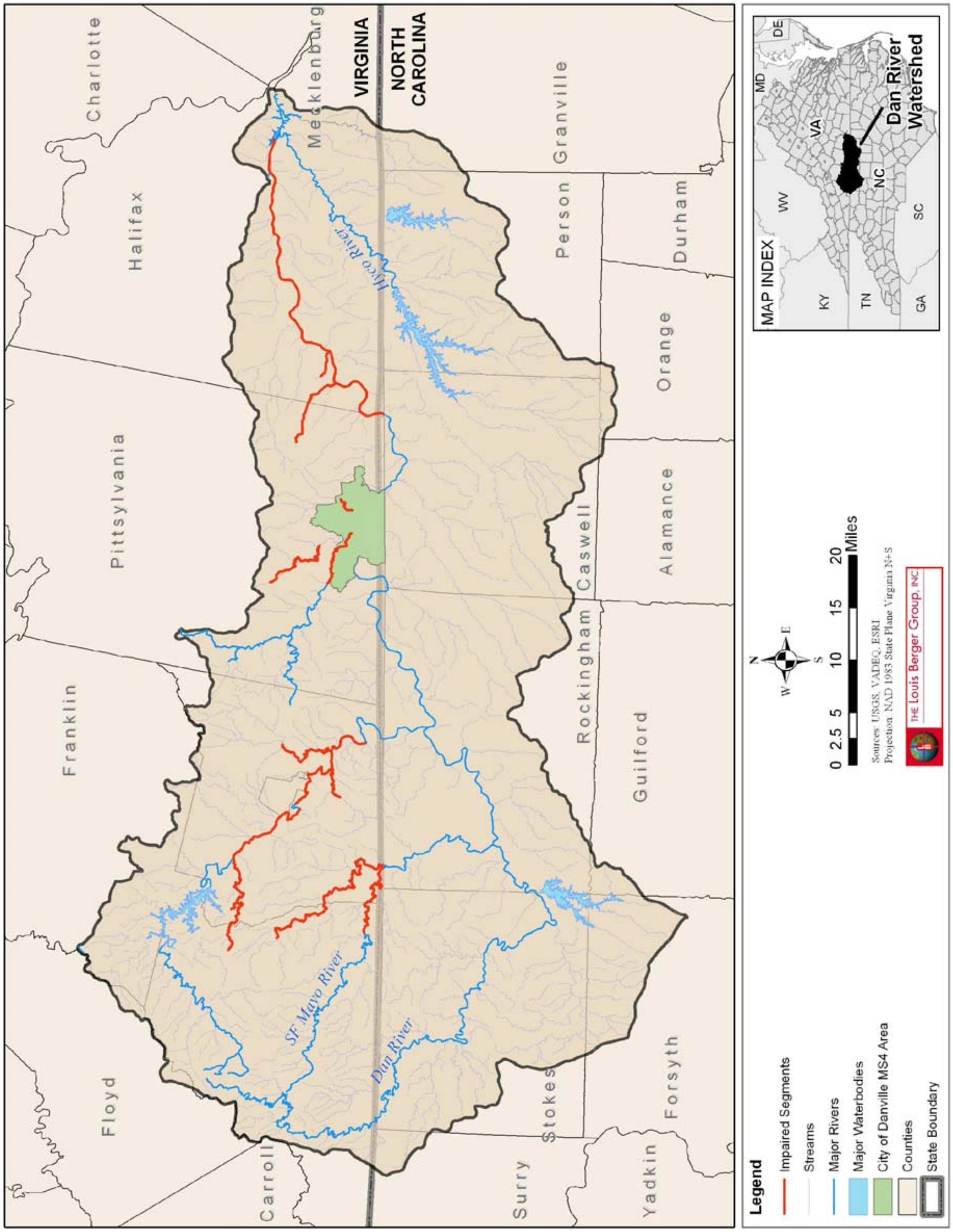

Figure 3-24: Dan River Watershed MS4 Permits

3.5.2 Extent of Sanitary Sewer Network

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

3.5.2.1 Septic Systems

There are no data available for the total number of septic systems in the watershed. Estimates of the total number of housing units located in the watershed and the identification of whether these housing units are connected to a public sewer or on septic systems were based U.S. Census Bureau data. The U.S. Census Bureau 2004 data for counties within the watershed were reviewed to establish the population growth rates in the counties and to validate the housing units' calculation. A summary of the census data and population estimates used for the Dan River watershed are presented in **Table 3-19**.

Table 3-19: 2004 Census Data Summary for the Dan River Watershed

County	Total Population	Total Households
Virginia		
Carroll	2	1
Danville	46,418	20,607
Floyd	389	152
Franklin	4,584	1,475
Halifax	19,585	7,915
Henry	56,687	23,648
Martinsville	14,801	6,498
Mecklenburg	896	384
Patrick	18,044	7,392
Pittsylvania	32,887	12,183
VA Total	*194,293*	*80,255*
North Carolina		
Caswell	22,296	7,800
Forsyth	29,319	10,987
Granville	973	312
Guilford	2,296	787
Orange	614	215
Person	23,989	9,238
Rockingham	75,929	29,930
Stokes	32,605	12,109

Table 3-19: 2004 Census Data Summary for the Dan River Watershed

County	Total Population	Total Households
Surry	1,959	759
NC Total	*189,980*	*72,137*
Watershed Total	***384,273***	***152,392***

Source: US Census Bureau

The 1990 U.S Census Report presents the percent of houses on each sewage disposal type as shown in **Table 3-20**. 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. The houses included in this category are assumed to be disposing of sewer directly via straight pipes if located within 200 feet of a stream.

Table 3-20: Percent of Houses within Each County on Public Sewers, Septic Systems, and Other Means

County	Public Sewer	Septic Tank	Other Means
Virginia			
Carroll	10%	85%	5%
Danville	88%	12%	1%
Floyd	7%	84%	9%
Franklin	15%	81%	4%
Halifax	14%	77%	10%
Henry	34%	63%	3%
Martinsville	99%	1%	0%
Mecklenburg	31%	60%	8%
Patrick	7%	86%	7%
Pittsylvania	8%	86%	6%
North Carolina			
Caswell	10%	83%	7%
Forsyth	67%	33%	0%
Granville	36%	58%	6%
Guilford	78%	21%	1%
Orange	61%	38%	1%
Person	31%	64%	5%
Rockingham	44%	54%	2%
Stokes	15%	81%	4%
Surry	23%	75%	2%

3.5.2.2 Failed Septic Systems

In order to determine the amount of fecal coliform contributed by human sources, the failure rates of septic systems must be estimated. Septic system failures are generally attributed to the age of a system. For this TMDL model, the failure rate was assumed to be three percent of the total septic systems in the watershed (Dodd Creek TMDL, 2002). In order to determine the load of bacteria from these sources, it was assumed that the septic system design flow is 75 gallons per person per day (based on previous studies and TMDLs). In addition, it was estimated that typical fecal coliform concentrations from a failed septic system is 10,000 cfu/100mL and from a straight pipe is 1,040,000 cfu/100mL (Tinker Creek TMDL Report, 2004). **Table 3-21** shows the estimates of the population on septic systems and straight pipes, the amount of failing systems, and the flow and fecal coliform load produced daily.

Table 3-21: Estimates of the Number of Septic Systems and Straight Pipes

Category	# Failing Systems	# People per Household	People Served	Flow (gal/day)	Daily Load (#cfu/day)
Septic Systems	189	2.47	464	34,837	1.3187E+10
Straight Pipe	421	2.47	1,034	77,561	3.0534E+12

3.5.3 Livestock

An inventory of the livestock residing in the Dan River watershed was conducted using data and information provided by United States Department of Agriculture (USDA) National Agricultural Statistics Service, Virginia's Department of Conservation and Recreation, NRCS, Virginia Agricultural Statistics Service (2002), the 2001 Virginia Equine Report, North Carolina Department of Agriculture & Consumer Services Agricultural Statistics (2006-2007), Soil and Water Conservation Districts (SWCD), as well as field surveys. Original estimates were reviewed and modified by stakeholders, in particular the Blue Ridge (Franklin and Henry counties), Halifax County, Patrick County, and Pittsylvania County SWCD. **Table 3-22** summarizes the livestock inventory in the watershed.

Table 3-22: Livestock Inventory

County	Livestock Type					
	Beef Cows	Milk Cows	Hogs and Pigs	Sheep and Lambs	Chickens	Horses
Virginia						
Carroll	19	1	0	1	0	3
Danville	0	0	0	0	0	0
Floyd	343	27	0	18	130	45
Franklin	1,067	375	31	0	79	115
Halifax	8,540	4	6,700	75	28,000	550
Henry	4,115	0	0	27	296	580
Martinsville	0	0	0	0	0	0
Mecklenburg	262	21	1	0	0	26
Patrick	7,500	800	245	125	225	350
Pittsylvania	5,830	795	708	125	0	636
South Boston	0	0	0	0	0	0
VA Total	*27,676*	*2,023*	*7,685*	*371*	*28,730*	*2,305*
North Carolina						
Caswell	3,134	680	347	64	181,461	289
Forsyth	700	47	15	61	0	840
Granville	184	215	1,256	10	122	57
Guilford	75	17	128	5	2,858	65
Orange	325	0	0	8	64,000	21
Person	2,500	400	1,400	50	10	1,200
Rockingham	7,336	370	3,077	429	20,000	2,633
Stokes	2,486	365	1,425	395	90,000	1,110
Surry	1,100	300	0	0	0	0
NC Total	*17,840*	*2,394*	*7,648*	*1,022*	*358,451*	*6,215*
Watershed Total	***45,516***	***4,417***	***15,333***	***1,393***	***387,181***	***8,520***

*Numbers have been revised by local SWCDs

The livestock inventory was used to determine the fecal coliform loading by livestock in the watershed. **Table 3-23** shows the average fecal coliform production per animal per day contributed by each type of livestock.

Table 3-23: Daily Fecal Coliform Production of Livestock

Livestock Type	Daily Fecal Coliform Production (millions of cfu/day)	Reference
Cattle and calves	5,400	Metcalf and Eddy, 1991
Beef Cows	100,000	ASAE, 1998
Dairy Cows	100,000	ASAE, 1998
Hogs & Pigs	8,900	Metcalf and Eddy, 1991
	11,000	ASAE, 1998
Sheep & Lambs	18,000	Metcalf and Eddy, 1991
	12,000	ASAE, 1998
Horses & Ponies	420	ASAE, 1998
Source: USEPA Protocol for Developing Pathogen TMDLs, 2001		

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.

For the Dan River watershed, the initial estimates of the beef cattle daily schedule were based on the Dodd Creek TMDL. The amount of time beef cattle spend in the pasture and stream was also presented during the TAC meetings where local stakeholders provided comments. The monthly schedule was adjusted to reflect the conditions in the watershed.

The daily schedule for beef cattle that was accepted by the stakeholders is presented in **Table 3-24**. The daily schedule for dairy cows that was accepted by the stakeholders is presented in **Table 3-25**. The time beef cattle and dairy cows spend in the pasture, or in loafing lots(?), 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 3-24: Daily Schedule for Beef Cattle

Month	Time Spent in		
	Pasture	Stream	Loafing Lot
	(Hour)	(Hour)	(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 3-25: Daily Schedule for Dairy Cows

Month	Time Spent in		
	Pasture	Stream	Loafing Lot
	(Hour)	(Hour)	(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
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.

3.5.4 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 Dan River TMDLs.

3.5.5 Land Application of Biosolids

Non-point human sources of fecal coliform can be associated with the spreading of biosolids. Data provided by Virginia Department of Health (VDH) indicated that there have been biosolids applications in both Franklin County and Pittsylvania County, both in Virginia, in 2004 and 2005. There are no available records for biosolids application on a county basis in North Carolina. Recorded biosolids application conducted in Virginia in 2004 and 2005 is presented in **Table 3-26**.

Table 3-26: Biosolids Application by County (dry ton/year) *

County	2004	2005
Carroll	---	---
Floyd	---	---
Franklin	4,851	5,809
Halifax	0	0
Henry	---	0
Mecklenburg	---	---
Patrick	---	0
Pittsylvania	3,239	2,344

* Source: VDH

3.5.6 Wildlife

Similar to livestock contributions, wildlife contributions of fecal coliform can be both indirect and 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 wildlife inventory for this TMDL was developed based on a number of information and data sources, including: (1) habitat availability, (2) Department of Game and Inland Fisheries (DGIF) harvest data and population estimates, and (3) stakeholder comments and observations.

A wildlife inventory was conducted based on habitat availability within the watershed. The number of animals in the watershed was estimated by combining typical wildlife densities with available stream wildlife habitat. Typical wildlife densities are presented in **Table 3-27.**

Table 3-27: Wildlife Densities

Wildlife type	Population Density	Habitat Requirements
Deer	0.047 animals/acre	Entire watershed
Raccoon	0.07 animals/acre	Within 600 feet of streams and ponds
Muskrat	2.75 animals/acre	Within 66 feet of streams and ponds
Beaver	4.8 animals/mile of stream	Within 66 feet of streams and ponds
Goose	0.02 animals/acre*	Entire Watershed
Mallard	0.002 animals/acre	Entire Watershed
Wood Duck	0.0018 animals/acre	Within 66 feet of streams and ponds
Wild Turkey	0.01 animals/acre	Entire watershed excluding urban land uses
Source: Map Tech, Inc., 2001 *Source: Goose Creek TMDL, 2004; Catoctin Creek TMDL, 2004		

The wildlife inventory presented in **Table 3-28** was presented to stakeholders and local residents for approval.

Table 3-28: Dan Watersheds Wildlife Inventory

County	Wildlife Animal							
	Deer	Raccoon	Muskrat	Beaver	Goose	Mallard	Wood Duck	Wild Turkey
Virginia								
Carroll	12	16	70	8	1	0	0	3
Danville	1,335	1,285	5,555	606	114	4	4	284
Floyd	441	352	1,520	166	38	1	1	94
Franklin	3,038	3,230	13,960	1,523	259	10	9	646
Halifax	10,882	11,131	48,102	5,248	926	35	31	2,315
Henry	11,042	11,416	49,335	5,382	940	36	32	2,349
Martinsville	272	276	1,194	130	23	1	1	58
Mecklenburg	413	413	1,785	195	35	1	1	88
Patrick	13,257	13,379	57,815	6,307	1,128	42	38	2,821
Pittsylvania	9,386	9,213	39,813	4,343	799	29	26	1,997
South Boston	80	101	438	48	7	0	0	17
VA Total	*50,158*	*50,812*	*219,587*	*23,956*	*4,270*	*159*	*143*	*10,672*

Table 3-28: Dan Watersheds Wildlife Inventory								
County	Wildlife Animal							
	Deer	Raccoon	Muskrat	Beaver	Goose	Mallard	Wood Duck	Wild Turkey
North Carolina								
Caswell	11,582	11,787	50,939	5,557	986	37	33	2,464
Forsyth	2,500	2,634	11,385	1,242	213	8	7	532
Granville	735	784	3,390	370	63	2	2	156
Guilford	222	257	1,110	121	19	1	1	47
Orange	143	223	962	105	12	1	1	31
Person	7,647	7,546	32,608	3,557	651	24	21	1,627
Rockingham	13,947	13,417	57,981	6,325	1,187	42	38	2,967
Stokes	12,047	12,014	51,916	5,664	1,025	38	34	2,563
Surry	521	535	2,314	252	44	2	2	111
NC Total	*49,344*	*49,197*	*212,605*	*23,193*	*4,200*	*155*	*139*	*10,498*
Watershed Total	***99,502***	***100,009***	***432,192***	***47,149***	***8,470***	***314***	***282***	***21,170***

The wildlife inventory was used to determine the fecal coliform loading by wildlife within the watershed. **Table 3-29** shows the average fecal coliform production per animal, per day, contributed by each type of wildlife. Separation of the wildlife daily fecal coliform load into direct and indirect deposits was based on estimates of the amount of time each type of wildlife spends on land versus time spent in the stream. **Table 3-29** also shows the percent of time each type of wildlife spends in the stream on a daily basis.

Table 3-29: Fecal Coliform Production from Wildlife		
Wildlife	**Daily Fecal Production (in millions of cfu/day)**	**Portion of the Day in Stream (%)**
Deer	347	1
Raccoon	113	10
Muskrat	25	50
Goose	799	50
Beaver	0.2	90
Duck	2,430	75
Wild Turkey	93	5
Source: ASAE, 1998; Map Tech, Inc., 2000; EPA, 2001.		

3.5.7 Pets

The contribution of fecal coliform loading from pets was also examined in the assessment of fecal coliform loading to the Dan River Watershed. The two types of domestic pets that were considered as sources of bacteria in this TMDL were cats and dogs. The number of pets residing in the watershed was estimated by determining the number of households in the watershed, and multiplying this number by national average estimates of the number of pets per household as 0.543 dogs per household and 0.593 cats per household (AVMA, 2005). The original estimates based on the AVMA values were presented to stakeholders and are shown in **Table 3-30.**

Table 3-30: Pet Estimates within the Dan River Watershed

County	**Dogs**	**Cats**
Virginia		
Carroll	0	1
Danville	11,190	12,323
Floyd	82	91
Franklin	801	882
Halifax	4,298	4,733
Henry	12,841	14,141
Martinsville	3,528	3,886
Mecklenburg	209	230
Patrick	4,014	4,421
Pittsylvania	6,615	7,286
VA Total	*43,578*	*47,994*
North Carolina		
Caswell	4,236	4,665
Forsyth	5,966	6,570
Granville	169	187
Guilford	427	471
Orange	116	128
Person	5,016	5,524
Rockingham	16,252	17,898
Stokes	6,575	7,241
Surry	412	454
NC Total	*39,169*	*43,138*
Watershed Total	***82,747***	***91,132***

Fecal coliform loading from pets occurs primarily in residential areas. The load was estimated based on daily fecal coliform production rate of 5.04 $x10^2$ cfu/day per cat and 4.09 $x10^9$ cfu/day per dog.

4.0 Modeling Approach

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

4.1 Modeling Goals

The goals of the modeling approach were to develop a predictive tool for the water body 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 in-stream pollutant concentrations and loadings under the various hydrologic conditions
- allow for direct comparisons between the in-stream conditions and the water quality standard

4.2 Watershed Boundaries

The impaired streams are located in the Dan River Basin in Virginia (USGS Cataloging Unit 3010103). Tributaries in the Dan River Basin include the Sandy River, Smith River, and the Mayo River. Segments of the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds are included as impaired.

The watershed that encompasses the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River bacteria impairments is approximately 2,117,103 acres. The watershed drains portions of Carroll, Floyd, Franklin, Halifax, Henry, Mecklenburg, Patrick, and Pittsylvania counties in Virginia, as well as Caswell, Forsyth, Granville, Guilford, Orange, Person, Rockingham, Stokes, and Surry counties in North Carolina. **Figure 4-1** shows the boundaries of the watershed that encompasses the impairments.

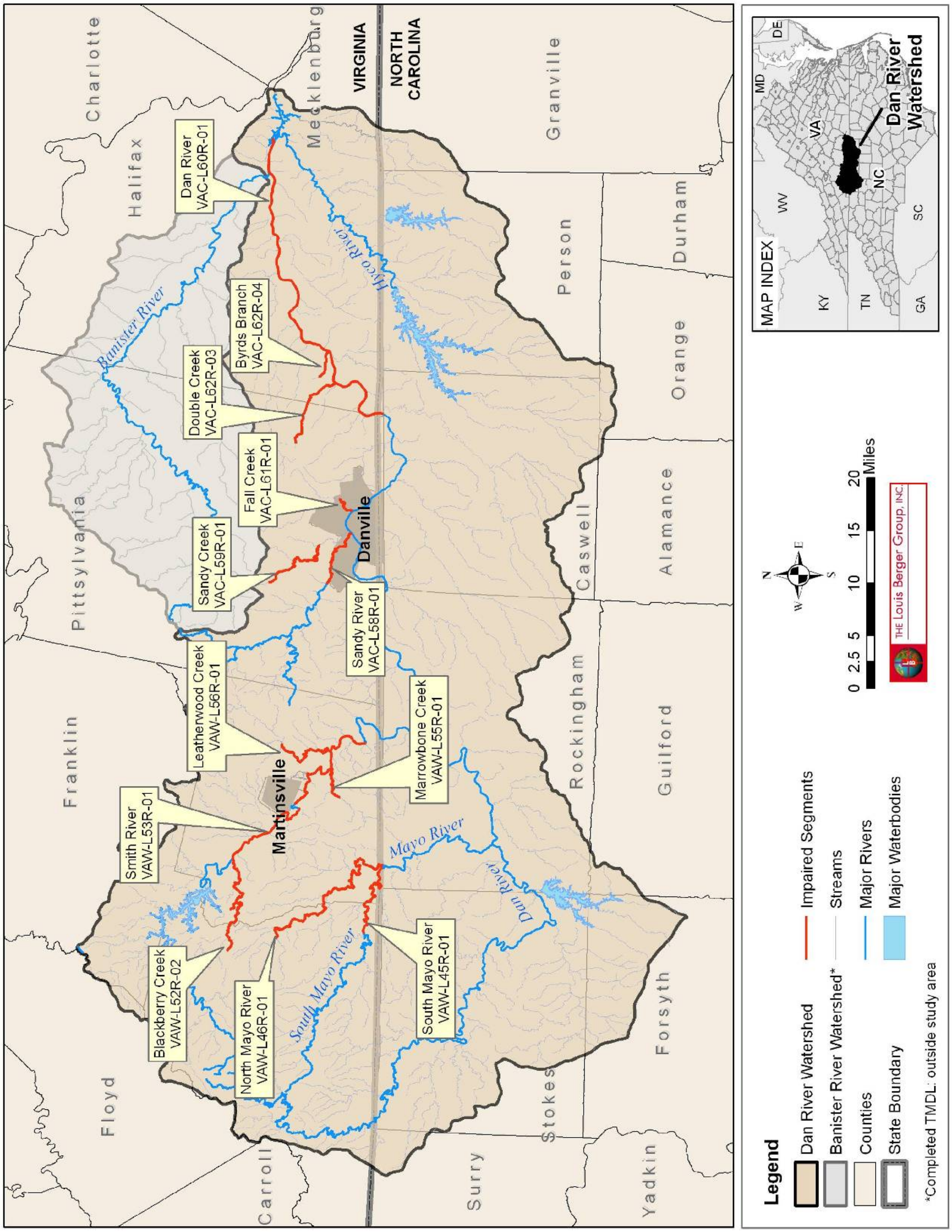

Figure 4-1: Watershed Boundary

4.3 Modeling Strategy

4.3.1 Model Selection

The Hydrologic Simulation Program-Fortran (HSPF) model was selected and used to predict the in-stream water quality conditions under varying scenarios of rainfall and fecal coliform loading. The results from the developed model are subsequently used to develop the TMDL allocations based on the existing fecal coliform load.

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 modeling process in HSPF starts with the following steps:

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

These steps are discussed in the next sections.

4.3.2 Modeling Approach – Boundary Conditions

There are twelve bacteria impaired segments in the Dan River watershed for which TMDLs are being developed. All of these streams flow into the Dan River, which then flows into the Roanoke River Basin.

Although the Banister River flows into the very end of the impaired Dan River segment, the Banister TMDL has not been included. The Banister River joins the Dan River below all calibration and validation stations and would therefore have no impact on the TMDL allocation scenarios for the impaired segments within the Dan River watershed.

4.4 Watershed Delineation

For this TMDL, the river watershed was delineated into 125 smaller subwatersheds to represent the watershed characteristics and to improve the accuracy of the HSPF model. This delineation was based on topographic characteristics, and was created using a Digital Elevation Model (DEM), stream reaches obtained from the National Hydrography Dataset (NHD), and stream flow and in-stream water quality data. Size distributions for the 125 subwatersheds are presented in **Table 4-1.** **Figure 4-2** is a map showing the delineated subwatersheds for Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River. As noted in **Figure 4-2**, the Hyco River watershed was not included in the modeling as it flows into the Dan River downstream of the impaired segment and therefore does not impact the hydrology or water quality of the impaired segments.

Table 4-1: Subwatershed Delineation

Sub-watershed	Drainage Area (acres)		Sub-watershed	Drainage Area (acres)		Sub-watershed	Drainage Area (acres)
1	7,946		43	16,227		85	16,594
2	20,217		44	14,446		86	13,038
3	4,131		45	18,848		87	2,139
4	18,731		46	7,711		88	24,851
5	9,643		47	2,668		89	15,829
6	40,448		48	2,094		90	7,511
7	10,014		49	24,308		91	17,080
8	6,481		50	8,707		92	28,010
9	1,812		51	17,859		93	27,741
10	18,325		52	20,892		94	8,884
11	9,212		53	31,071		95	3,518
12	19,140		54	439		96	19,520
13	12,238		55	9,977		97	3,073
14	2,619		56	3,604		98	12,525
15	5,634		57	16,843		99	20,590
16	13,917		58	11,693		100	46,092
17	3,413		59	17,618		101	28,582
18	1,459		60	9,870		102	11,083
19	250		61	19,224		103	23,816
20	3,410		62	1,666		104	11,908
21	11,720		63	16,649		105	12,587
22	23,896		64	718		106	27,516
23	3,140		65	14,073		107	10,478
24	20,654		66	11,185		108	10,565
25	139		67	3,094		109	8,643
26	5,920		68	14,418		110	1,559
27	28,537		69	883		111	14,169
28	25,135		70	2,362		112	11,590
29	17,659		71	34,931		113	15,884
30	12,319		72	4,091		114	23,750
31	27,553		73	1,461		115	14,980
32	27,090		74	2,094		116	43,983
33	22,626		75	17,326		117	25,141
34	5,266		76	4,870		118	12,952
35	12,675		77	33,629		119	29,172
36	13,390		78	10,714		120	31,174
37	11,020		79	1,152		121	16,082
38	17,126		80	8,656		122	24,701
39	18,616		81	12,469		123	35,587
40	2,510		82	1,868		124	28,556
41	10,623		83	769		125	25,217
42	7,303		84	37,141			
Acreage Grand Total				**1,790,947**			

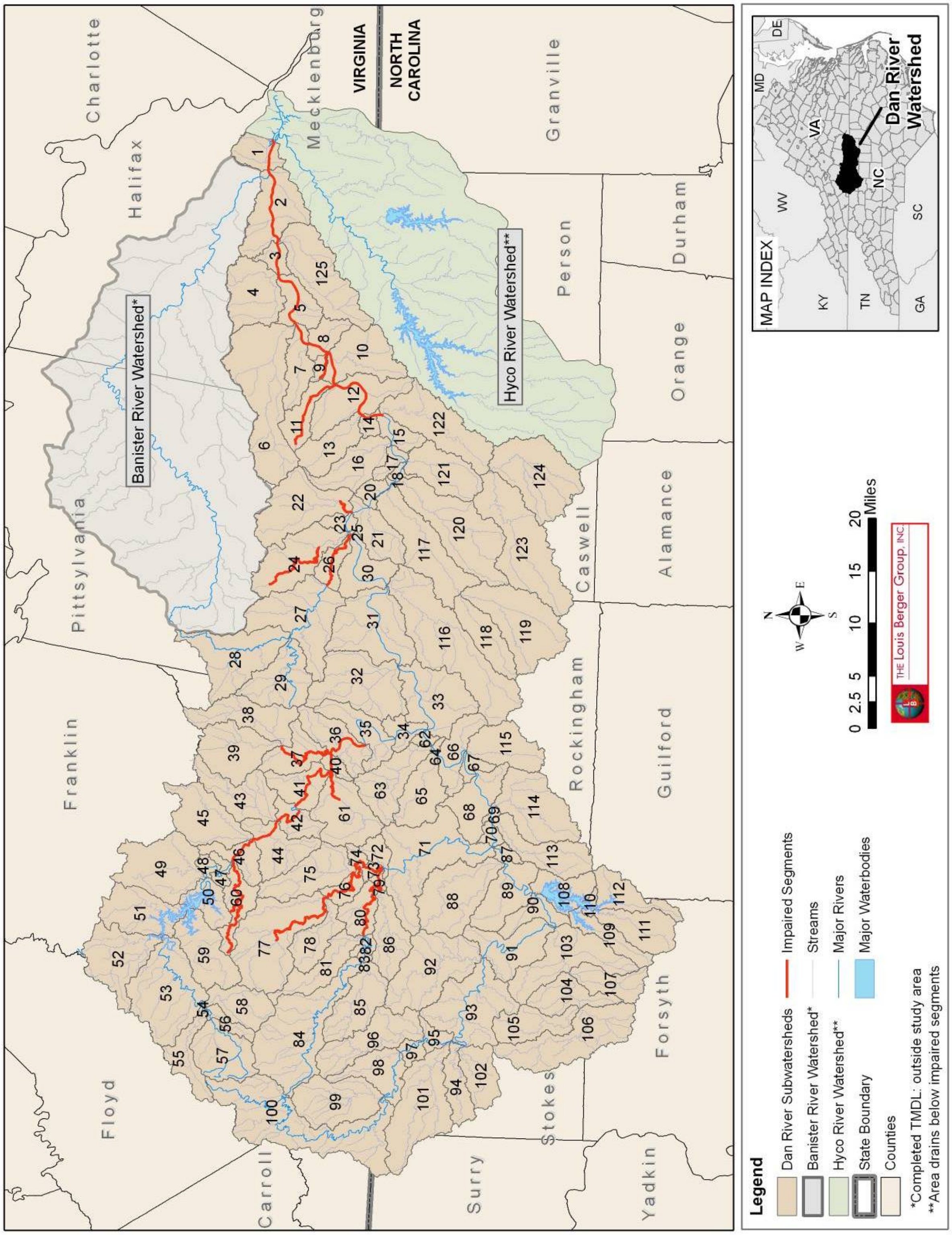

Figure 4-2: Subwatershed Delineation

4.5 Land Use Reclassification

As previously mentioned, land use distribution in the study area was determined using USGS NLCD data. The land use data and distribution of land uses were presented in Chapter 3. There are 14 land use classes present in the watershed; the dominant land uses are forest and agriculture. The original 14 land use types were consolidated into 8 land use categories to meet modeling goals, facilitate model parameterization, and reduce modeling complexity. This reclassification reduced the 14 land use types to a representative number of categories that best describe conditions and the dominant fecal coliform source categories in the Dan River basin. Land use reclassification was based on similarities in hydrologic characteristics and potential fecal coliform production characteristics. The reclassified land uses are presented in **Tables 4-2** through **4-14** for Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River.

Table 4-2: Dan River Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	94,747	5%
Cropland	10,571	<1%
Forest	1,213,436	68%
High Density Residential	3,737	<1%
Medium Density Residential	8,084	<1%
Low Density Residential	28,317	2%
Pasture	404,838	23%
Water/Wetland	27,248	1%
Total	**1,790,978**	**100%**

Table 4-3: Blackberry Creek Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	676	7%
Cropland	18	<1%
Forest	7,888	80%
Medium Density Residential	12	<1%
Low Density Residential	110	1%
Pasture	1,160	12%
Water/Wetland	6	<1%
Total	**9,870**	**100%**

Table 4-4: Byrds Branch Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	87	5%
Cropland	16	1%
Forest	1,185	65%
Low Density Residential	1	<1%
Pasture	510	28%
Water/Wetland	13	<1%
Total	**1,812**	**100%**

Table 4-5: Double Creek Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	251	3%
Cropland	75	<1%
Forest	6,610	72%
Low Density Residential	26	<1%
Pasture	2,198	24%
Water/Wetland	52	<1%
Total	**9,212**	**100%**

Table 4-6: Fall Creek Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	2,249	9%
Cropland	269	1%
Forest	13,083	55%
High Density Residential	154	<1%
Medium Density Residential	466	2%
Low Density Residential	1,371	6%
Pasture	6,236	26%
Water/Wetland	69	<1%
Total	**23,897**	**100%**

Table 4-7: Leatherwood Creek Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	1,917	4%
Cropland	50	<1%
Forest	35,430	76%
High Density Residential	18	<1%
Medium Density Residential	96	<1%
Low Density Residential	626	1%
Pasture	8,385	18%
Water/Wetland	240	<1%
Total	**46,762**	**100%**

Table 4-8: Marrowbone Creek Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	944	5%
Cropland	11	<1%
Forest	14,797	77%
High Density Residential	65	<1%
Medium Density Residential	126	<1%
Low Density Residential	374	2%
Pasture	2,799	15%
Water/Wetland	109	<1%
Total	**19,225**	**100%**

Table 4-9: North Fork Mayo River Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	2,667	4%
Cropland	147	<1%
Forest	54,687	78%
High Density Residential	2	<1%
Medium Density Residential	64	<1%
Low Density Residential	299	<1%
Pasture	12,101	17%
Water/Wetland	129	<1%
Total	**70,096**	**100%**

Table 4-10: Smith River (Upper Segment) Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	12,730	5%
Cropland	350	<1%
Forest	190,597	79%
High Density Residential	631	<1%
Medium Density Residential	1,604	<1%
Low Density Residential	4,989	2%
Pasture	27,904	12%
Water/Wetland	3,376	1%
Total	**242,181**	**100%**

Table 4-11: Smith River (Lower Segment) Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	17,509	5%
Cropland	491	<1%
Forest	259,126	77%
High Density Residential	895	<1%
Medium Density Residential	2,196	1%
Low Density Residential	7,127	2%
Pasture	43,363	13%
Water/Wetland	3,985	1%
Total	**334,692**	**100%**

Table 4-12: South Fork Mayo River Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	4,305	5%
Cropland	278	<1%
Forest	67,832	74%
High Density Residential	11	<1%
Medium Density Residential	119	<1%
Low Density Residential	381	<1%
Pasture	18,655	20%
Water/Wetland	109	<1%
Total	**91,690**	**100%**

Table 4-13: Sandy Creek Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	1,686	8%
Cropland	205	1%
Forest	11,230	54%
High Density Residential	106	<1%
Medium Density Residential	158	<1%
Low Density Residential	685	3%
Pasture	6,545	32%
Water/Wetland	40	<1%
Total	**20,655**	**100%**

Table 4-14: Sandy River Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
Commercial/Industrial	3,667	5%
Cropland	519	<1%
Forest	47,005	61%
High Density Residential	141	<1%
Medium Density Residential	189	<1%
Low Density Residential	914	1%
Pasture	24,599	32%
Water/Wetland	219	<1%
Total	**77,253**	**100%**

4.6 Hydrographic Data

Hydrographic data describing the stream network of the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River were obtained from the National Hydrography Dataset (NHD). These data were used for HSPF model development and TMDL development. Information regarding the reach number, reach name, and length of each stream segment of Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River are included in the NHD database. Due to the size of this basin, reach information for the entire Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River drainage is presented in Appendix A.

The stream geometry was obtained from topographic (DEM) data using GIS. The stage flow relationship required by HSPF was developed based on the USGS stream flow gage data for the Dan River.

The Dan River and its tributaries were represented as irregular channels based on actual data. The channel slopes were estimated using the reach length and the corresponding change in elevation from DEM data. The flow was calculated using the Manning's equation using a 0.05 roughness coefficient. Model representation of the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River stream reach segments is presented in Appendix A.

4.7 Fecal Coliform Sources Representation

This section discusses how the fecal coliform sources identified in Chapter 3 were included or represented in the model. These sources include permitted sources, human sources (failed septic systems and straight pipes), livestock, wildlife, pets, and land application of manure and biosolids.

4.7.1 Permitted Facilities

In Virginia, there are 24 individual permitted facilities and 32 general permits, which include permits for residences, businesses, a Post office, and an Airport. In North Carolina, there are 57 individual permitted facilities in the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds. The permit number, design flow, and status for each facility were presented in **Table 3-12**.

For TMDL development, average discharge flow values were considered representative of flow conditions at each permitted facility, and were used in HSPF model set-up and calibration. For TMDL allocation development, permitted facilities were represented as constant sources discharging at their design flow and permitted fecal coliform concentrations.

4.7.2 Failed Septic Systems

Failed septic system loading to the streams in the Dan River watershed can be direct (point) or land-based (indirect or non-point), depending on the proximity of the septic system to the stream. 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). For TMDL development, it was assumed that a 3% failure rate for septic systems would be representative of conditions in the watershed. As explained in Chapter 3, the number of failed septic systems (including straight pipes and septic systems) in the watersheds that were within this 200-foot buffer was estimated at 610 systems. After excluding the numbers within the Hyco River watershed for the purposes of modeling, this number is reduced to 573 systems. Therefore, the failed septic system load was considered a land-based load in the watershed.

To account for uncontrolled discharges in the watershed and failed septic systems within the stream buffer, a total of 405 straight pipes were included in the model. This number is slightly less than the 421 straight pipes listed in Chapter 3 due to the exclusion of the Hyco River watershed from the modeling. This estimate was based on, discussions with DCR and DEQ, stakeholder comments, evaluation of the BST results, and 1990 Census data which indicated that approximately 4.3% of households in the watershed are on other treatment systems.

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' design flow of 75 gallons per person per day and a fecal coliform concentration of 10,000 cfu/100ml were used in the fecal coliform load calculations. Fecal coliform loading from failed septic systems that are not within the 200-foot buffer of the stream is considered to be a predominantly indirect source. Failed septic systems within the stream buffer and straight pipes were represented as constant sources of fecal coliform. **Table 4-15** shows the distribution of the septic systems and the straight pipes in the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds. The monthly load from septic systems is presented in Appendix E.

Table 4-15: Failed Septic Systems and Straight Pipes Assumed in Model Development

Sub-watershed ID	# of Septic Systems (Total)	# of Failed Septic Systems (200ft of Stream)	# of Straight Pipes	Sub-watershed ID	# of Septic Systems (Total)	# of Failed Septic Systems (200ft of Stream)	# of Straight Pipes
1	209	0	1	**64**	39	0	0
2	498	1	3	**65**	766	2	2
3	98	0	1	**66**	609	1	1
4	493	2	3	**67**	169	0	0
5	254	1	1	**68**	785	2	2
6	1508	3	6	**69**	48	0	0
7	279	1	1	**70**	129	0	0
8	171	0	1	**71**	1808	4	4
9	48	0	0	**72**	247	1	1
10	519	1	2	**73**	93	0	0
11	410	1	1	**74**	133	0	1
12	626	1	2	**75**	1099	2	6
13	641	2	2	**76**	293	1	2
14	127	0	0	**77**	1043	2	3
15	154	0	0	**78**	243	1	0
16	752	2	7	**79**	70	0	0
17	108	0	0	**80**	285	1	1
18	38	0	0	**81**	281	1	0
19	7	0	0	**82**	42	0	0
20	229	1	7	**83**	17	0	0
21	767	2	27	**84**	837	2	1
22	1383	3	17	**85**	386	2	0
23	273	1	12	**86**	467	1	1
24	1129	3	8	**87**	116	0	0
25	12	0	1	**88**	1119	3	3
26	417	1	12	**89**	709	2	2
27	1498	3	5	**90**	287	1	1
28	1362	3	5	**91**	654	1	2
29	1002	2	4	**92**	1072	2	3
30	802	2	22	**93**	1061	2	3
31	1463	3	4	**94**	340	1	1
32	1460	3	5	**95**	135	0	0
33	1232	3	3	**96**	559	1	1
34	287	1	1	**97**	118	0	0
35	789	2	4	**98**	394	1	1
36	849	2	5	**99**	471	1	0
37	699	2	4	**100**	1163	3	1
38	1026	2	5	**101**	1182	3	3
39	1135	3	6	**102**	424	1	1
40	159	0	1	**103**	1094	2	9
41	522	1	16	**104**	516	1	3
42	391	1	8	**105**	482	1	1
43	918	2	11	**106**	1359	3	14

Table 4-15: Failed Septic Systems and Straight Pipes Assumed in Model Development

Sub-watershed ID	# of Septic Systems (Total)	# of Failed Septic Systems (200ft of Stream)	# of Straight Pipes	Sub-watershed ID	# of Septic Systems (Total)	# of Failed Septic Systems (200ft of Stream)	# of Straight Pipes
44	916	2	5	**107**	646	1	10
45	996	2	5	**108**	496	1	1
46	489	1	3	**109**	515	1	7
47	169	0	1	**110**	73	0	1
48	133	0	1	**111**	966	2	17
49	652	1	2	**112**	647	1	12
50	423	1	2	**113**	865	2	2
51	340	1	1	**114**	1294	3	3
52	372	1	1	**115**	816	3	2
53	671	2	1	**116**	2260	5	5
54	10	0	0	**117**	737	2	3
55	212	0	0	**118**	705	2	1
56	81	0	0	**119**	1484	3	3
57	380	1	0	**120**	819	2	1
58	264	1	0	**121**	422	1	0
59	397	1	0	**122**	649	1	0
60	529	1	3	**123**	994	2	1
61	1218	3	6	**124**	750	2	1
62	91	0	0	**125**	664	1	3
63	958	2	3				
Total					**74991**	**168**	**405**

4.7.3 Livestock

Livestock contribution to the total fecal coliform load in the watershed was represented in a number of ways, which are presented in **Figure 4-3**. 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.

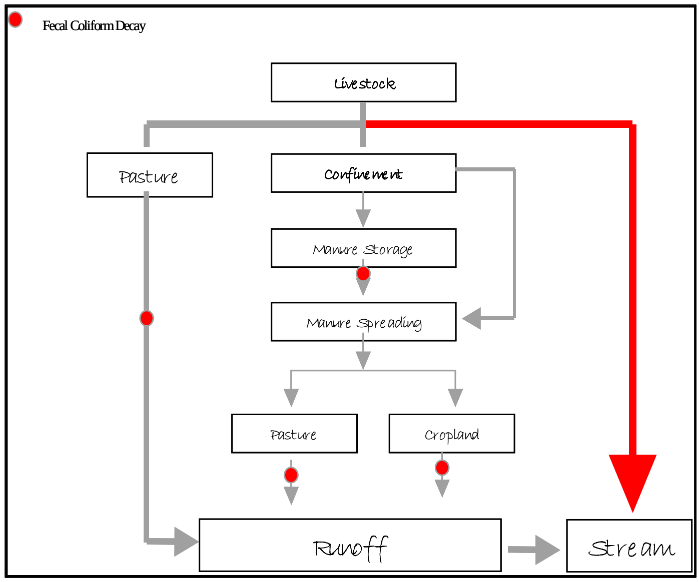

Figure 4-3: Livestock Contribution to Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds

Based on the inventory of livestock in the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds, it was determined that cattle and chickens are the predominant types of livestock. The inventory indicated that there are also horses, sheep, and swine in the watershed. Twenty-two animal operations are permitted in the watershed: eight in Virginia and 14 in North Carolina. Of the 22, 14 are hog farms, seven are dairy cattle operations, and one is a beef cattle operation. Appendix B provides a summary of the wildlife and livestock within each subwatershed.

The distribution of the daily fecal coliform load between direct in-stream 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 3.

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. The monthly loading rates are presented in Appendix C.

4.7.4 Land Application of Manure

Hog, beef cattle, and dairy operations are present in the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds. It was assumed that the daily produced manure is applied to pastureland in the watershed, and was treated as an indirect source in the development of the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River TMDL. 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.

4.7.5 Land Application of Biosolids

Biosolids application in the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watershed was considered under this TMDL development. Biosolids were modeled as land based loads applied to crop and pasture lands in each watershed. The loads modeled were based on county specific annual application estimates reported by the Virginia Department of Health. At the time of this TMDL preparation, there was no county-specific biosolids data available for North Carolina (NC DENR, 2006).

4.7.6 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 3). 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 Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River 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.

4.7.7 Pets

For the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River TMDL, pet fecal coliform loading was considered a land-based load that was primarily deposited in residential areas of 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.

4.8 Fecal Coliform Die-off Rates

Representative fecal coliform decay rates were included in the HSPF model developed for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds. 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.

In the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River TMDLs, in-storage die-off was not included in the model because there is no manure storage facility located in the watershed. Decay rates of 1.37 and 1.152 per day were used to estimate die-off rates for on-surface and in-stream fecal coliform, respectively (EPA, 1985).

4.9 Model Set-up, 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.

4.9.1 Model Set-Up

The HSPF model was set up based on flow data taken at two USGS stations within the watershed, one for calibration and the other for validation. A total of ten USGS gaging stations had available data and flows were modeled at each station to be sure of proper model calibration. However, only the two selected stations were used in for the formal calibration-validation process. A complete list of USGS streamflow stations were presented in Section 3.3. The two selected stations are presented in **Table 4-16**.

Table 4-16: USGS Flow Stations used for Hydrology Calibration and Validation

Station ID	Station Name	Station Type	Area (mi^2)	Begin Date	End Date
02071000	Dan River near Wentworth, NC	Calibration	1,044	1/1/1995	12/31/2005
02075500	Dan River at Paces, VA	Validation	2,585	1/1/1995	12/31/2005

4.9.1.1 Stream Flow Data

These two stations were selected because of their locations within the watershed. Station 02075500 (Dan River at Paces, VA) has a drainage area of 2,585 square miles and is the most downstream station, with continuous record, from the impaired segment of the Dan River. Station 02071000 (Dan River near Wentworth, NC) drains 1,044 square miles, is located on the Dan River in the upstream part of the watershed, has continuous records, and drains several tributaries within the study area. The entire drainage area of the area of concern is 2,800 square miles. In other words, the two flow stations selected for the hydrology calibration and verification capture the complete hydrologic response within the study area. Average flow data for the period of 1995 to 2005 for these two stations are plotted in **Figures 4-4** and **4-5**.

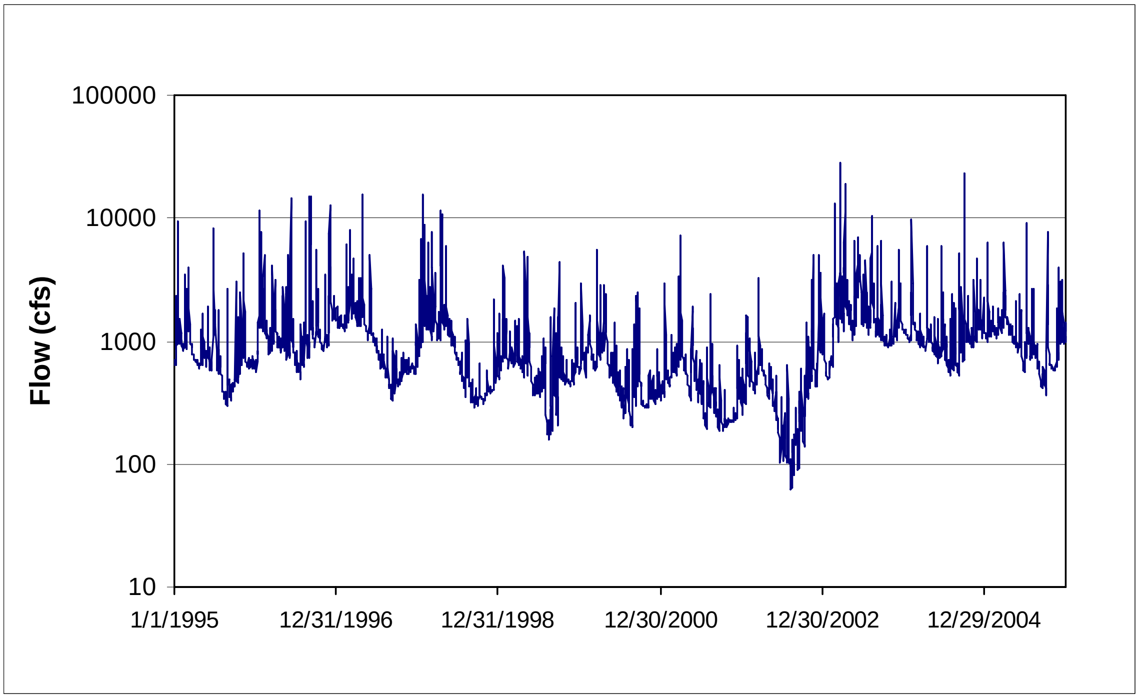

Figure 4-4: Daily Mean Flow at USGS Station 02071000 (Dan River at Wentworth, NC)

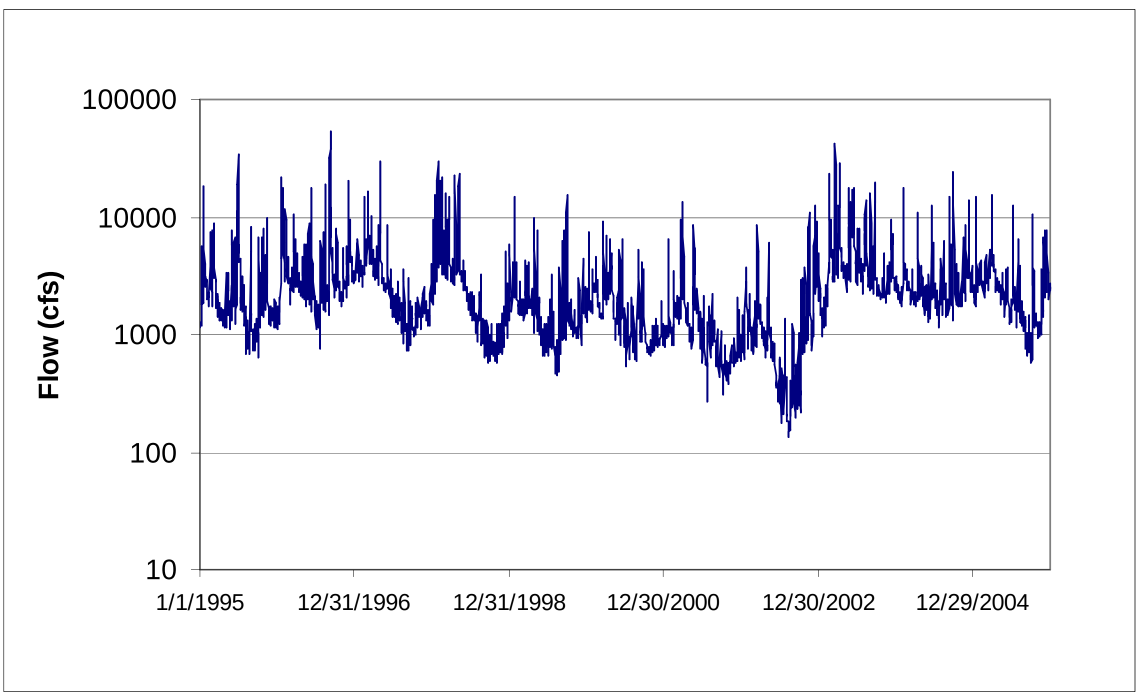

Figure 4-5: Daily Mean Flow at USGS Station 02075500 (Dan River at Paces, VA)

An eleven-year period (1995-2005) was selected as both the calibration and validation period for Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River hydrologic model.

4.9.1.2 Rainfall and Climate Data

Weather data for the Roanoke International Airport, the Greensboro WSO Airport, and the Lynchburg International Airport were obtained from the National Climatic Data Center (NCDC). The data include meteorological data (hourly precipitation) and surface airways data (including wind speed/direction, ceiling height, dry bulb temperature, dew point temperature, and solar radiation). For this TMDL, the recorded data at the three stations were combined based on their proximity to each model segment in the watershed. After several iterations of weighted-combinations of the data from the three stations, the final weather-stations' combined record for each segment is shown in **Table 4-17**.

Table 4-17: Proportion of Rainfall from each Gauging Stations used for Hydrology Calibration and Validation

Model Segments	Greensboro WSO Airport (%)	Roanoke Airport (%)	Lynchburg Airport (%)
1-14, 16, 20-32, 125, 126	0	0	100
15,17-19, 33-124	70	30	0

4.9.2 Model Hydrologic Calibration Results

HSPEXP software was used to calibrate the hydrology of the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds. After each iteration of the model, 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 Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River model was calibrated for January 1995 to December 2005 at the flow station 02071000 (Dan River near Wentworth, NC). Calibration results at station USGS 02071000 are presented in **Table 4-18**, showing the simulated and observed values for nine flow characteristics. An error statistics summary for seven flow conditions is presented in **Table 4-19**. The breakdown of the overall percent base, storm and interflow contribution is presented in **Table 4-20**. The model results and the observed daily average flow at the calibration station are plotted in **Figure 4-6**.

Table 4-18: USGS 02071000 (Dan River near Wentworth, NC) Model Calibration Results

Category	Simulated	Observed
Total runoff, in inches	162.50	154.08
Total of highest 10% flows, in inches	52.44	52.81
Total of lowest 50% flows, in inches	35.54	34.74
Evapotranspiration, in inches	254.50	416.50
Total storm volume, in inches	2.76	2.89
Baseflow recession rate	0.97	0.97
Summer flow volume, in inches	28.51	31.57
Winter flow volume, in inches	46.83	43.26
Summer storm volume, in inches	0.22	0.23

Table 4-19: USGS 02071000 (Dan River near Wentworth, NC) Model Calibration Error Statistics

Category	Current	Criterion
Error in total volume	5.50	± 10.000
Error in low flow recession	0.00	± 0.01
Error in 50% lowest flows	2.30	± 10.000
Error in 10% highest flows	-0.70	± 15.000

Table 4-20: USGS 02071000 (Dan River near Wentworth, NC) Simulation Water Budget

Year	Surface Runoff (inch)	Interflow (inch)	Base flow (inch)	Surface runoff	Interflow	Base flow
2000	1.12	1.33	10.40	9%	10%	81%
2001	0.63	0.16	5.90	9%	2%	88%
2002	0.97	0.49	9.60	9%	4%	87%
2003	2.27	6.69	19.80	8%	23%	69%
2005	1.14	2.45	10.00	8%	18%	74%
Average	**1.16**	**1.92**	**10.72**	**8%**	**14%**	**78%**

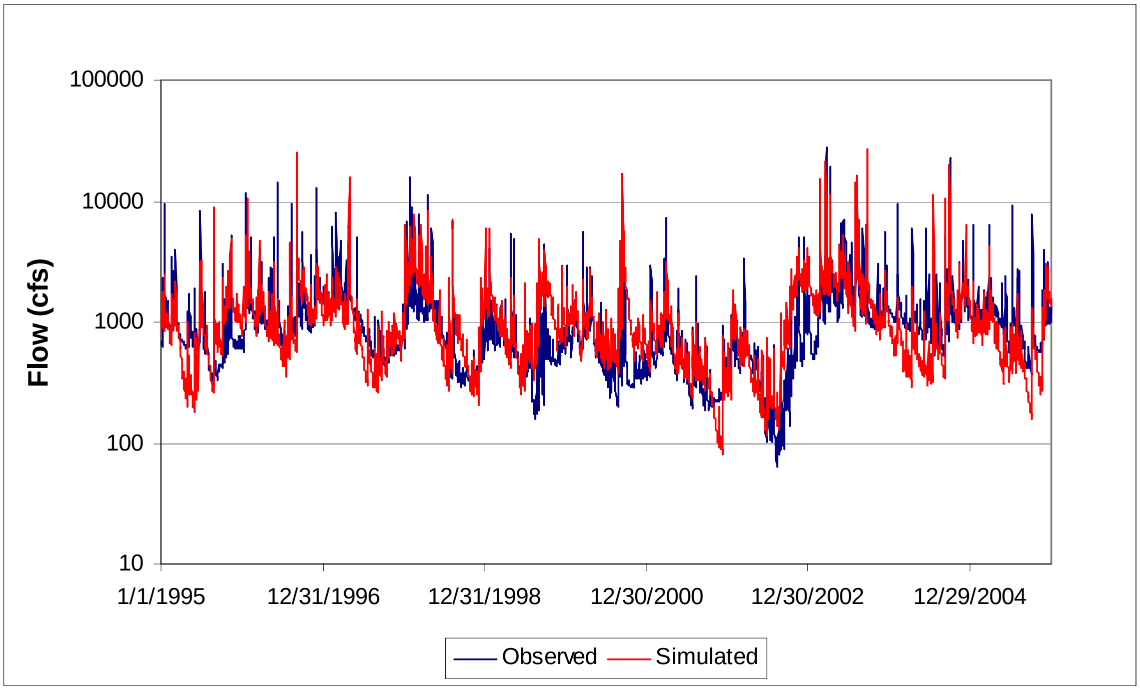

Figure 4-6: USGS 02071000 (Dan River at Wentworth, NC) Model Hydrologic Calibration Results

4.9.3 Model Hydrologic Validation Results

The period of January 1995 to December 2005 was used to validate the HSPF model. Model validation results at the USGS 02075500 (Dan River at Paces, VA) are presented in **Table 4-21**, showing the simulated and observed values for nine flow characteristics. An error statistics summary for seven flow conditions is also presented for this station in **Table 4-22**.

The error statistics indicate that the validation results were within the recommended ranges in HSPF. The breakdown of the overall percent base, storm and interflow contribution is presented in **Table 4-23** for the USGS Station 02075500. The model's hydrology validation results are plotted in **Figure 4-7**. For comparison, Figure 4-11 present the validation results of the Mayo River.

Table 4-21: USGS 02075500 (Dan River at Paces, VA) Model Validation Results

Category	Simulated	Observed
Total runoff, in inches	163.70	158.95
Total of highest 10% flows, in inches	55.20	56.07
Total of lowest 50% flows, in inches	33.25	34.28
Evapotranspiration, in inches	257.60	416.50
Total storm volume, in inches	2.60	1.53
Baseflow recession rate	0.95	0.94
Summer flow volume, in inches	28.79	32.65
Winter flow volume, in inches	48.25	44.97
Summer storm volume, in inches	0.20	0.24

Table 4-22: USGS 02075500 (Dan River at Paces, VA) Model Validation Error Statistics

Category	Current	Criterion
Error in total volume	3.00	± 10.000
Error in low flow recession	-0.01	± 0.01
Error in 50% lowest flows	-3.00	± 10.000
Error in 10% highest flows	-1.60	± 15.000

Table 4-23: USGS 02075500 (Dan River at Paces, VA) Validation Water Budget

Year	Surface Runoff (inch)	Interflow (inch)	Base flow (inch)	Surface runoff	Interflow	Base flow
2001	1.08	1.31	10.90	8%	10%	82%
2002	0.61	0.15	6.30	9%	2%	89%
2003	0.94	0.47	9.40	9%	4%	87%
2004	2.20	6.60	20.60	7%	22%	70%
2005	1.11	2.42	10.40	8%	17%	75%
Average	**0.61**	**0.15**	**6.30**	**9%**	**2%**	**89%**

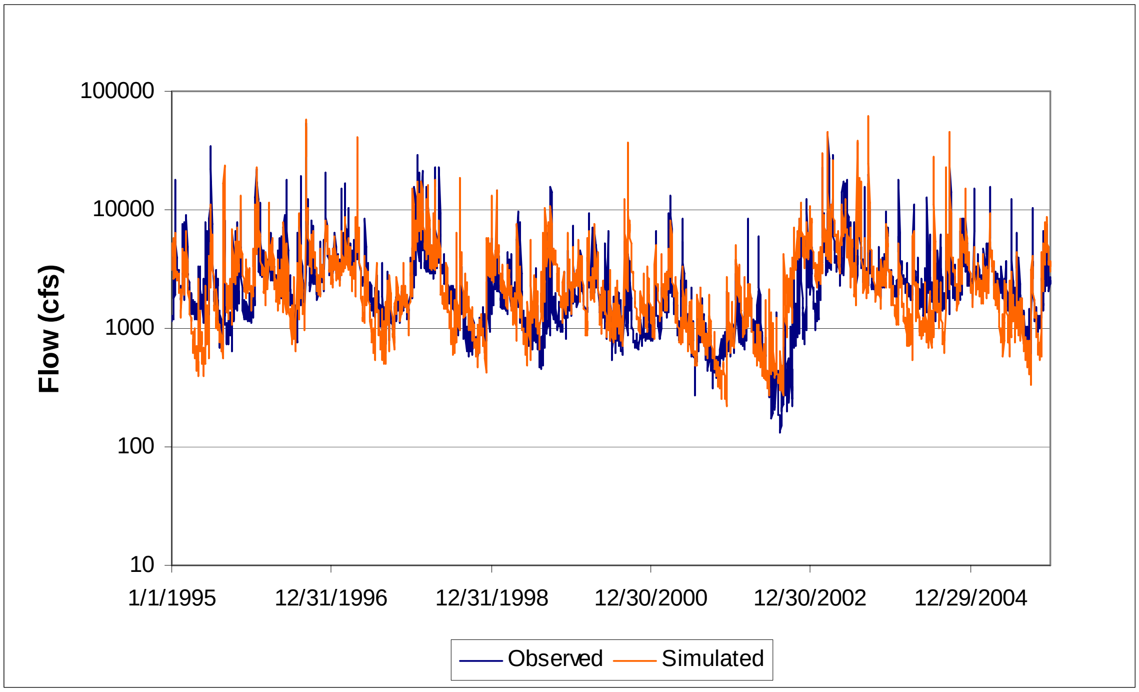

Figure 4-7: USGS 02075500 (Dan River at Paces, VA) Model Hydrologic Calibration Results

There is 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. The final parameter values of the calibrated model are listed in **Table 4-24**.

Table 4-24: Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds HSPF Calibration Parameters (Typical, Possible and Final Values)

Parameter	Definition	Units	Typical		Possible		Final
			Min	Max	Min	Max	
FOREST	Fraction forest cover	None	0.00	0.5	0	0.95	0.0-1.0
LZSN	Lower zone nominal soils moisture	inch	3	8	2	15	3.5-5.0
INFILT	Index to infiltration capacity	Inch/hour	0.01	0.25	0.001	0.5	0.22-0.24
LSUR	Length of overland flow	Ft	200	500	100	700	350
SLSUR	Slope of overland flowplane	None	0.01	0.15	0.001	0.3	0.02
KVARY	Groundwater recession variable	1/inch	0	3	0	5	0
AGWRC	Basic groundwater recession	None	0.92	0.99	0.85	0.999	0.88-0.97
PETMAX	Air temp below which ET is reduced	Deg F	35	45	32	48	40
PETMIN	Air temp below which ET is set to zero	Deg F	30	35	30	40	32
INFEXP	Exponent in infiltration equation	None	2	2	1	3	2
INFILD	Ratio of max/mean infiltration capacities	None	2	2	1	3	2
DEEPER	Fraction of groundwater inflow to deep recharge	None	0	0.2	0	0.5	0
BASETP	Fraction of remaining ET from base flow	None	0	0.05	0	0.2	0.15
AGWETP	Fraction of remaining ET from active groundwater	None	0	0.05	0	0.2	0.15
CEPSC	Interception storage capacity	Inch	0.03	0.2	0.01	0.4	0.05
UZSN	Upper zone nominal soils moisture	inch	0.10	1	0.05	2	0.1 - 0.25
NSUR	Manning's n	None	0.15	0.35	0.1	0.5	0.2-0.3

Table 4-24: Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds HSPF Calibration Parameters (Typical, Possible and Final Values)

Parameter	Definition	Units	Typical		Possible		Final
			Min	Max	Min	Max	
INTFW	Interflow/surface runoff partition parameter	None	1	3	1	10	1.9
IRC	Interflow recession parameter	None	0.5	0.7	0.3	0.85	0.3
LZETP	Lower zone ET parameter	None	0.2	0.7	0.1	0.9	0.2 - 0.35
RETSC	Retention storage capacity of the surface	inch					---
ACQOP	Rate of accumulation of constituent	#/ac day					1.744E7 – 1.19E10
SQOLIM	Maximum accumulation of constituent	#					3.12E7 – 2.13E10
WSQOP	Wash-off rate	Inch/hour					0.55 - 1.2
IOQC	Constituent concentration in interflow	#/CF					1416
AOQC	Constituent concentration in active groundwater	#/CF					283
KS	Weighing factor for hydraulic routing						0.5
FSTDEC	First order decay rate of the constituent	1/day					1.152
THFST	Temperature correction coefficient for FSTDEC	none					1.07

4.9.4 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 in-stream fecal coliform data, and the model parameters are adjusted until there is an acceptable agreement between the observed and simulated in-stream 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 3, in-stream monitoring stations on the impaired segments were listed and sampling events conducted on the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River were summarized and presented. **Table 4-25** lists the stations assessed for the water quality calibration. Final calibration used water quality station 4ADAN015.30 along the Dan River and final validation used water quality used water quality station 4ADBC002.19 along Double Creek.

Table 4-25: Water Quality Station used in the HSPF Fecal Coliform Simulations

Watershed	Water Quality Station	HSPF Model segment
Dan River	4ADAN015.30	2
Dan River	4ADAN042.80	15
Blackberry Creek	4ABRY000.05	60
Byrds Branch	4ABYR000.80	9
Double Creek	4ADBC002.19	11
Fall Creek	4AFAL001.58	22
Leatherwood Creek	4ALWD002.54	37
Marrowbone Creek	4AMRR000.02	61
North Fork Mayo River	4ANMR002.60	73
Sandy Creek	4ASCR007.06	24
Sandy River	4ASRV000.20	26
Smith River	4ASRE015.43	36
Smith River	4ASRE022.71	41
Smith River	4ASRE033.19	44
South Fork Mayo River	4ASMR004.14	80

The period used for water quality calibration of the model and the period (1998-2005) used for model validation were the same and depended on the time the water quality observations were collected. It is important to keep in mind that the observed fecal coliform concentrations are instantaneous values that are highly dependent on the time and location the sample was collected. The model-simulated fecal coliform concentrations represent the average daily values. **Figure 4-8** summarizes the calibration results of the HSPF fecal coliform simulations for the Dan River station and **Figure 4-9** summarizes the validation results of the HSPF fecal coliform simulations for the Double Creek stations. Results from all station used in the HSPF fecal coliform simulations are summarized in Appendix D.

The goodness of fit for the water quality calibration was evaluated visually. Analysis of the model results indicated that the model was capable of predicting the range of fecal coliform concentrations under both wet and dry weather conditions, and thus was well-calibrated. **Table 4-26** shows the observed and simulated geometric mean fecal coliform concentration for all 15 stations spanning the period from 1998 to 2005. **Table 4-27** shows the observed and simulated exceedance rates for all 15 stations of the 400 cfu/100 ml instantaneous fecal coliform standard.

Table 4-26: Observed and Simulated Geometric Mean Fecal Coliform Concentration 1998-2005

Reach	Water Quality Station	Watershed	Geometric Mean (cfu/100ml)	
			Observed	Simulated
2	4ADAN015.30	Dan River	213	228
15	4ADAN042.80	Dan River	323	214
60	4ABRY000.05	Blackberry Creek	251	166
9	4ABYR000.80	Byrds Branch	318	315
11	4ADBC002.19	Double Creek	156	154
22	4AFAL001.58	Fall Creek	197	225
37	4ALWD002.54	Leatherwood Creek	222	228
61	4AMRR000.02	Marrowbone Creek	197	185
73	4ANMR002.60	North Fork Mayo River	138	138
24	4ASCR007.06	Sandy Creek	239	210
26	4ASRV000.20	Sandy River	284	236
36	4ASRE015.43	Smith River	154	184
41	4ASRE022.71	Smith River	198	182
44	4ASRE033.19	Smith River	157	156
80	4ASMR004.14	South Fork Mayo River	164	161

Table 4-27: Observed and Simulated Exceedance Rates of the 400 cfu/100ml Instantaneous Fecal Coliform Standard

Reach	Water Quality Station	Watershed	Rate of Exceedance (%)	
			Observed	Simulated
2	4ADAN015.30	Dan River	30.6	31.2
15	4ADAN042.80	Dan River	32.4	29.0
60	4ABRY000.05	Blackberry Creek	23.1	20.0
9	4ABYR000.80	Byrds Branch	44.4	53.4
11	4ADBC002.19	Double Creek	16.1	14.1
22	4AFAL001.58	Fall Creek	21.4	23.6
37	4ALWD002.54	Leatherwood Creek	16.7	36.1
61	4AMRR000.02	Marrowbone Creek	13.3	21.8
73	4ANMR002.60	North Fork Mayo River	10.7	17.4
24	4ASCR007.06	Sandy Creek	21.4	22.8
26	4ASRV000.20	Sandy River	28.6	37.5
36	4ASRE015.43	Smith River	15.8	21.3
41	4ASRE022.71	Smith River	19.5	21.4
44	4ASRE033.19	Smith River	16.5	17.6
80	4ASMR004.14	South Fork Mayo River	12.5	19.6

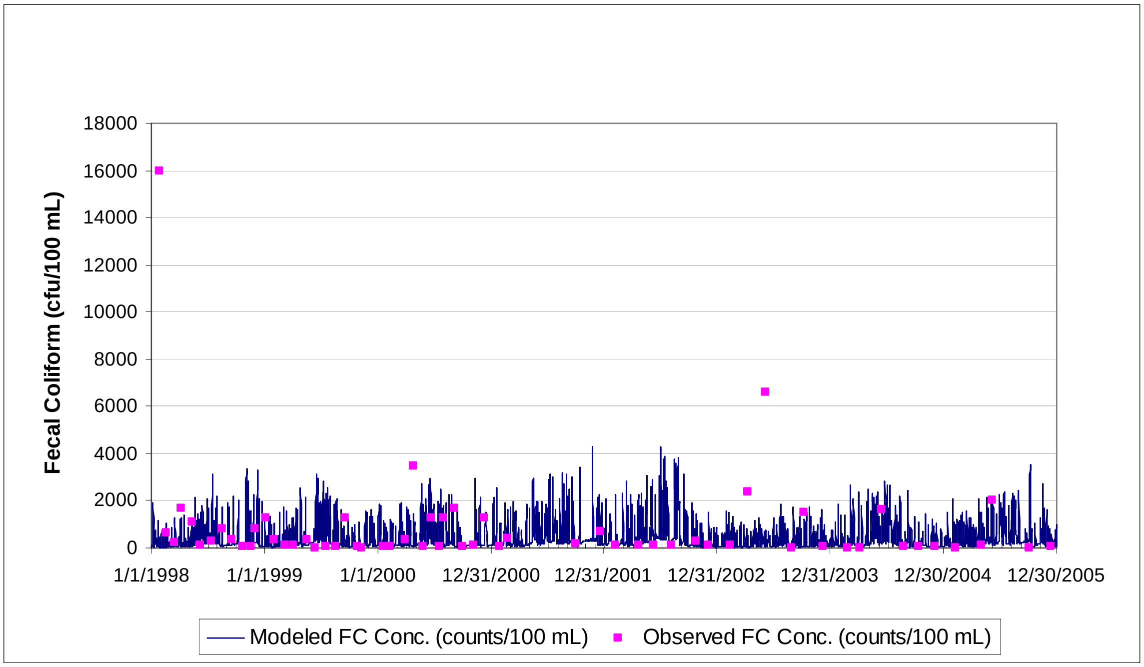

Figure 4-8: Fecal Coliform Calibration Dan River (Reach 2)

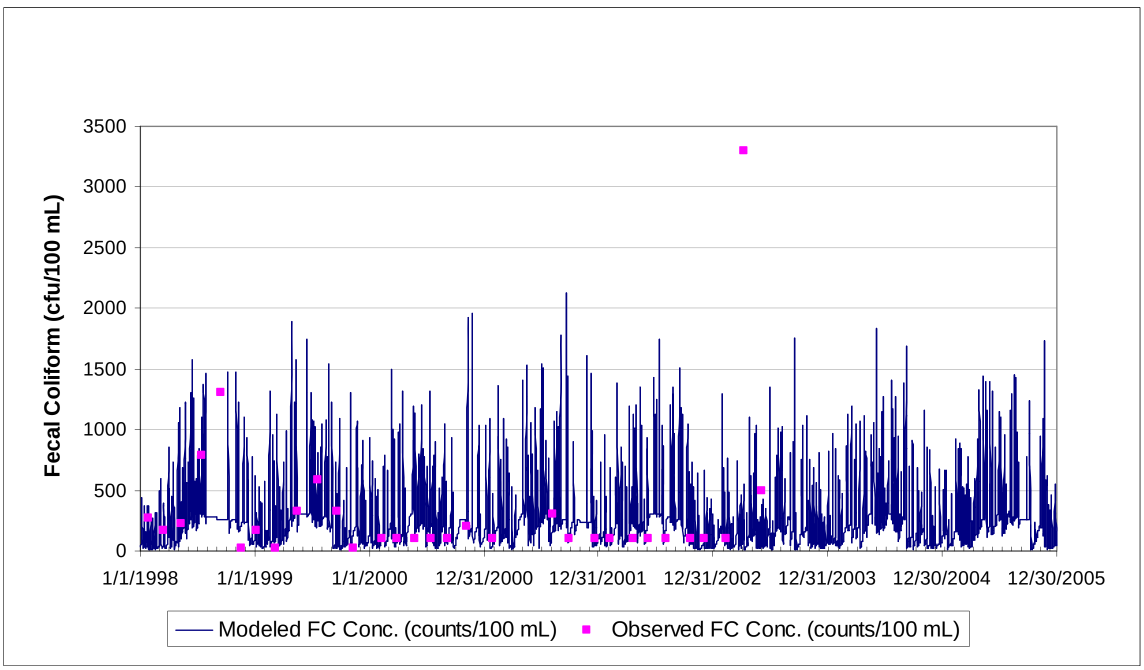

Figure 4-9: Fecal Coliform Validation Double Creek (Reach 11)

4.10 Existing Bacteria Loading

The existing fecal coliform loading for each watershed was calculated based on current watershed conditions. Model input parameters reflected conditions during the period of 1998 to 2005. The standards used for fecal coliform concentrations were a geometric mean standard of 200 cfu/100 ml and an instantaneous standard of 400 cfu/100 ml. For *E. coli* concentrations, the standards used were a geometric mean of 126 cfu/100ml and an instantaneous standard of 235 cfu/100ml. The *E. coli* concentrations in the impaired Dan River (Reaches 2 and 15), Blackberry Creek (Reach 60), Byrds Branch (Reach 9), Double Creek (Reach 11), Fall Creek (Reach 22), Leatherwood Creek (Reach 37), Marrowbone Creek (Reach 61), North Fork Mayo River (Reach 73), South Fork Mayo River (Reach 80), Sandy Creek (Reach 24), Sandy River (Reach 26), and Smith River (Reaches 36, 41, and 44) were calculated from fecal coliform concentrations using a regression-based instream translator, which is presented below:

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

4.10.1 Dan River

Under existing conditions, the instream concentration of bacteria in the Dan River is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-10** and **Figure 4-12** show the fecal coliform geometric mean existing conditions and **Figure 4-11** and **Figure 4-13** shows the *E. coli* geometric mean concentrations under existing conditions for both Dan River reaches. **Figure 4-14** and **Figure 4-16** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-15 and Figure 4-17** shows the *E. coli* instantaneous concentrations under existing conditions for both Dan River reaches.

Distribution of the existing fecal coliform load by source in the Dan River is presented in **Table 4-28**. The corresponding *E. coli* loading is presented in **Table 4-29**. *E. coli* concentrations in the impaired Dan River (Reaches 2 and 15) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-28** and **Table 4-29** show that loading from commercial/industrial areas, pasture, and low density residential areas are the predominant sources of bacteria in the Dan River watershed.

However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate.

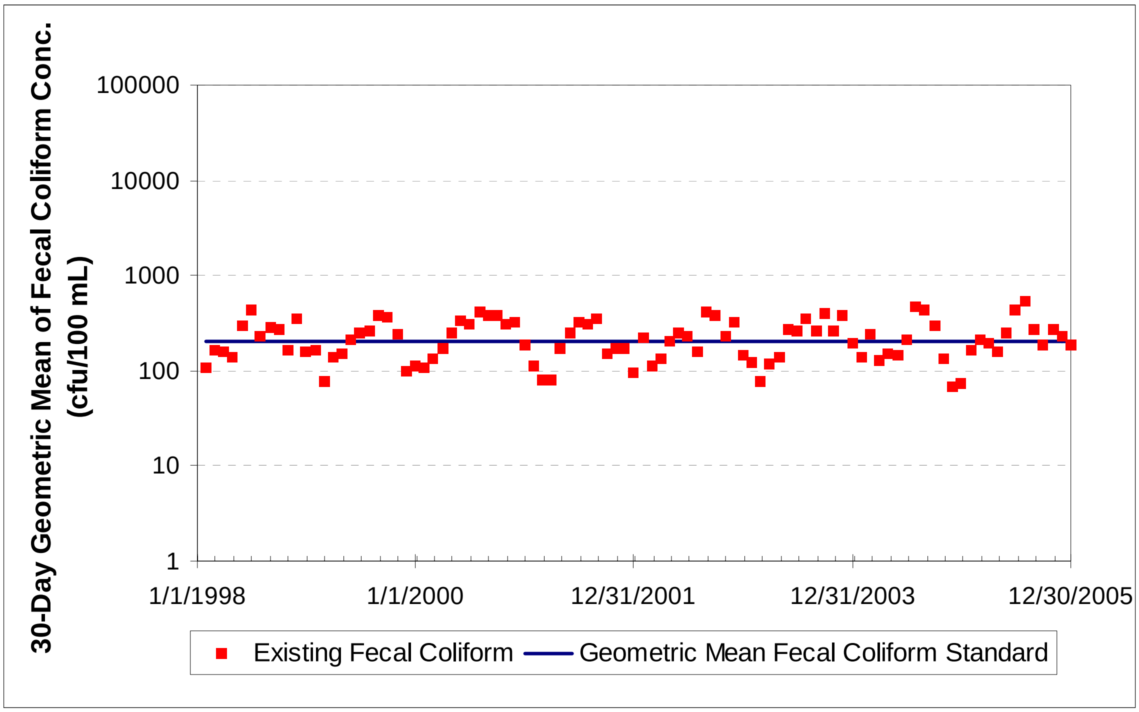

Figure 4-10: Dan River Fecal Coliform Geometric Mean Existing Conditions (Reach 2)

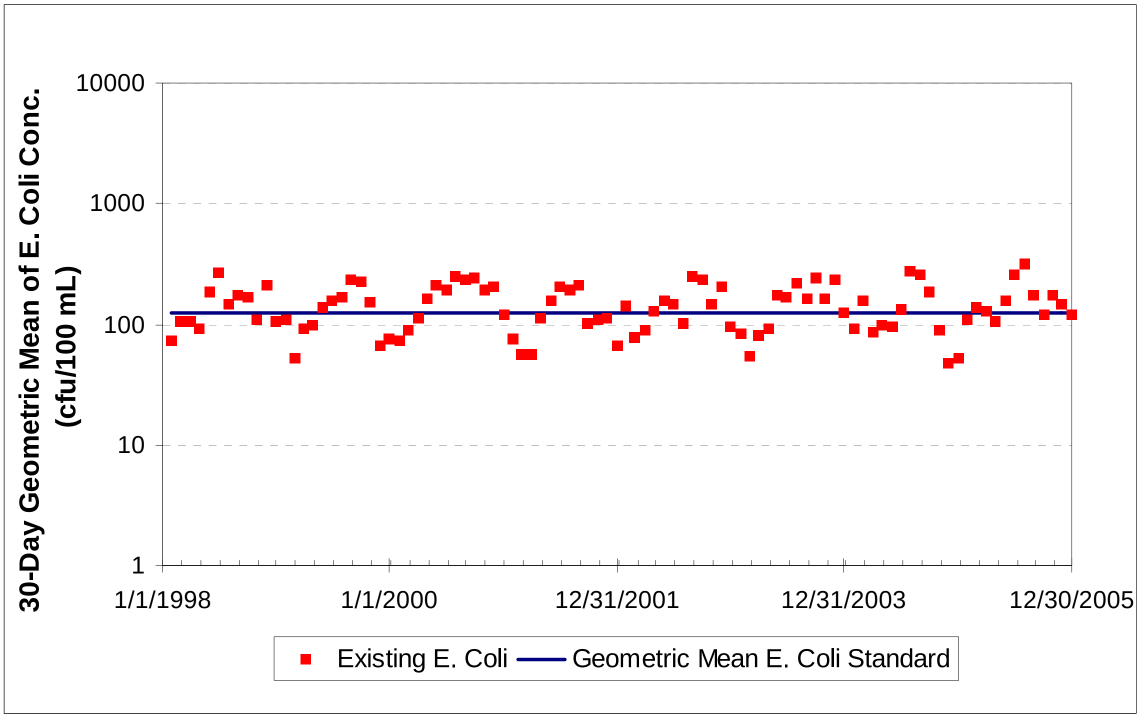

Figure 4-11: Dan River *E. coli* Geometric Mean Existing Conditions (Reach 2)

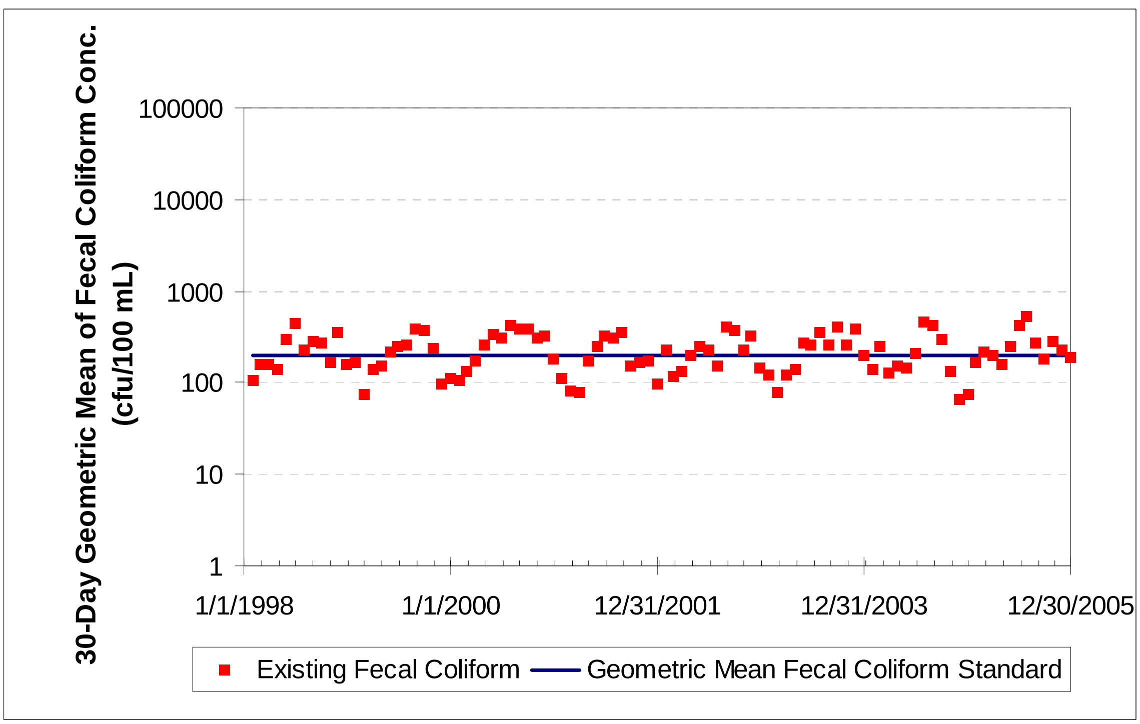

Figure 4-12: Dan River Fecal Coliform Geometric Mean Existing Conditions (Reach 15)

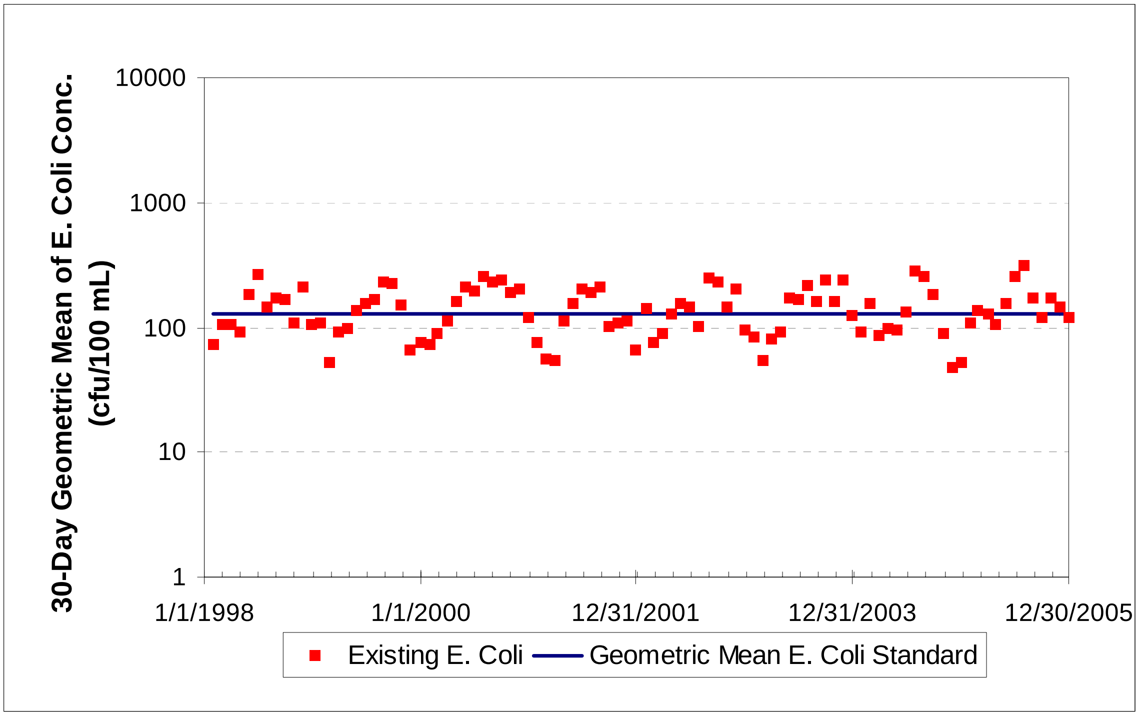

Figure 4-13: Dan River *E. coli* Geometric Mean Existing Conditions (Reach 15)

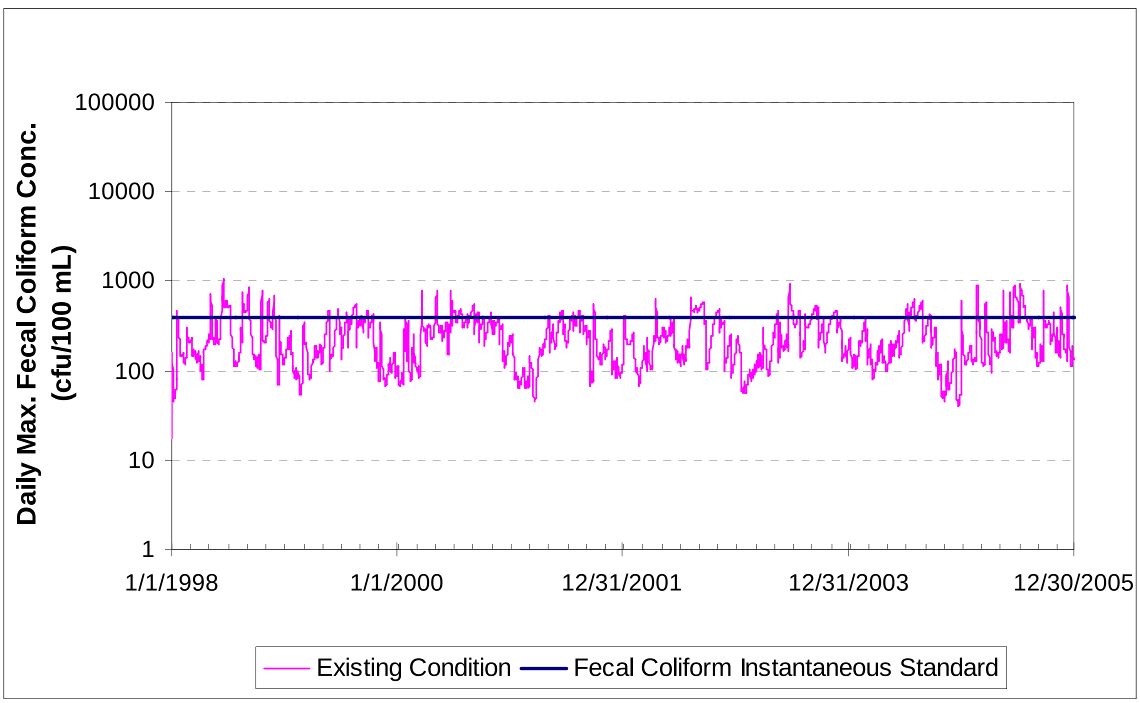

Figure 4-14: Dan River Fecal Coliform Instantaneous Existing Conditions (Reach 2)

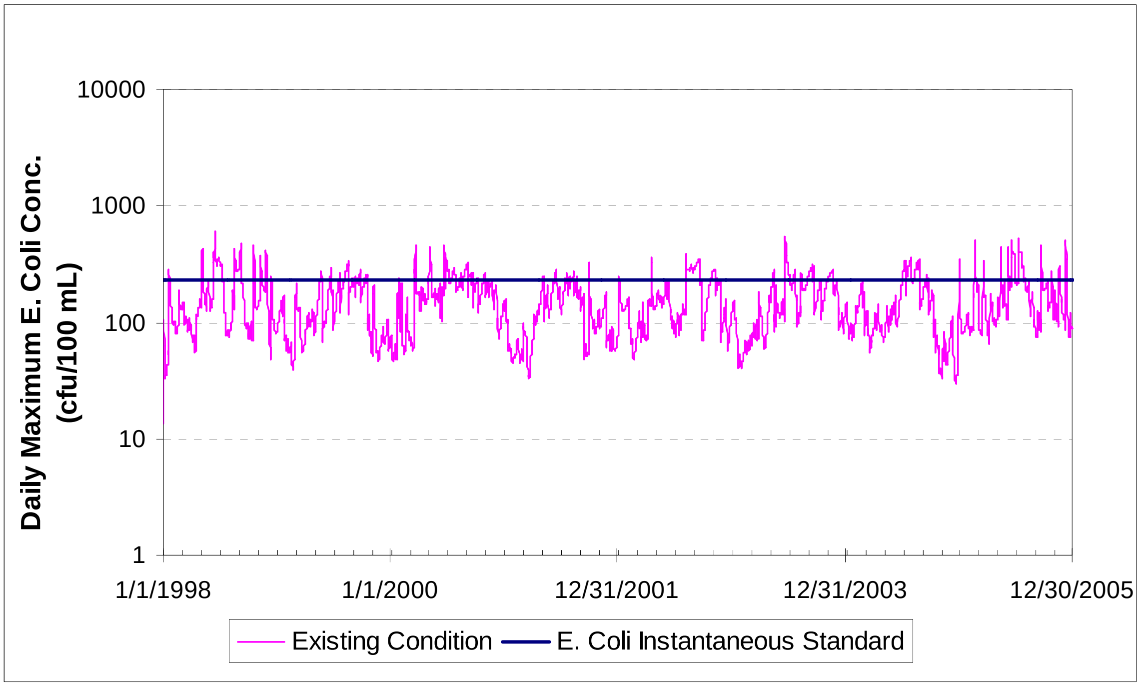

Figure 4-15: Dan River *E. coli* Instantaneous Existing Conditions (Reach 2)

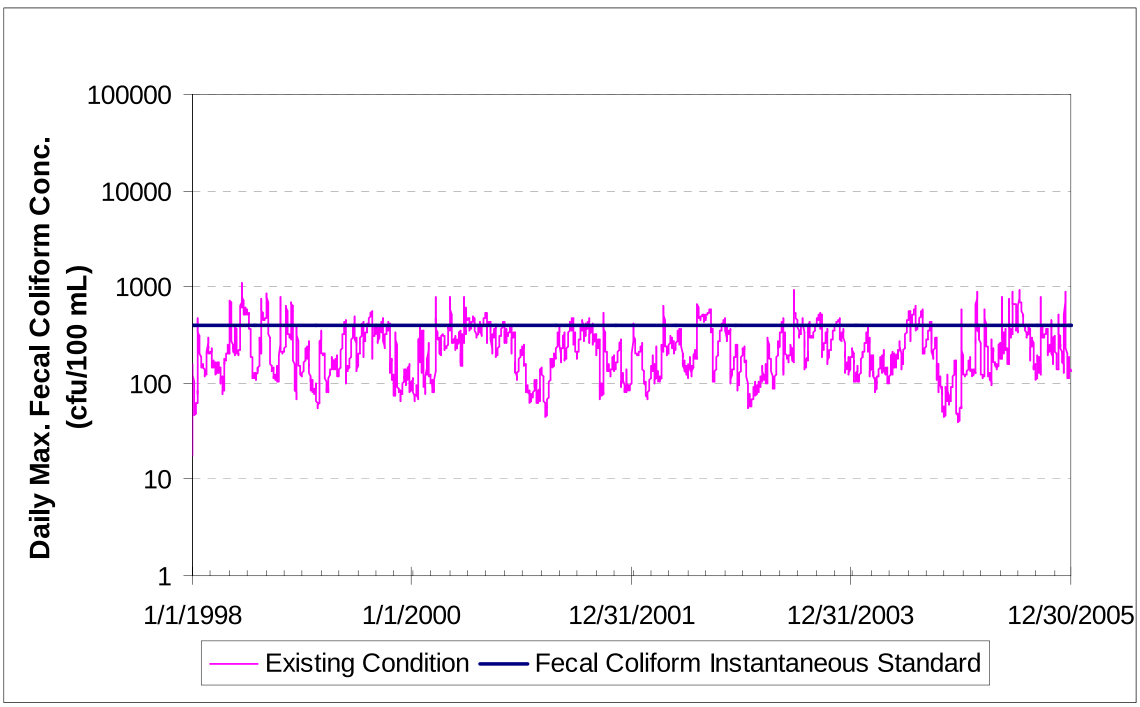

Figure 4-16: Dan River Fecal Coliform Instantaneous Existing Conditions (Reach 15)

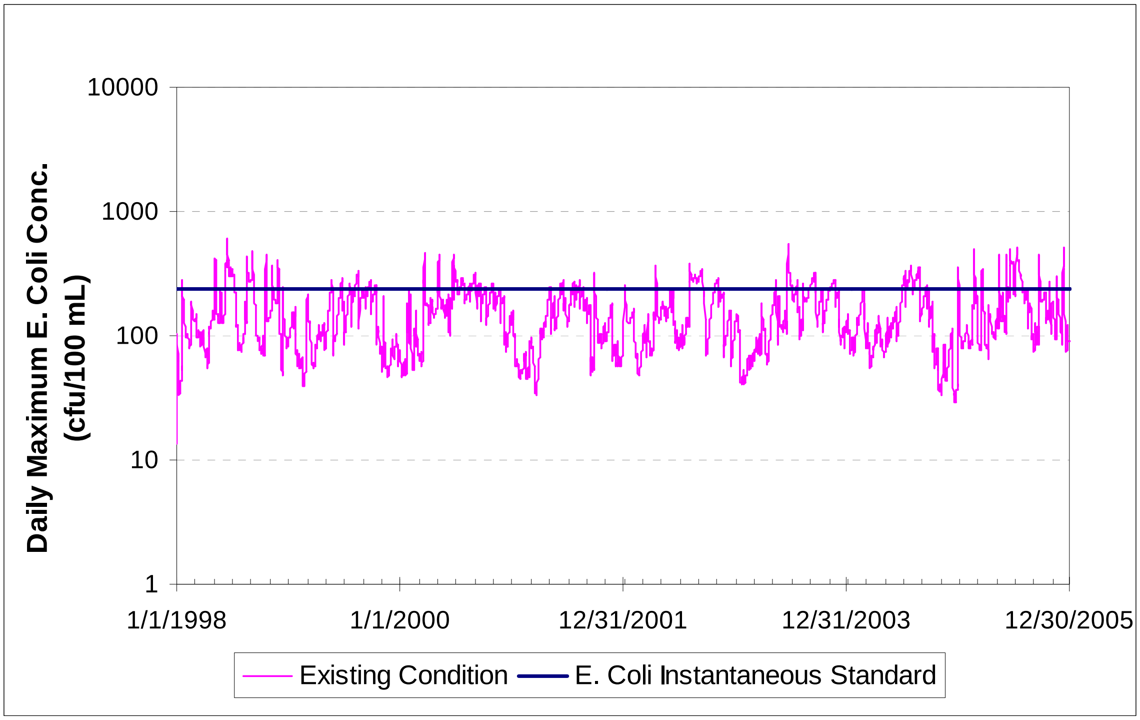

Figure 4-17: Dan River *E. coli* Instantaneous Existing Conditions (Reach 15)

Table 4-28: Dan River Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	**3.33E+13**	**0.3%**
Cropland	**5.46E+13**	**0.6%**
Pasture	**5.01E+15**	**52.7%**
Low Density Residential	**1.34E+15**	**14.1%**
Medium Density Residential	**7.02E+14**	**7.4%**
High Density Residential	**5.50E+14**	**5.8%**
Commercial/Industrial	**6.16E+14**	**6.5%**
Failed Septic - direct deposition	**2.32E+14**	**2.4%**
Wildlife - direct deposition	**9.15E+14**	**9.6%**
Cattle - direct deposition	**7.66E+10**	**<0.1%**
Point Source	**6.18E+13**	**0.6%**
Total	**9.51E+15**	**100.0%**

Table 4-29: Dan River *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	2.06E+13	0.4%
Cropland	3.37E+13	0.6%
Pasture	3.10E+15	52.7%
Low Density Residential	8.27E+14	14.1%
Medium Density Residential	4.33E+14	7.4%
High Density Residential	3.40E+14	5.8%
Commercial/Industrial	3.80E+14	6.5%
Failed Septic - direct deposition	1.43E+14	2.4%
Wildlife - direct deposition	5.65E+14	9.6%
Cattle - direct deposition	4.73E+10	<0.1%
Point Source	3.89E+13	0.7%
Total	5.88E+15	100.0%

4.10.2 Blackberry Creek

Under existing conditions, the instream concentration of bacteria in Blackberry Creek is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-18** shows the fecal coliform geometric mean existing conditions and **Figure 4-19** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-20** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-21** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in Blackberry Creek is presented in **Table 4-30**. The corresponding *E. coli* loading is presented in **Table 4-31**. *E. coli* concentrations in the impaired Blackberry Creek (Reach 60) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-30** and **Table 4-31** show that loading from commercial/industrial, low density residential, and wildlife areas are the predominant sources of bacteria in the Blackberry Creek watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate. It should be noted that the point sources' existing-conditions bacteria loads are not included in **Tables 4-30** and **4-31** since existing fecal coliform concentrations were insignificant.

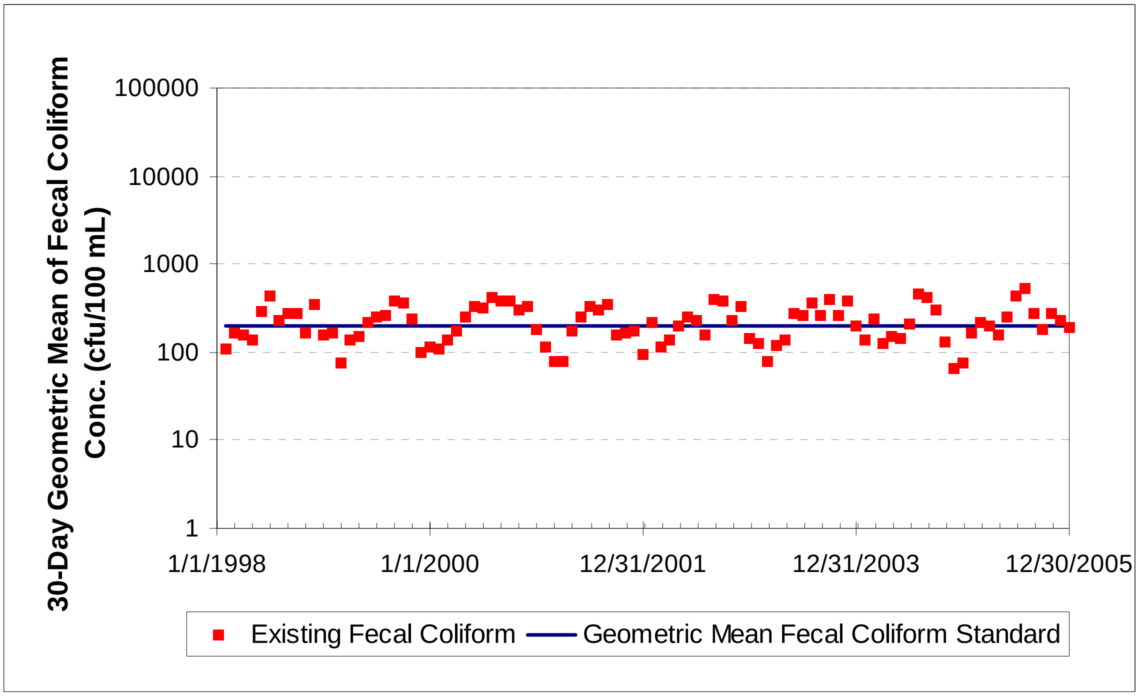

Figure 4-18: Blackberry Creek Fecal Coliform Geometric Mean Existing Conditions

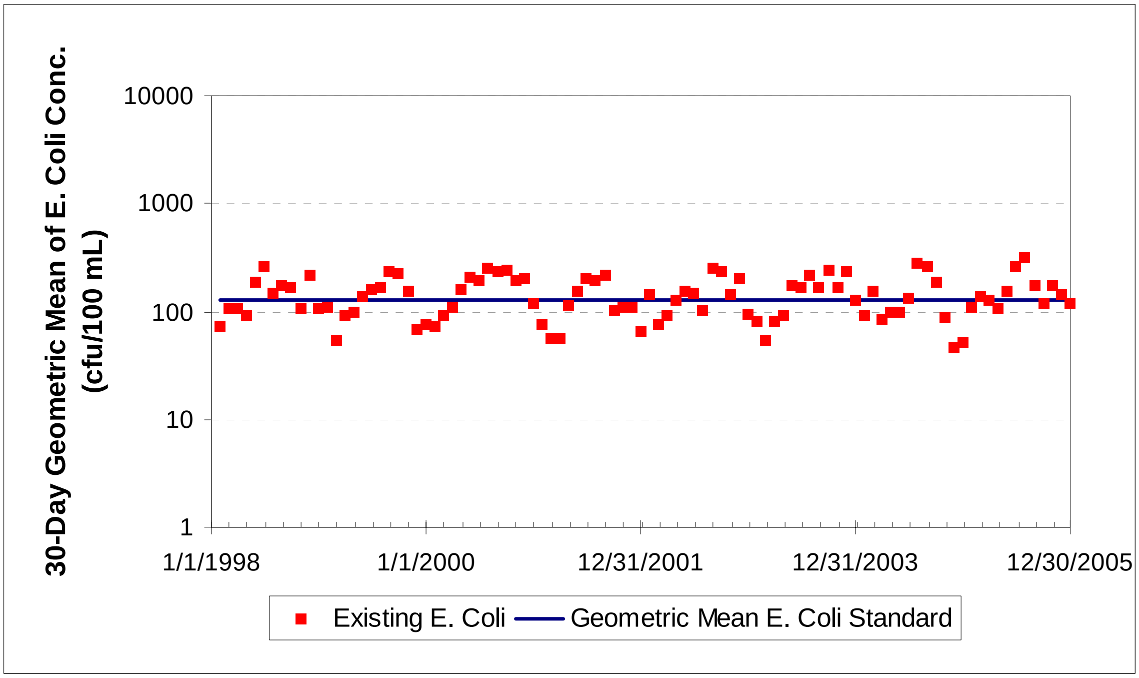

Figure 4-19: Blackberry Creek *E. coli* Geometric Mean Existing Conditions

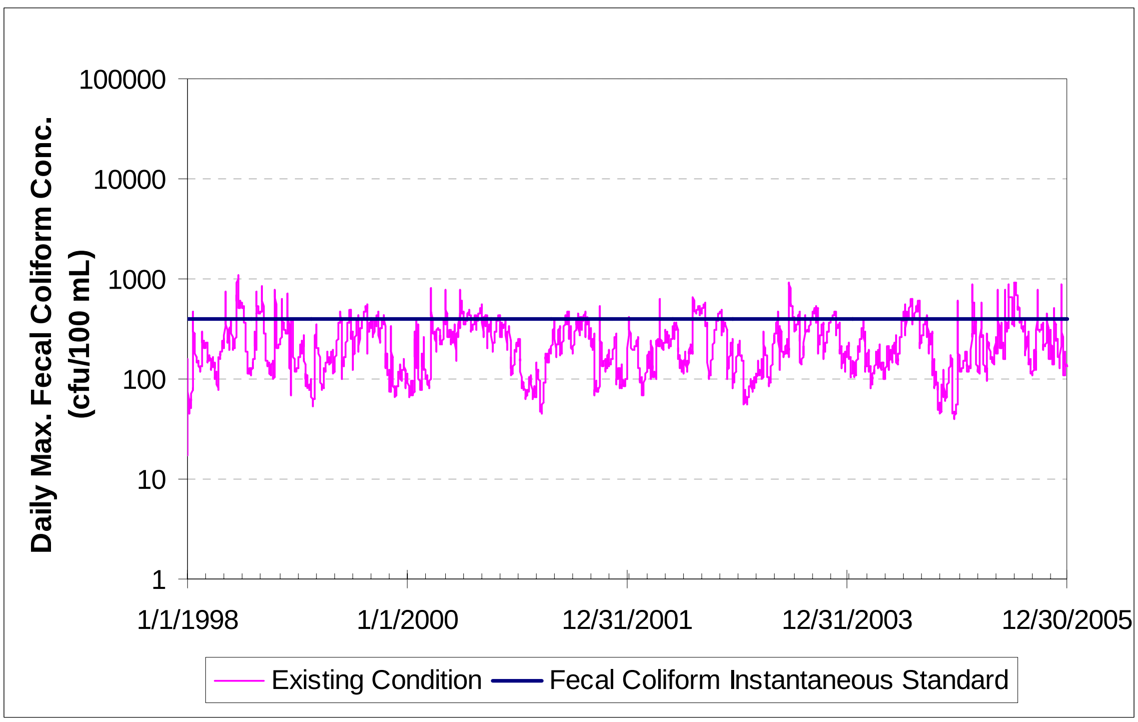

Figure 4-20: Blackberry Creek Fecal Coliform Instantaneous Existing Conditions

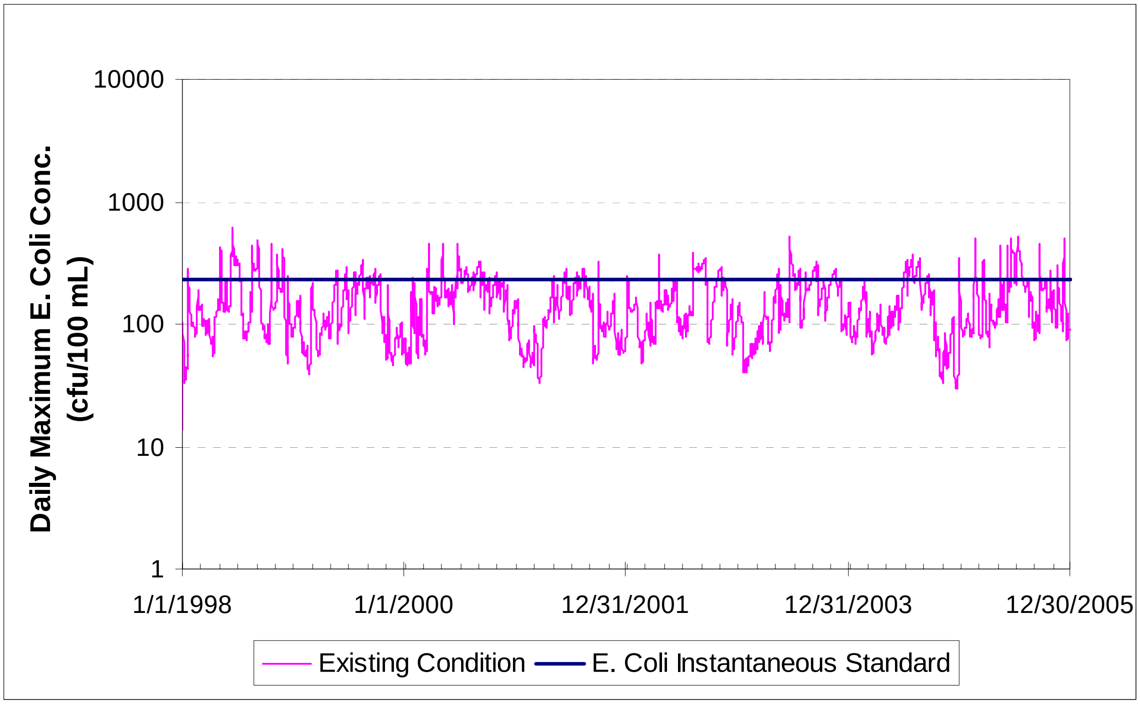

Figure 4-21: Blackberry Creek *E. coli* Instantaneous Existing Conditions

Table 4-30: Blackberry Creek Fecal Coliform Existing Load Distribution by Source

Source	**Annual Average Fecal Coliform Loads**	
	cfu/year	**Percent (%)**
Forest	**3.84E+11**	**1.0%**
Cropland	**1.10E+11**	**0.3%**
Pasture	**1.44E+13**	**36.8%**
Low Density Residential	**8.58E+12**	**22.0%**
Medium Density Residential	**1.66E+12**	**4.3%**
Commercial/Industrial	**4.39E+12**	**11.3%**
Failed Septic - direct deposition	**1.74E+12**	**4.5%**
Wildlife - direct deposition	**7.78E+12**	**19.9%**
Cattle - direct deposition	**8.55E+07**	**<0.1%**
Total	**3.90E+13**	**100.0%**

Table 4-31: Blackberry Creek *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	2.46E+11	1.0%
Cropland	7.06E+10	0.3%
Pasture	9.19E+12	36.8%
Low Density Residential	5.49E+12	22.0%
Medium Density Residential	1.06E+12	4.3%
Commercial/Industrial	2.81E+12	11.3%
Failed Septic - direct deposition	1.12E+12	4.5%
Wildlife - direct deposition	4.98E+12	19.9%
Cattle - direct deposition	5.47E+07	<0.1%
Total	2.50E+13	100.0%

4.10.3 Byrds Branch

Under existing conditions, the instream concentration of bacteria in Byrds Branch is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-22** shows the fecal coliform geometric mean existing conditions and **Figure 4-23** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-24** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-25** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in Byrds Branch is presented in **Table 4-32**. The corresponding *E. coli* loading is presented in **Table 4-33**. *E. coli* concentrations in the impaired Byrds Branch (Reach 9) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-32** and **Table 4-33** show that loading from the commercial/industrial, pasture, and wildlife are the predominant sources of bacteria in the Byrds Branch watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife and failed septics will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate.

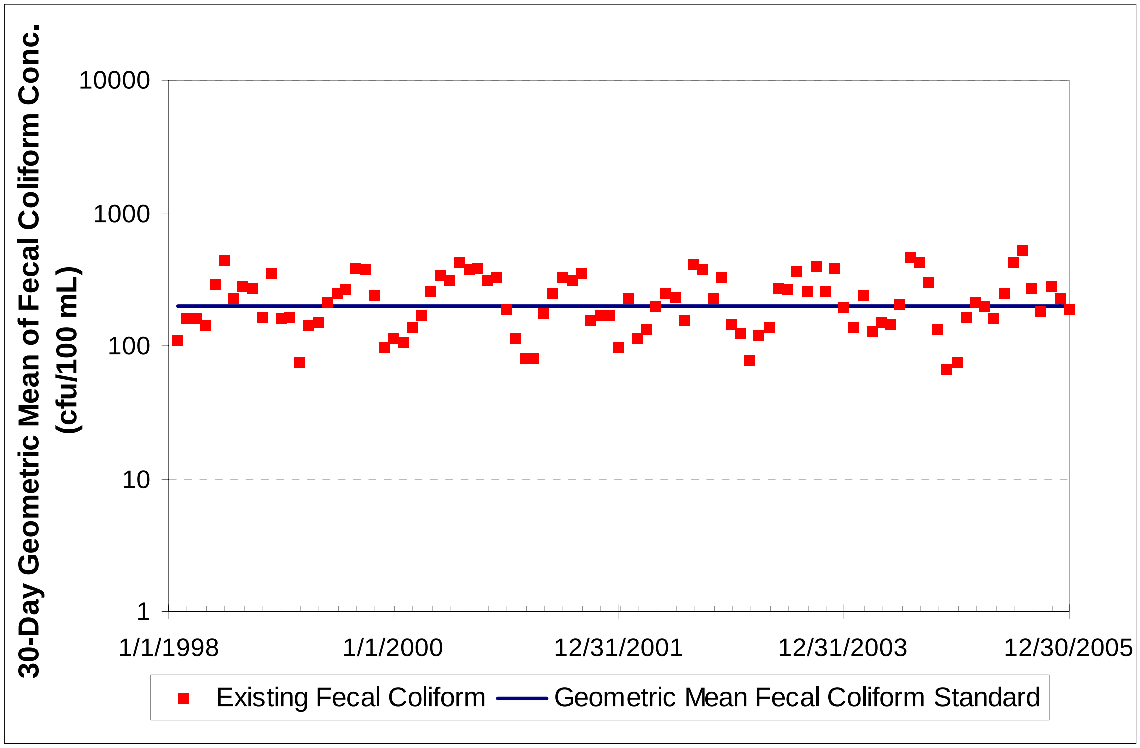

Figure 4-22: Byrds Branch Fecal Coliform Geometric Mean Existing Conditions

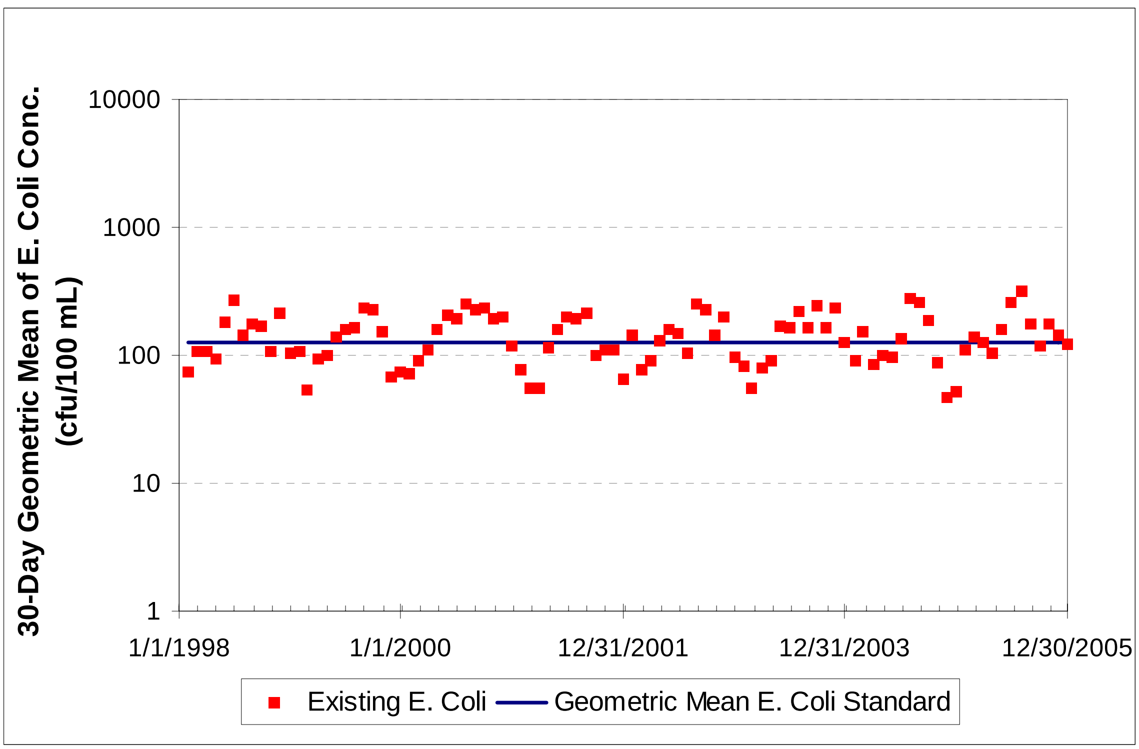

Figure 4-23: Byrds Branch *E. coli* Geometric Mean Existing Conditions

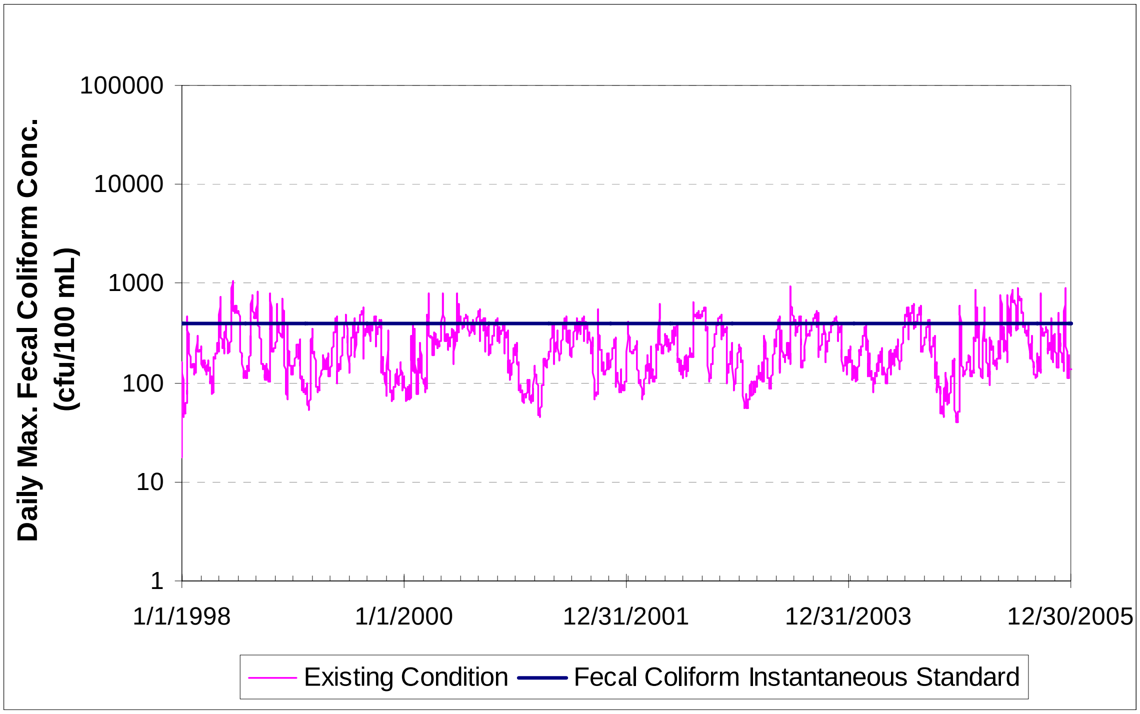

Figure 4-24: Byrds Branch Fecal Coliform Instantaneous Existing Conditions

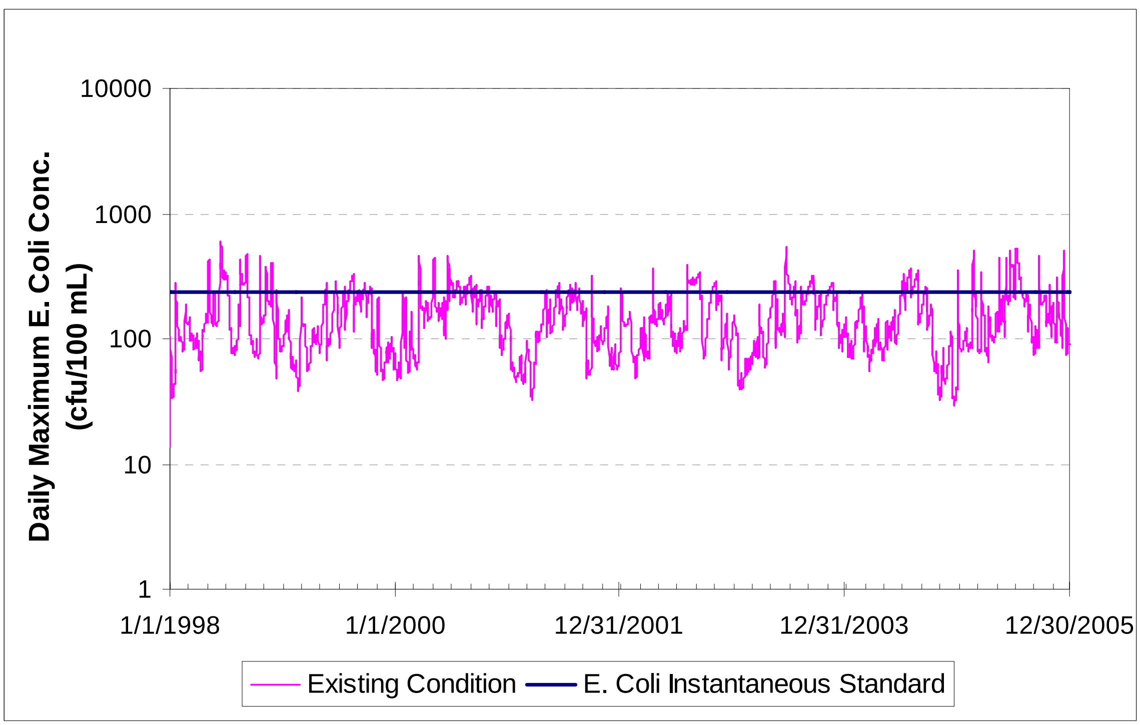

Figure 4-25: Byrds Branch *E. coli* Instantaneous Existing Conditions

Table 4-32: Byrds Branch Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	5.76E+10	0.6%
Cropland	1.08E+11	1.2%
Pasture	6.32E+12	68.8%
Low Density Residential	1.23E+11	1.3%
Commercial/Industrial	5.66E+11	6.2%
Failed Septic - direct deposition	5.88E+11	6.4%
Wildlife - direct deposition	1.42E+12	15.5%
Cattle - direct deposition	8.07E+06	<0.1%
Point Source	8.27E+09	0.1%
Total	9.19E+12	100.0%

Table 4-33: Byrds Branch *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	3.61E+10	0.6%
Cropland	6.76E+10	1.2%
Pasture	3.96E+12	68.8%
Low Density Residential	7.70E+10	1.3%
Commercial/Industrial	3.54E+11	6.2%
Failed Septic - direct deposition	3.69E+11	6.4%
Wildlife - direct deposition	8.90E+11	15.5%
Cattle - direct deposition	5.06E+06	<0.1%
Point Source	1.04E+09	<0.1%
Total	5.75E+12	100.0%

4.10.4 Double Creek

Under existing conditions, the instream concentration of bacteria in Double Creek is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-26** shows the fecal coliform geometric mean existing conditions and **Figure 4-27** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-28** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-29** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in Double Creek is presented in **Table 4-34**. The corresponding *E. coli* loading is presented in **Table 4-35**. *E. coli* concentrations in the impaired Double Creek (Reach 11) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-34** and **Table 4-35** show that loading from the commercial/industrial, pasture, and wildlife are the predominant sources of bacteria in the Double Creek watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate. It should be noted that the point sources' existing-conditions bacteria loads are not included in **Tables 4-34 and 4-35** since existing fecal coliform concentrations were insignificant.

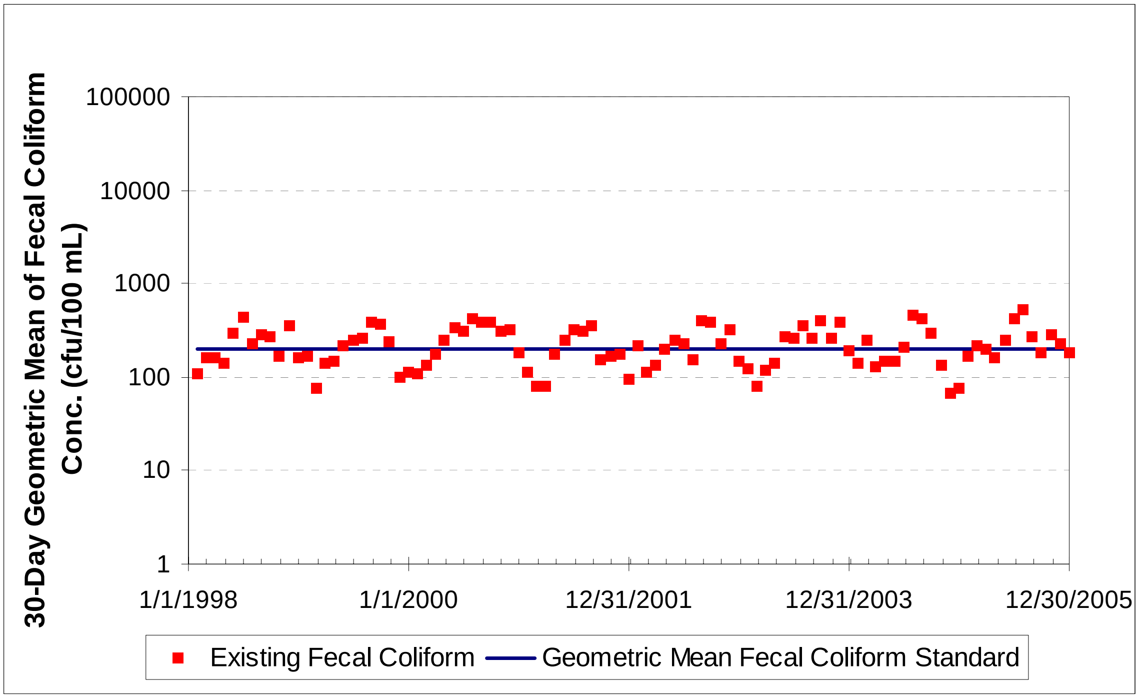

Figure 4-26: Double Creek Fecal Coliform Geometric Mean Existing Conditions

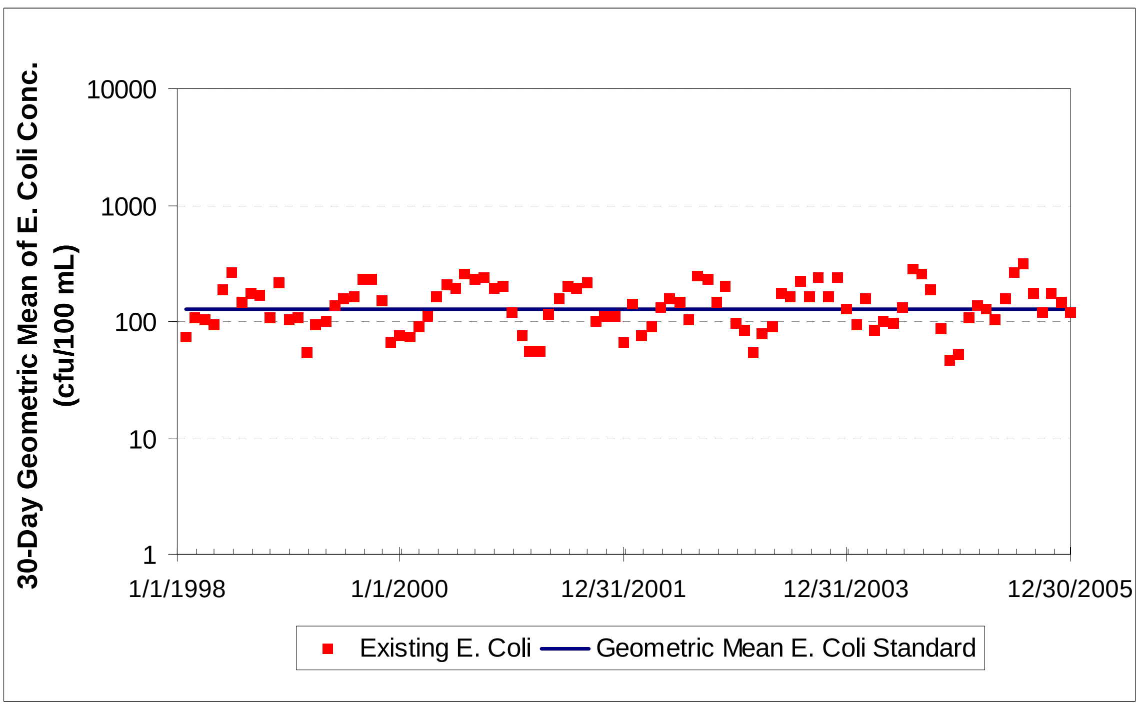

Figure 4-27: Double Creek *E. coli* Geometric Mean Existing Conditions

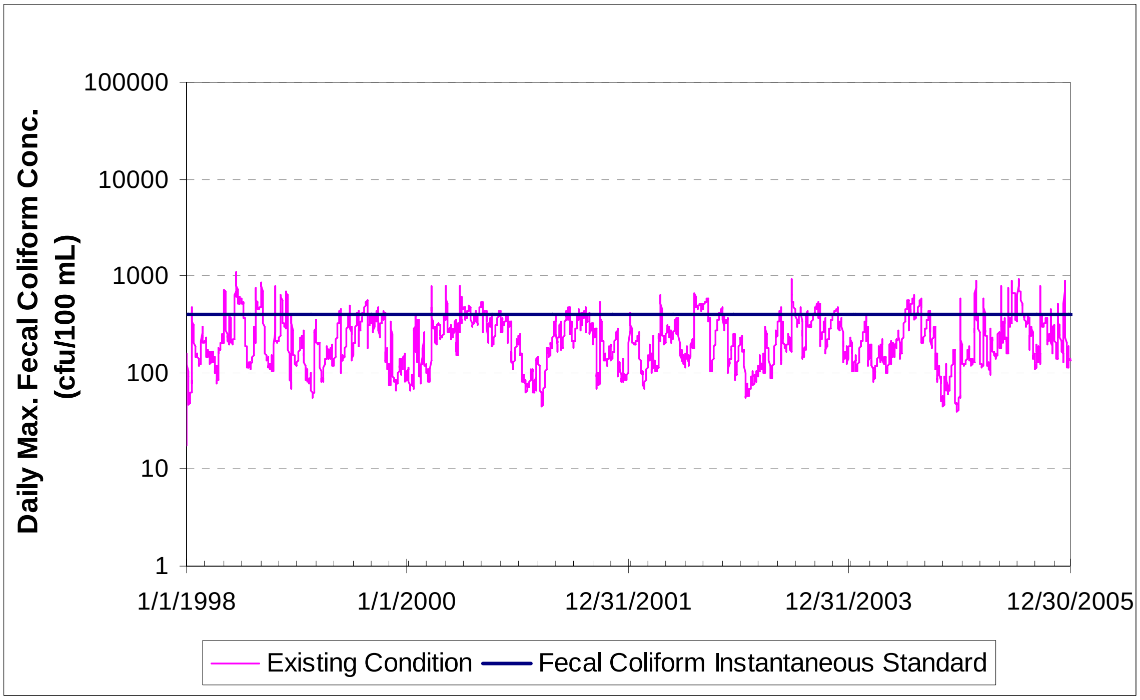

Figure 4-28: Double Creek Fecal Coliform Instantaneous Existing Conditions

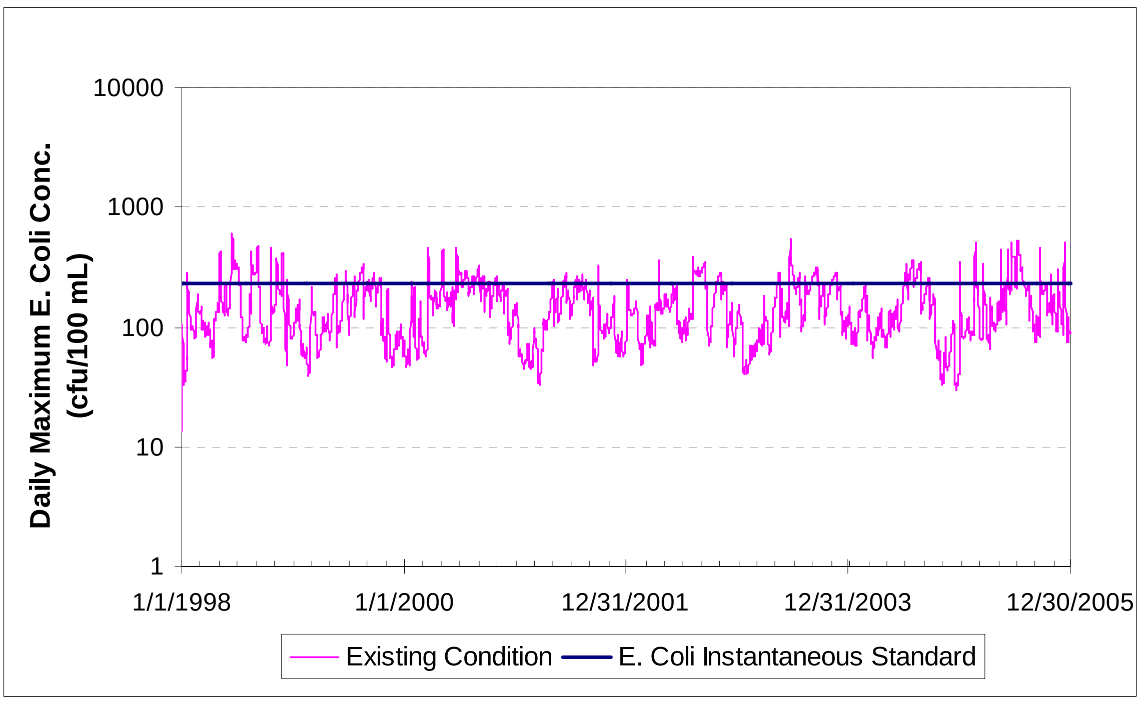

Figure 4-29: Double Creek *E. coli* Instantaneous Existing Conditions

Table 4-34: Double Creek Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	3.22E+11	0.8%
Cropland	4.94E+11	1.2%
Pasture	2.72E+13	65.7%
Low Density Residential	1.96E+12	4.7%
Commercial/Industrial	1.63E+12	3.9%
Failed Septic - direct deposition	2.68E+12	6.5%
Wildlife - direct deposition	7.12E+12	17.2%
Cattle - direct deposition	4.88E+07	<0.1%
Total	4.14E+13	100.0%

Table 4-35: Double Creek *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	2.05E+11	0.8%
Cropland	3.15E+11	1.2%
Pasture	1.74E+13	65.7%
Low Density Residential	1.25E+12	4.7%
Commercial/Industrial	1.04E+12	3.9%
Failed Septic - direct deposition	1.71E+12	6.5%
Wildlife - direct deposition	4.54E+12	17.2%
Cattle - direct deposition	3.11E+07	<0.1%
Total	2.64E+13	100.0%

4.10.5 Fall Creek

Under existing conditions, the instream concentration of bacteria in Fall Creek is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-30** shows the fecal coliform geometric mean existing conditions and **Figure 4-31** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-32** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-33** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in Fall Creek is presented in **Table 4-36.** The corresponding *E. coli* loading is presented in **Table 4-37**. *E. coli* concentrations in the impaired Fall Creek (Reach #) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-36** and **Table 4-37** show that loading from the commercial/industrial, low density residential, and medium density areas are the predominant sources of bacteria in the Fall Creek watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife, failed septic systems, and straight pipes will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate.

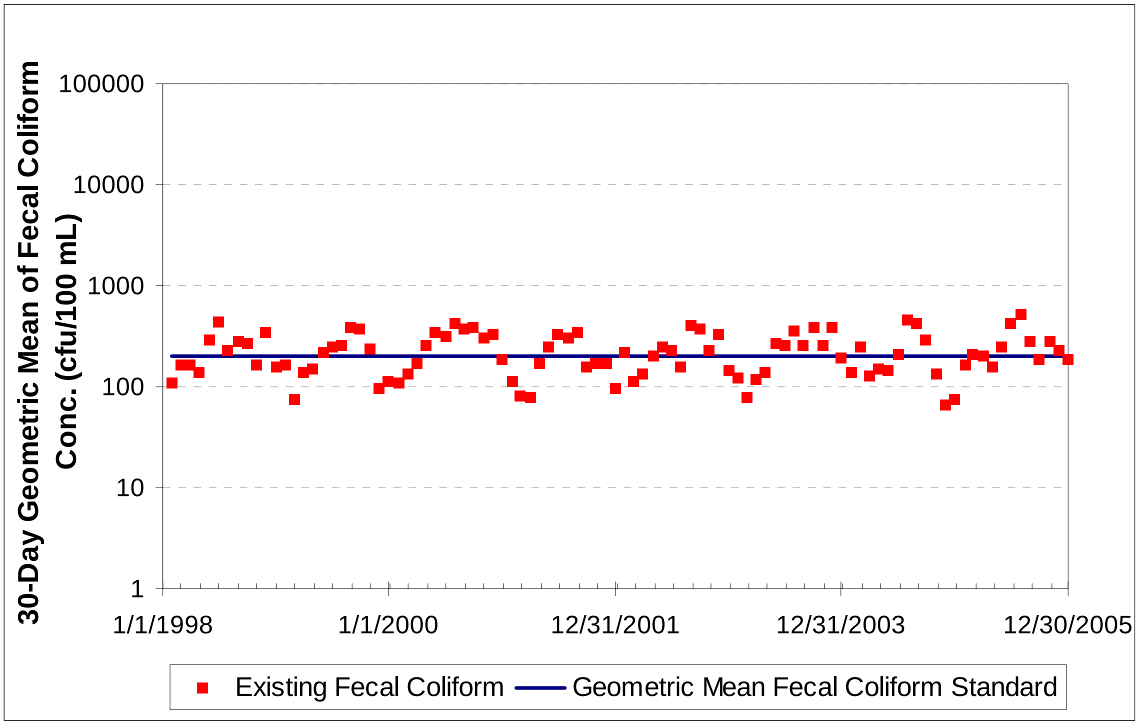

Figure 4-30: Fall Creek Fecal Coliform Geometric Mean Existing Conditions

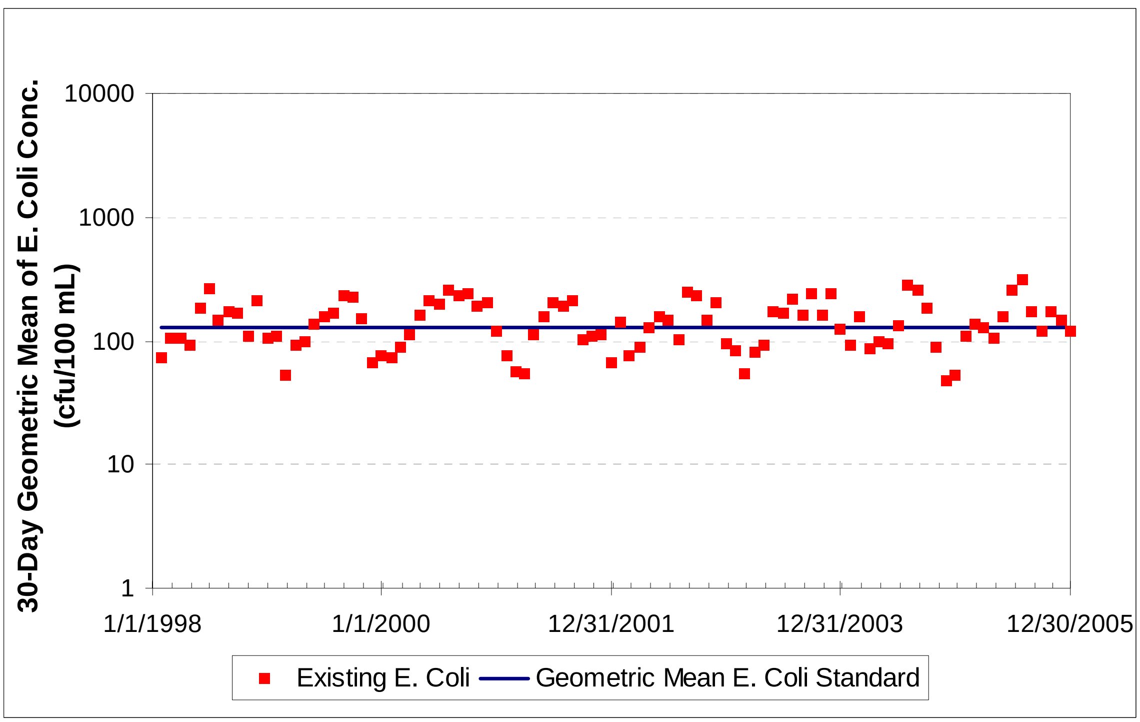

Figure 4-31: Fall Creek *E. coli* Geometric Mean Existing Conditions

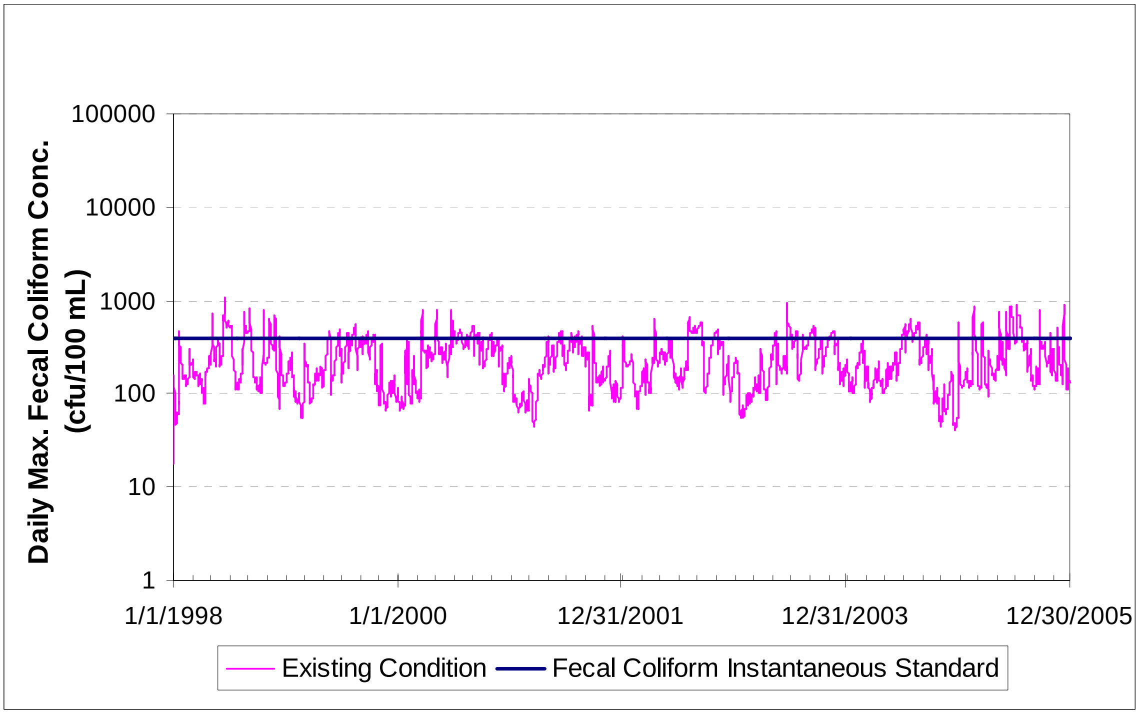

Figure 4-32: Fall Creek Fecal Coliform Instantaneous Existing Conditions

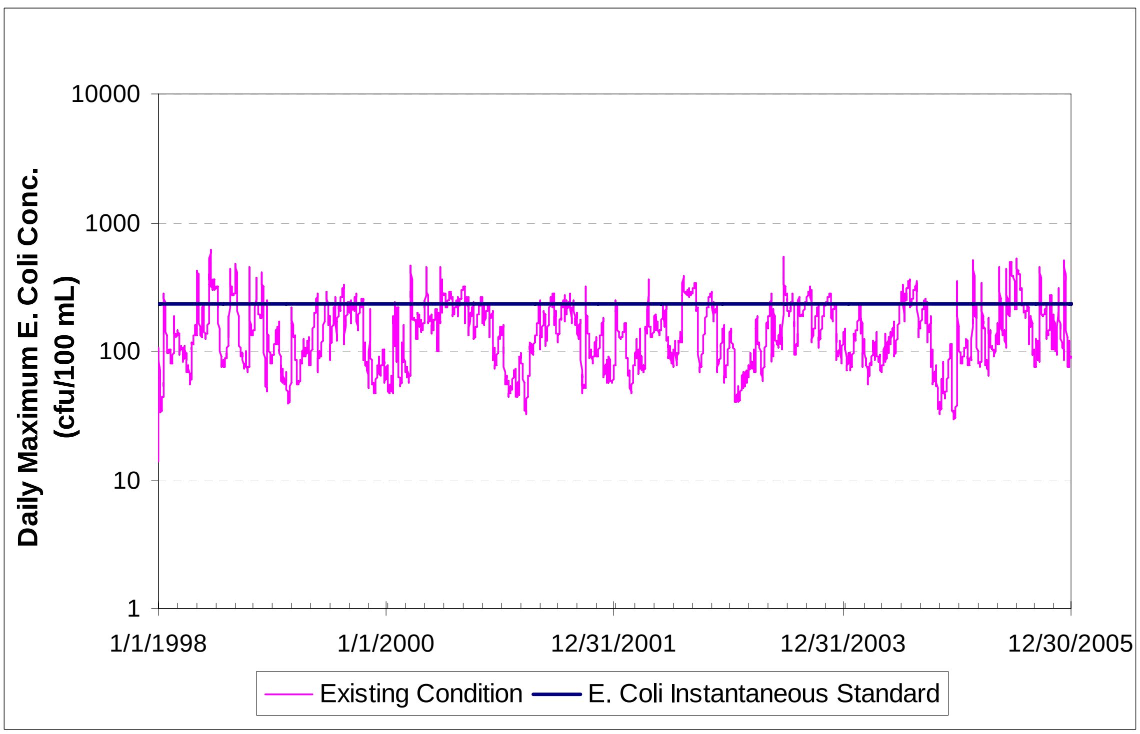

Figure 4-33: Fall Creek *E. coli* Instantaneous Existing Conditions

Table 4-36: Fall Creek Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	6.36E+11	0.2%
Cropland	1.75E+12	0.5%
Pasture	7.72E+13	23.7%
Low Density Residential	1.07E+14	32.9%
Medium Density Residential	6.64E+13	20.4%
High Density Residential	3.39E+13	10.4%
Commercial/Industrial	1.46E+13	4.5%
Failed Septic - direct deposition	5.57E+12	1.7%
Wildlife - direct deposition	1.82E+13	5.6%
Cattle - direct deposition	1.19E+10	<0.1%
Point Source	1.44E+11	<0.1%
Total	3.25E+14	100.0%

Table 4-37: Fall Creek *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	3.72E+11	0.2%
Cropland	1.02E+12	0.5%
Pasture	4.51E+13	23.7%
Low Density Residential	6.25E+13	32.9%
Medium Density Residential	3.88E+13	20.4%
High Density Residential	1.98E+13	10.4%
Commercial/Industrial	8.54E+12	4.5%
Failed Septic - direct deposition	3.25E+12	1.7%
Wildlife - direct deposition	1.07E+13	5.6%
Cattle - direct deposition	6.97E+09	<0.1%
Point Source	1.81E+10	<0.1%
Total	1.90E+14	100.0%

4.10.6 Leatherwood Creek

Under existing conditions, the instream concentration of bacteria in Leatherwood Creek is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-34** shows the fecal coliform geometric mean existing conditions and **Figure 4-35** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-36** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-37** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in Leatherwood Creek is presented in **Table 4-38.** The corresponding *E. coli* loading is presented in **Table 4-39**. *E. coli* concentrations in the impaired Leatherwood Creek (Reach 37) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-38** and **Table 4-39** show that loading from the commercial/industrial, low density residential, pasture, and wildlife areas are the predominant sources of bacteria in the Leatherwood Creek watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife, failed septic systems, and straight pipes will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate.

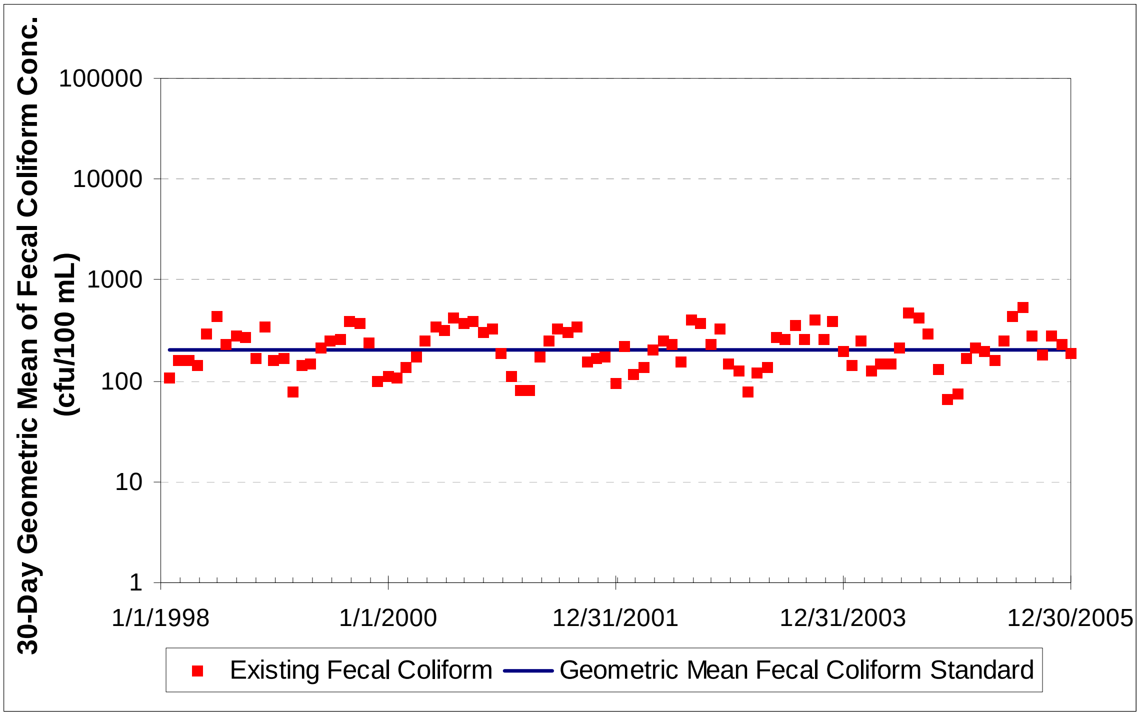

Figure 4-34: Leatherwood Creek Fecal Coliform Geometric Mean Existing Conditions

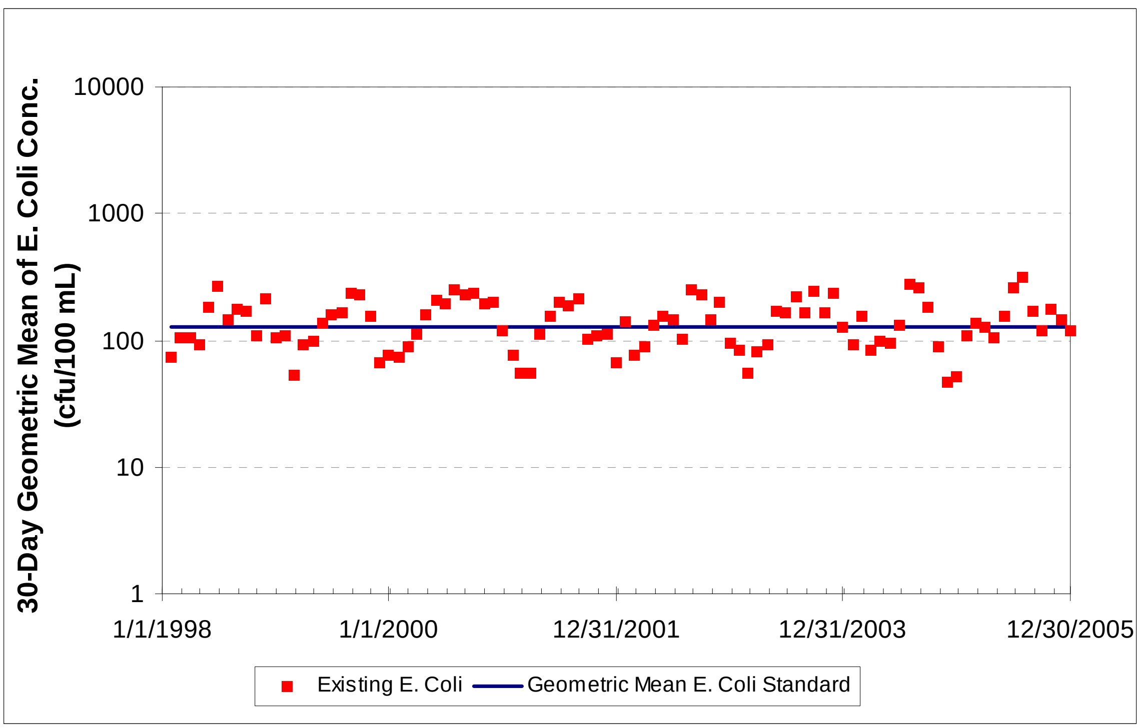

Figure 4-35: Leatherwood Creek E. coli Geometric Mean Existing Conditions

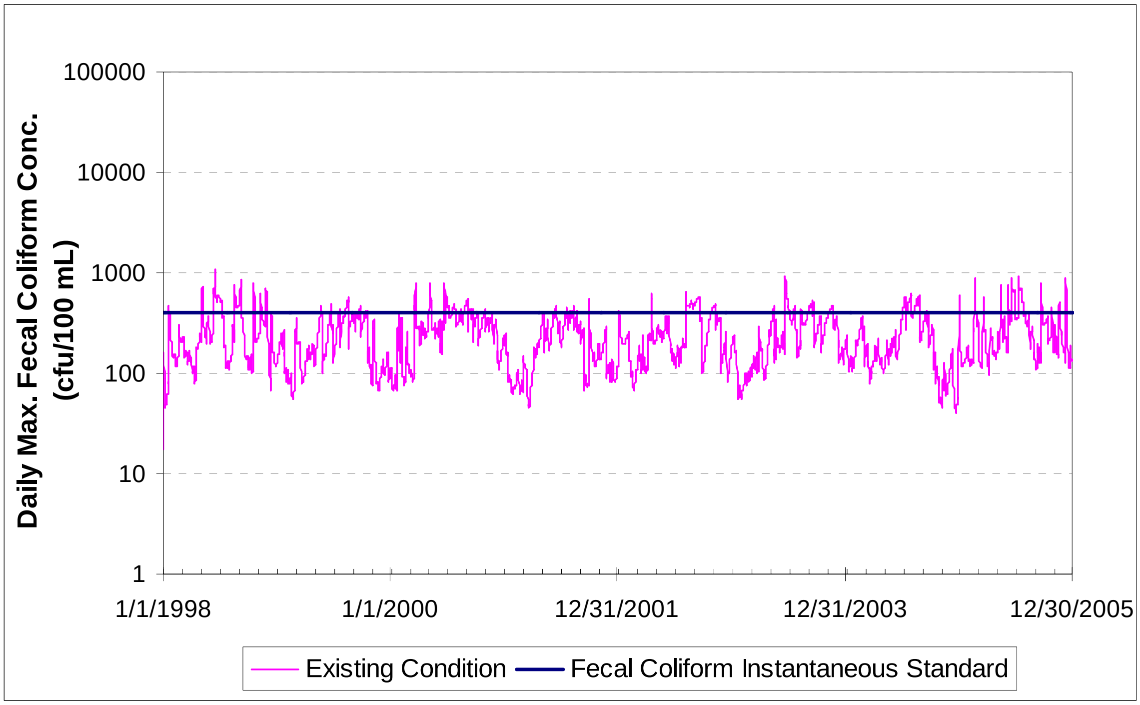

Figure 4-36: Leatherwood Creek Fecal Coliform Instantaneous Existing Conditions

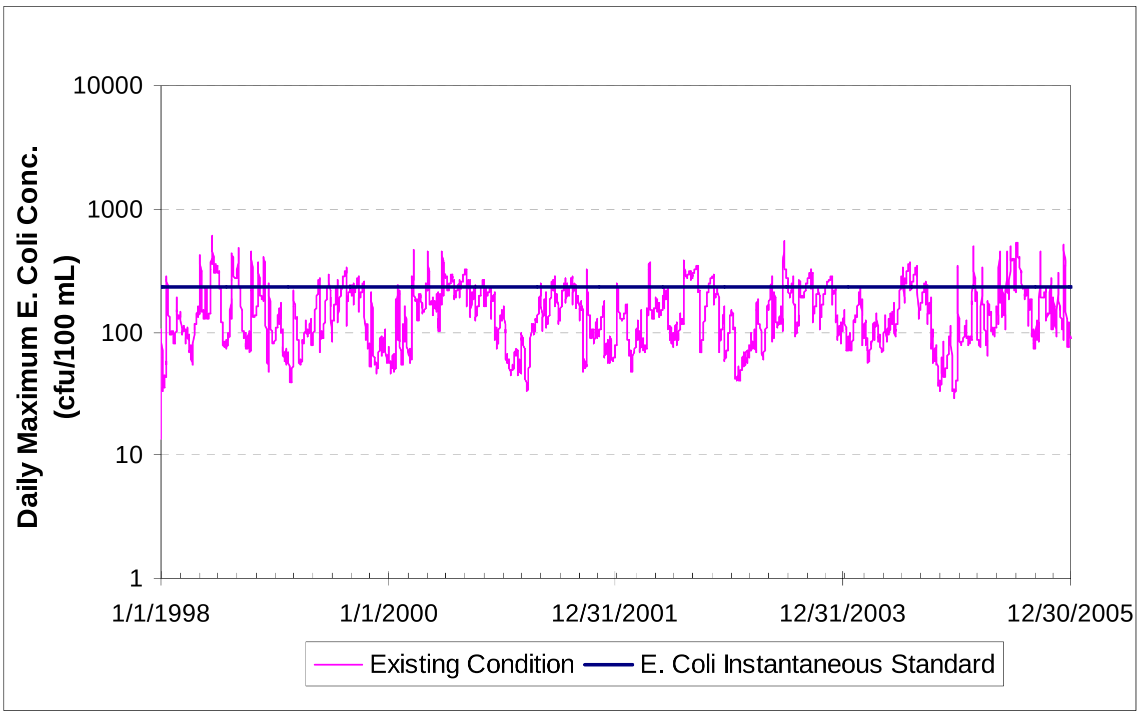

Figure 4-37: Leatherwood Creek *E. coli* Instantaneous Existing Conditions

Table 4-38: Leatherwood Creek Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	1.72E+12	0.8%
Cropland	3.25E+11	0.1%
Pasture	1.04E+14	45.2%
Low Density Residential	4.88E+13	21.2%
Medium Density Residential	1.36E+13	5.9%
High Density Residential	3.96E+12	1.7%
Commercial/Industrial	1.25E+13	5.4%
Failed Septic - direct deposition	7.25E+12	3.2%
Wildlife - direct deposition	3.70E+13	16.1%
Cattle - direct deposition	5.02E+08	<0.1%
Point Source	5.53E+11	0.2%
Total	2.30E+14	100.0%

Table 4-39: Leatherwood Creek *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	1.08E+12	0.8%
Cropland	2.03E+11	0.1%
Pasture	6.49E+13	45.2%
Low Density Residential	3.05E+13	21.2%
Medium Density Residential	8.52E+12	5.9%
High Density Residential	2.47E+12	1.7%
Commercial/Industrial	7.78E+12	5.4%
Failed Septic - direct deposition	4.53E+12	3.2%
Wildlife - direct deposition	2.31E+13	16.1%
Cattle - direct deposition	3.14E+08	<0.1%
Point Source	6.97E+10	<0.1%
Total	1.43E+14	100.0%

4.10.7 Marrowbone Creek

Under existing conditions, the instream concentration of bacteria in Marrowbone Creek is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-38** shows the fecal coliform geometric mean existing conditions and **Figure 4-39** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-40** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-41** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in Marrowbone Creek is presented in **Table 4-40.** The corresponding *E. coli* loading is presented in **Table 4-41**. *E. coli* concentrations in the impaired Marrowbone Creek (Reach 61) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-40** and **Table 4-41** show that loading from the commercial/industrial, low density residential, medium density residential, and pasture areas are the predominant sources of bacteria in the Marrowbone Creek watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife, failed septic systems, and straight pipes will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate. It should be noted that the point sources' existing-conditions bacteria loads are not included in **Tables 4-40 and 4-41** since existing fecal coliform concentrations were insignificant.

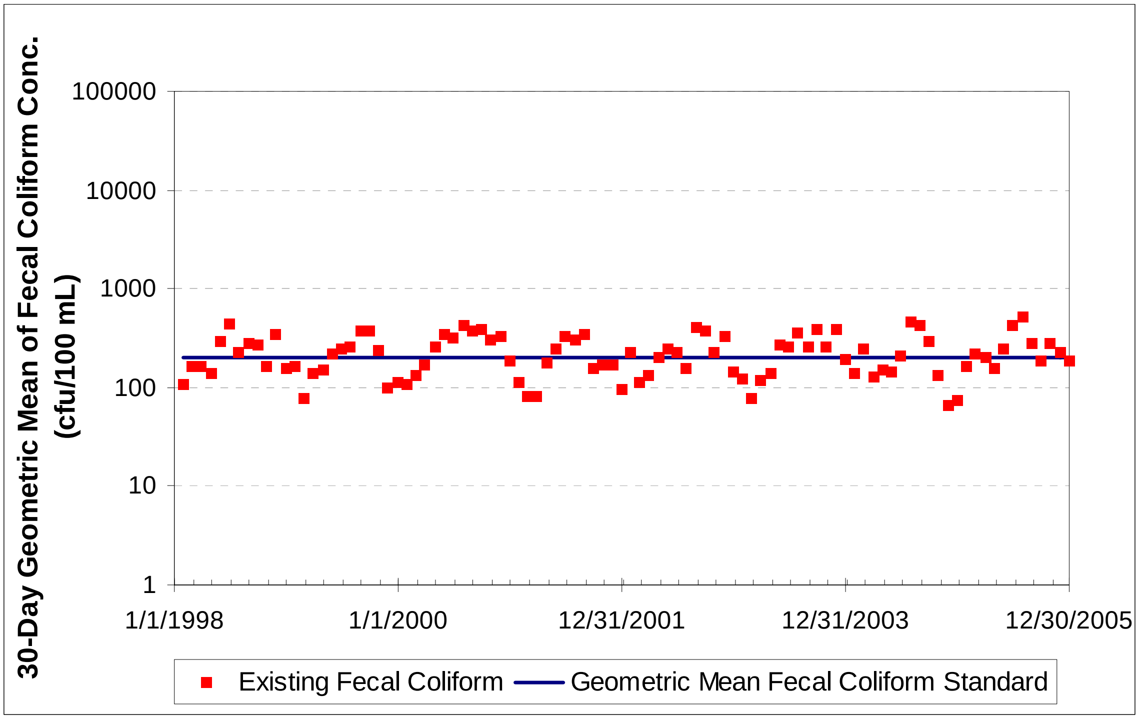

Figure 4-38: Marrowbone Creek Fecal Coliform Geometric Mean Existing Conditions

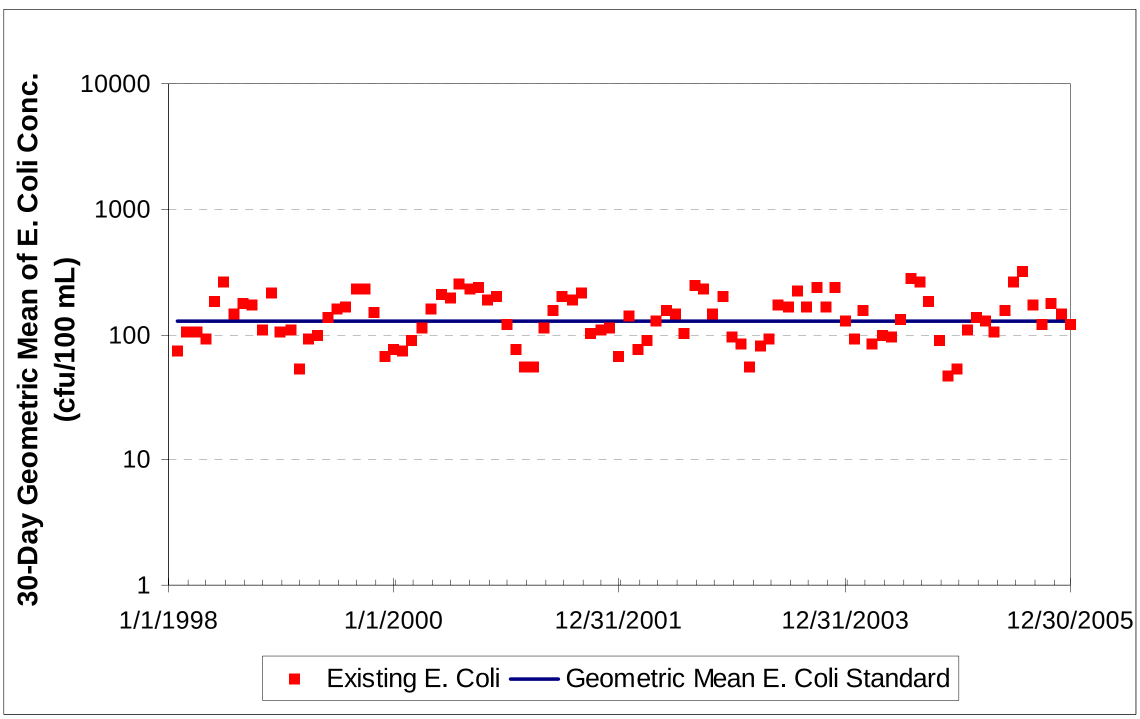

Figure 4-39: Marrowbone Creek E. coli Geometric Mean Existing Conditions

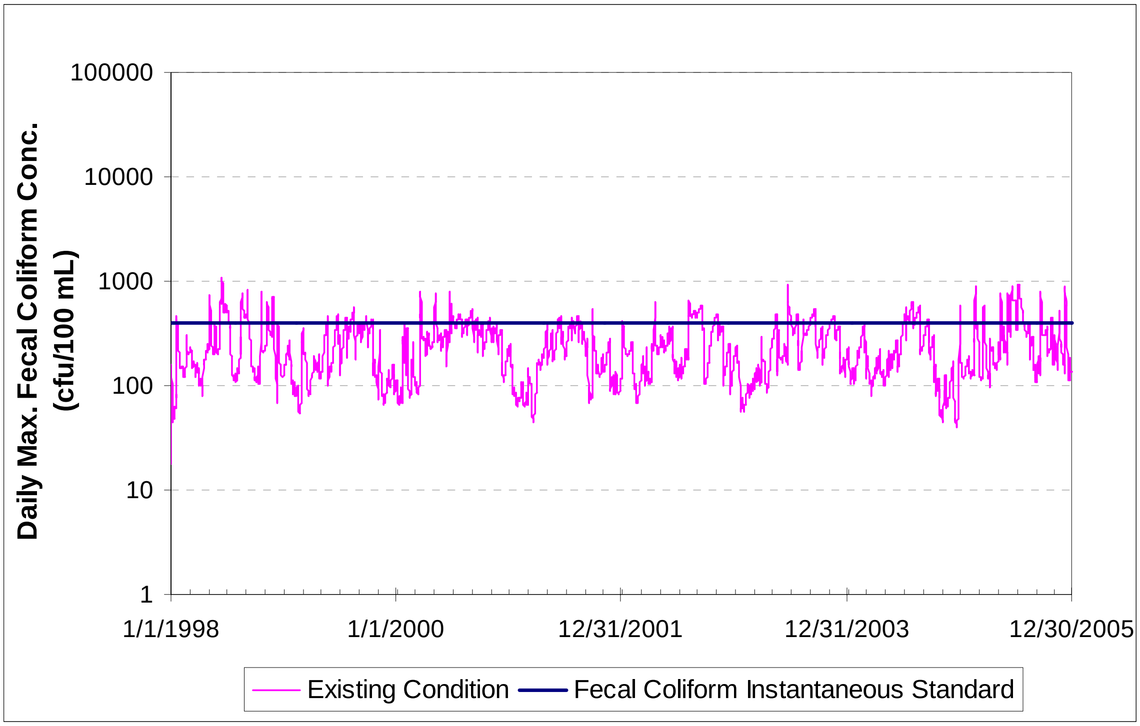

Figure 4-40: Marrowbone Creek Fecal Coliform Instantaneous Existing Conditions

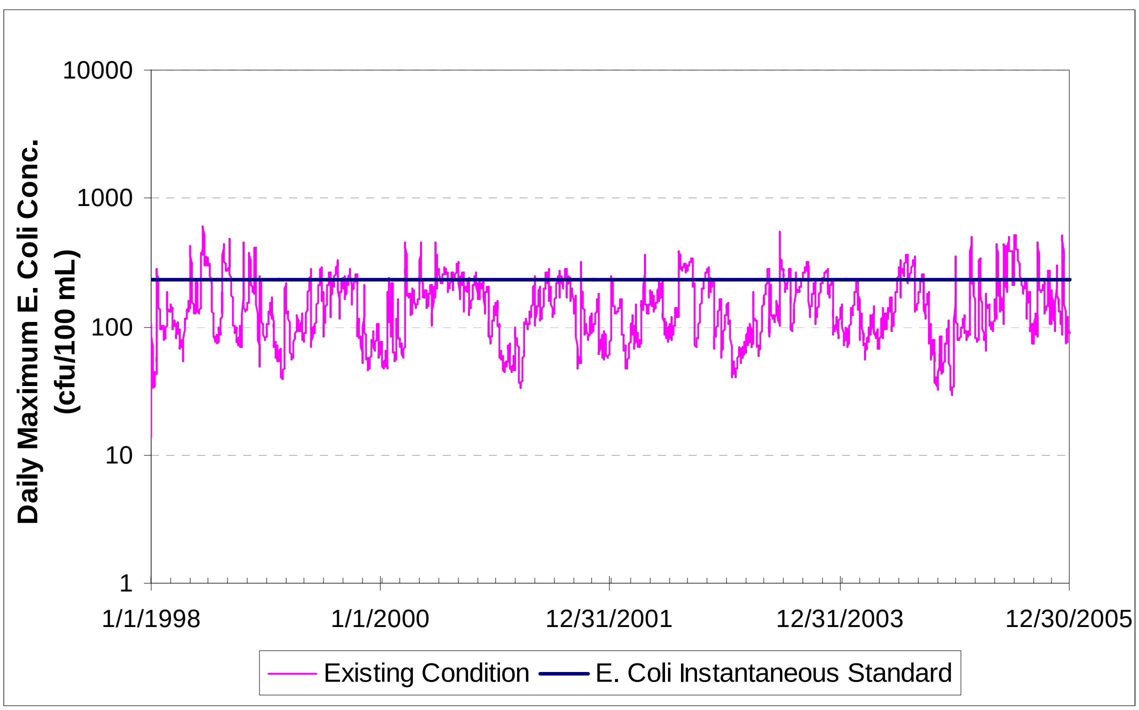

Figure 4-41: Marrowbone Creek *E. coli* Instantaneous Existing Conditions

Table 4-40: Marrowbone Creek Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	**7.20E+11**	**0.6%**
Cropland	**6.72E+10**	**0.1%**
Pasture	**3.47E+13**	**28.6%**
Low Density Residential	**2.91E+13**	**24.0%**
Medium Density Residential	**1.79E+13**	**14.8%**
High Density Residential	**1.43E+13**	**11.8%**
Commercial/Industrial	**6.13E+12**	**5.1%**
Failed Septic - direct deposition	**2.96E+12**	**2.4%**
Wildlife - direct deposition	**1.53E+13**	**12.6%**
Cattle - direct deposition	**2.16E+08**	**<0.1%**
Total	**1.21E+14**	**100%**

Table 4-41: Marrowbone Creek *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	**4.42E+11**	**0.6%**
Cropland	**4.13E+10**	**0.1%**
Pasture	**2.13E+13**	**28.6%**
Low Density Residential	**1.79E+13**	**24.0%**
Medium Density Residential	**1.10E+13**	**14.8%**
High Density Residential	**8.79E+12**	**11.8%**
Commercial/Industrial	**3.77E+12**	**5.1%**
Failed Septic - direct deposition	**1.82E+12**	**2.4%**
Wildlife - direct deposition	**9.37E+12**	**12.6%**
Cattle - direct deposition	**1.32E+08**	**<0.1%**
Total	**7.44E+13**	**100%**

4.10.8 North Fork Mayo River

Under existing conditions, the instream concentration of bacteria in the North Fork Mayo River is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-42** shows the fecal coliform geometric mean existing conditions and **Figure 4-43** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-44** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-45** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in the North Fork Mayo River is presented in **Table 4-42.** The corresponding *E. coli* loading is presented in **Table 4-43**. *E. coli* concentrations in the impaired North Fork Mayo River (Reach 73) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-42** and **Table 4-43** show that loading from the commercial/industrial, pasture, and wildlife areas are the predominant sources of bacteria in the North Fork Mayo River watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife, failed septic systems, and straight pipes will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate.

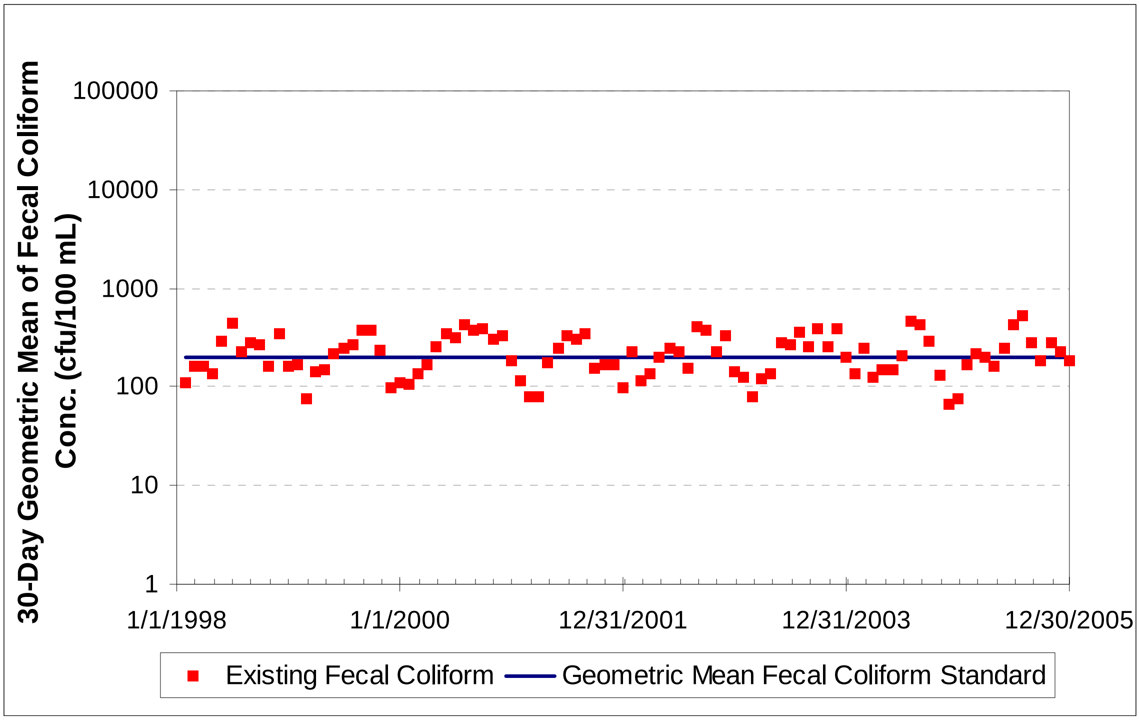

Figure 4-42: North Fork Mayo River Fecal Coliform Geometric Mean Existing Conditions

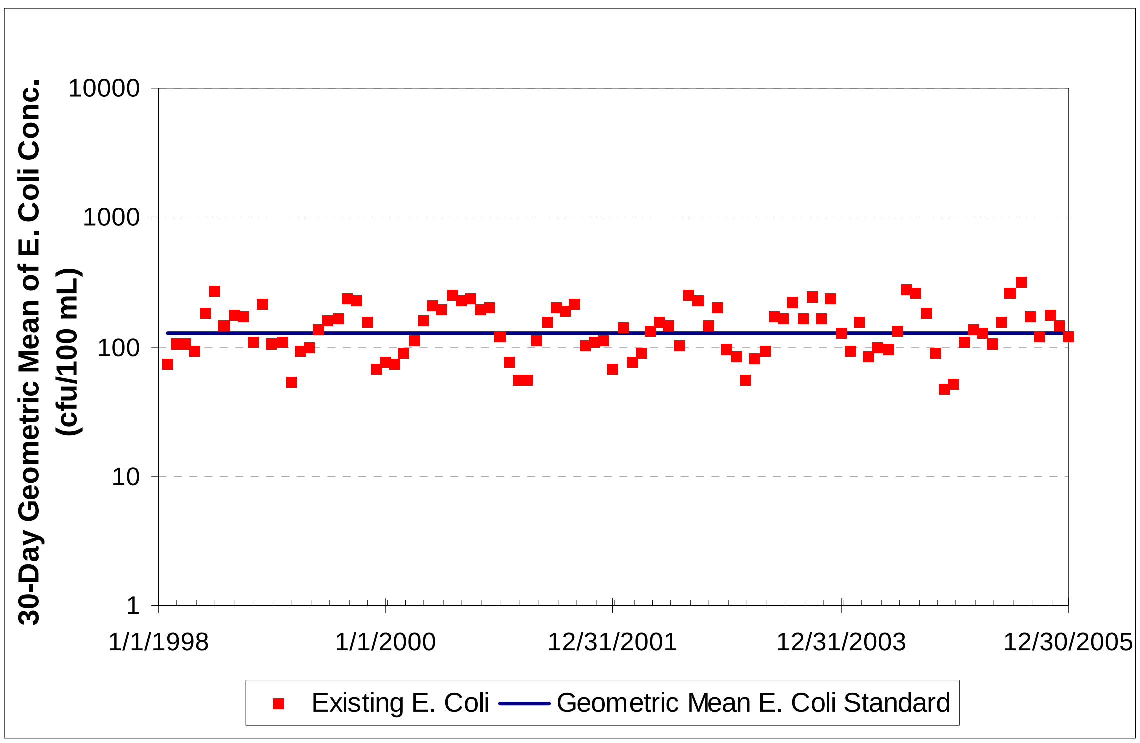

Figure 4-43: North Fork Mayo River E. coli Geometric Mean Existing Conditions

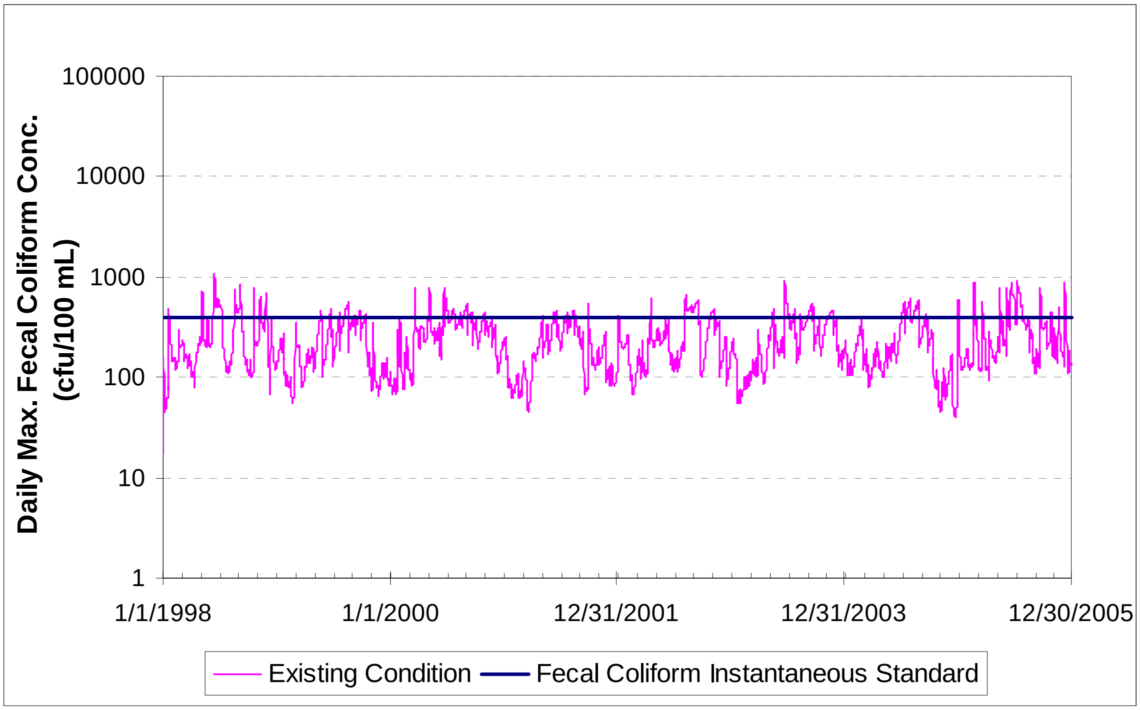

Figure 4-44: North Fork Mayo River Fecal Coliform Instantaneous Existing Conditions

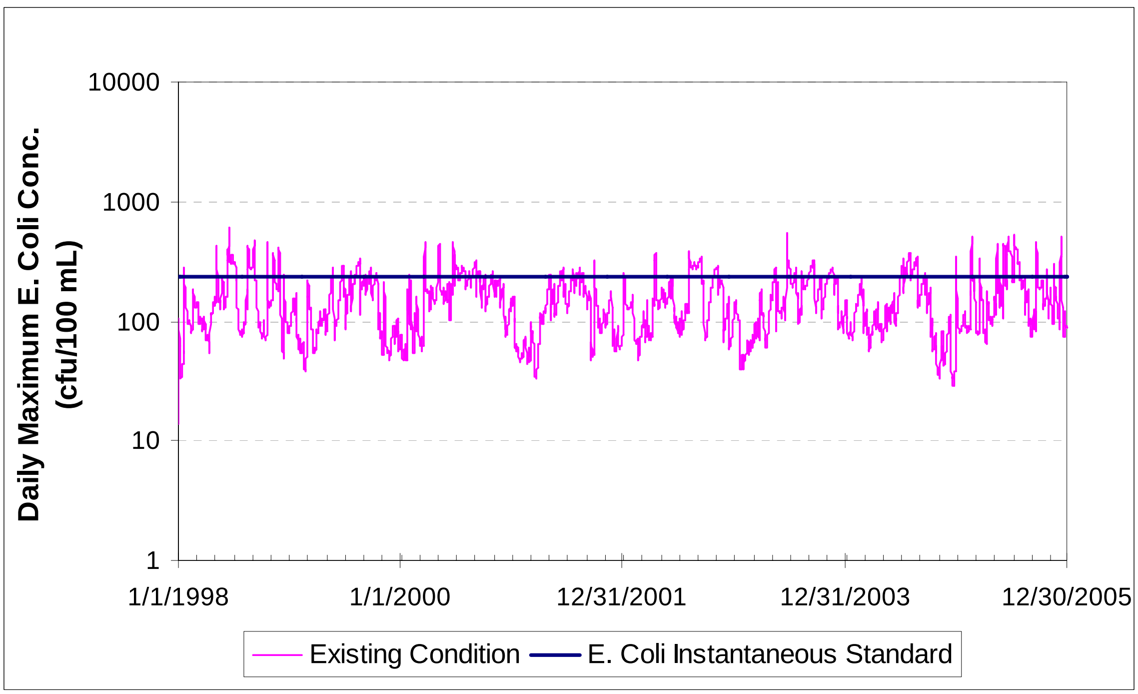

Figure 4-45: North Fork Mayo River *E. coli* Instantaneous Existing Conditions

Table 4-42: North Fork Mayo River Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	**2.66E+12**	**1.0%**
Cropland	**9.51E+11**	**0.3%**
Pasture	**1.50E+14**	**54.8%**
Low Density Residential	**2.34E+13**	**8.5%**
Medium Density Residential	**9.03E+12**	**3.3%**
High Density Residential	**5.45E+11**	**0.2%**
Commercial/Industrial	**1.73E+13**	**6.3%**
Failed Septic - direct deposition	**1.43E+13**	**5.2%**
Wildlife - direct deposition	**5.50E+13**	**20.1%**
Cattle - direct deposition	**3.82E+08**	**<0.1%**
Point Source	**3.87E+11**	**0.1%**
Total	**2.74E+14**	**100.0%**

Table 4-43: North Fork Mayo River *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	**1.70E+12**	**1.0%**
Cropland	**6.07E+11**	**0.3%**
Pasture	**9.57E+13**	**54.9%**
Low Density Residential	**1.49E+13**	**8.5%**
Medium Density Residential	**5.76E+12**	**3.3%**
High Density Residential	**3.48E+11**	**0.2%**
Commercial/Industrial	**1.11E+13**	**6.4%**
Failed Septic - direct deposition	**9.15E+12**	**5.2%**
Wildlife - direct deposition	**3.51E+13**	**20.1%**
Cattle - direct deposition	**2.44E+08**	**<0.1%**
Point Source	**4.88E+10**	**<0.1%**
Total	**1.75E+14**	**100.0%**

4.10.9 Smith River

Under existing conditions, the instream concentration of bacteria in the Smith River is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figures 4-46**, **4-48**, and **4-50** show the fecal coliform geometric mean existing conditions and **Figures 4-47**, **4-49**, and **4-51** show the *E. coli* geometric mean concentrations under existing conditions for the Smith River reaches 36, 41, and 44. **Figures 4-52**, **4-54**, and **4-56** show the fecal coliform instantaneous concentrations under existing conditions and **Figures 4-53**, **4-55**, and **4-57** show the *E. coli* instantaneous concentrations under existing conditions for the Smith River reaches 36, 41, and 44.

Distribution of the existing fecal coliform load by source in Smith River is presented in **Table 4-44.** The corresponding *E. coli* loading is presented in **Table 4-45**. *E. coli* concentrations in the impaired Smith River (Reaches 36, 41, and 44) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-44** and **Table 4-45** show that loading from point sources, commercial/industrial, and low and medium density residential areas are the predominant sources of bacteria in the Smith River watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife, failed septic systems, and straight pipes will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate.

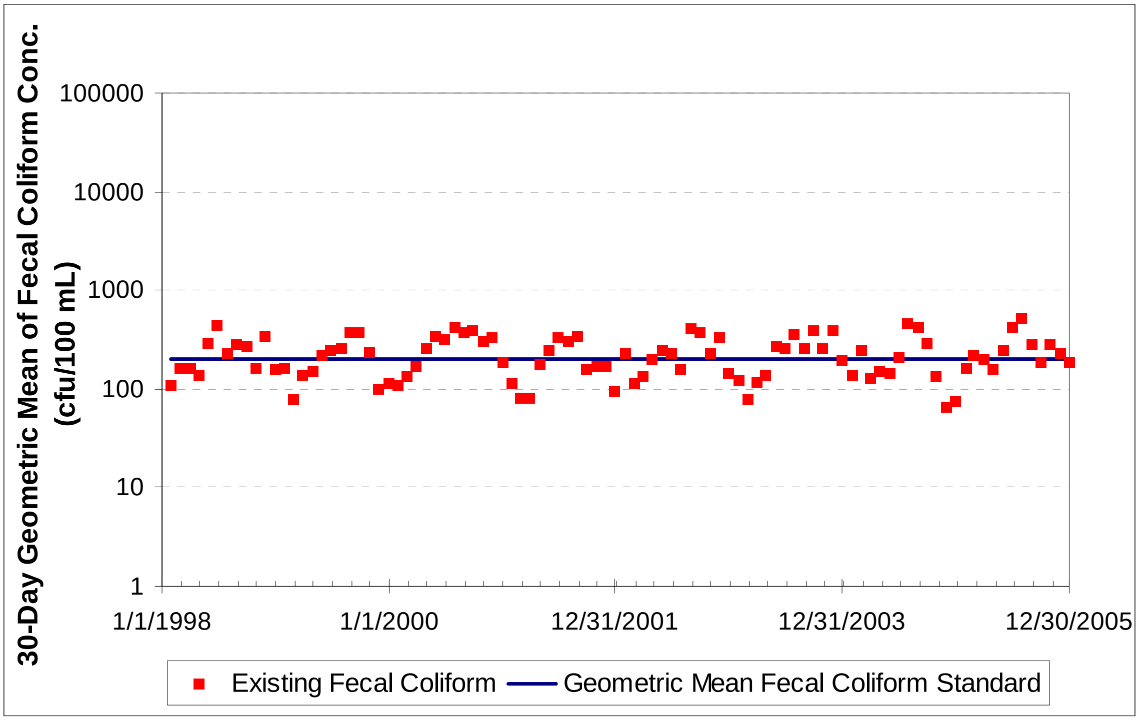

Figure 4-46: Smith River Fecal Coliform Geometric Mean Existing Conditions (Reach 36)

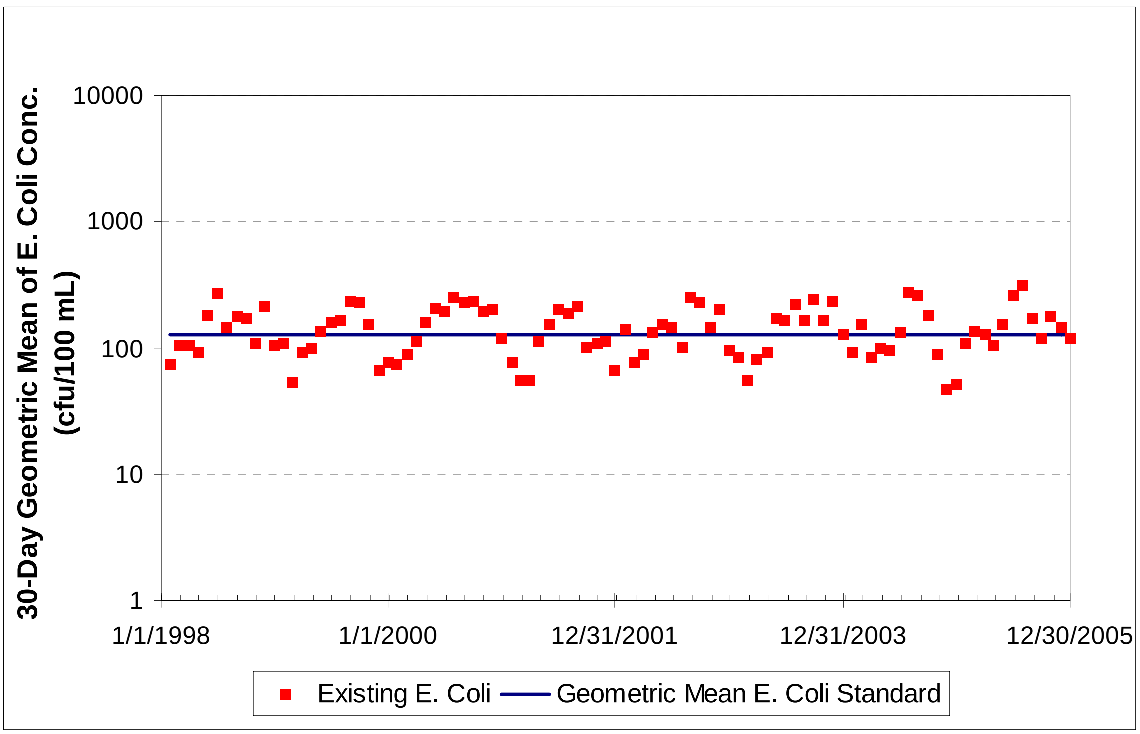

Figure 4-47: Smith River E. coli Geometric Mean Existing Conditions (Reach 36)

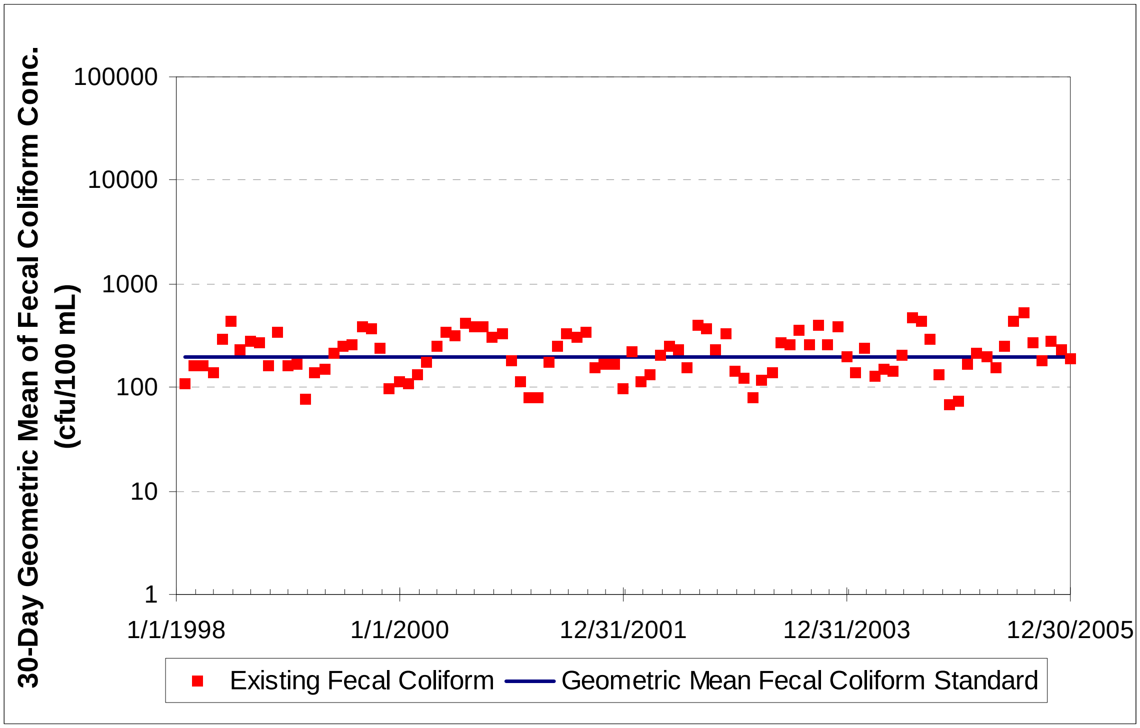

Figure 4-48: Smith River Fecal Coliform Geometric Mean Existing Conditions (Reach 41)

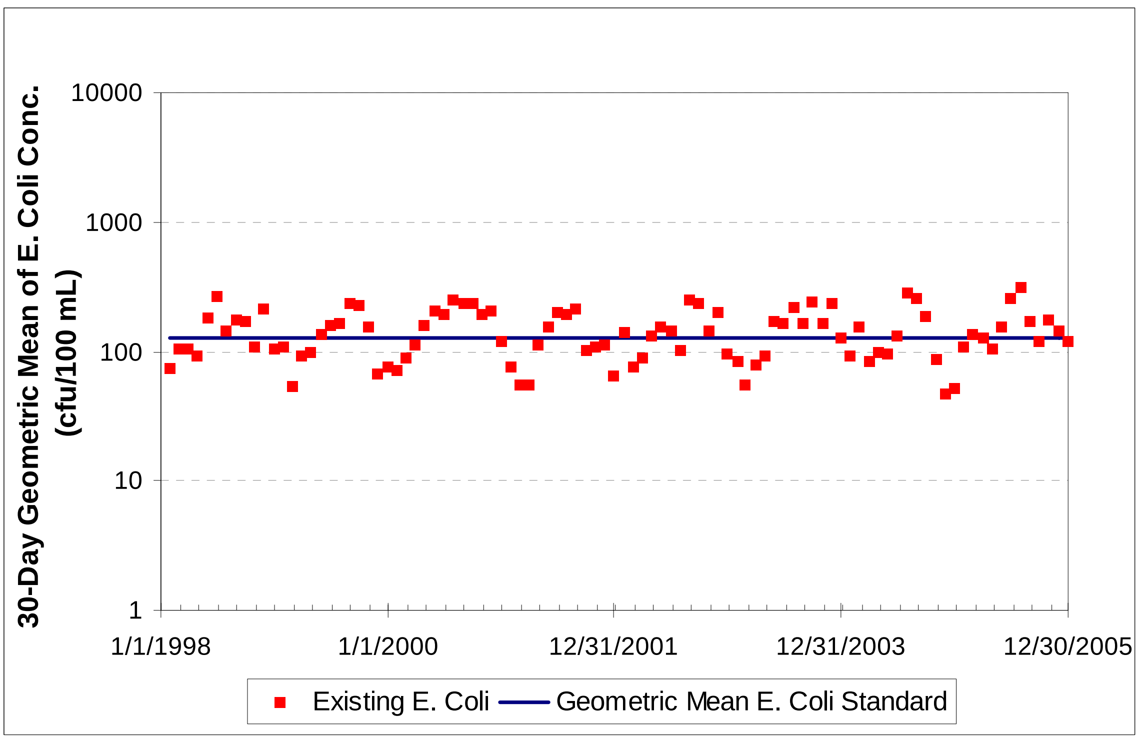

Figure 4-49: Smith River E. coli Geometric Mean Existing Conditions (Reach 41)

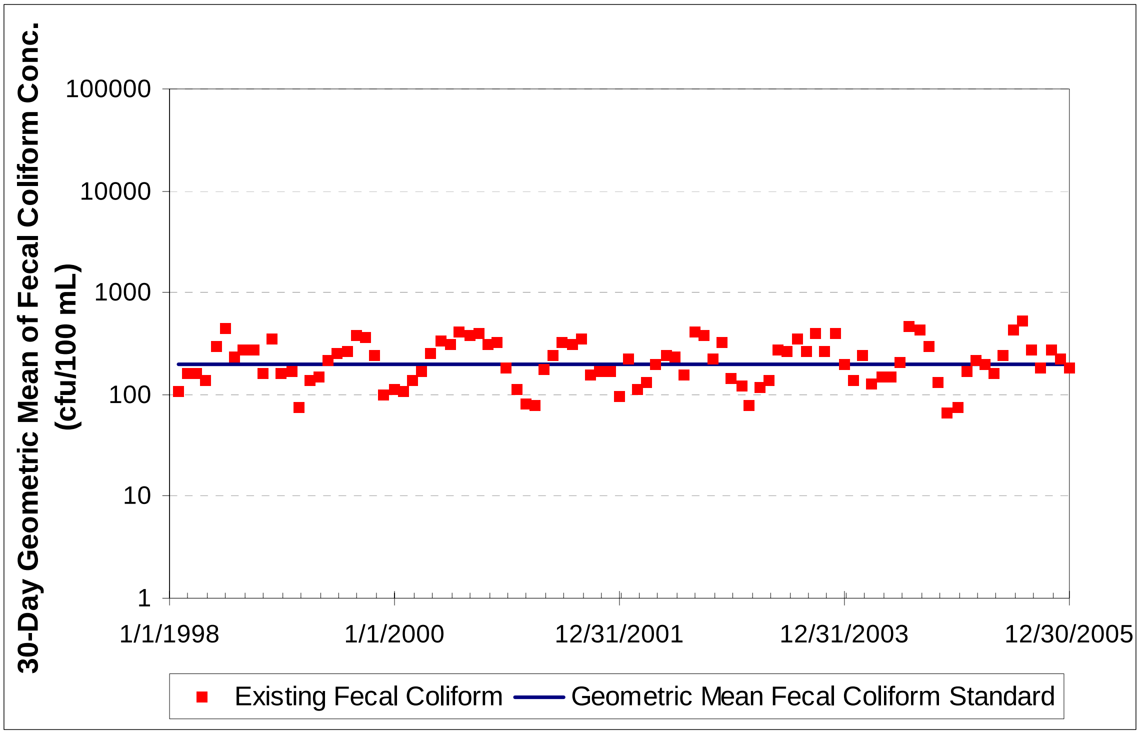

Figure 4-50: Smith River Fecal Coliform Geometric Mean Existing Conditions (Reach 44)

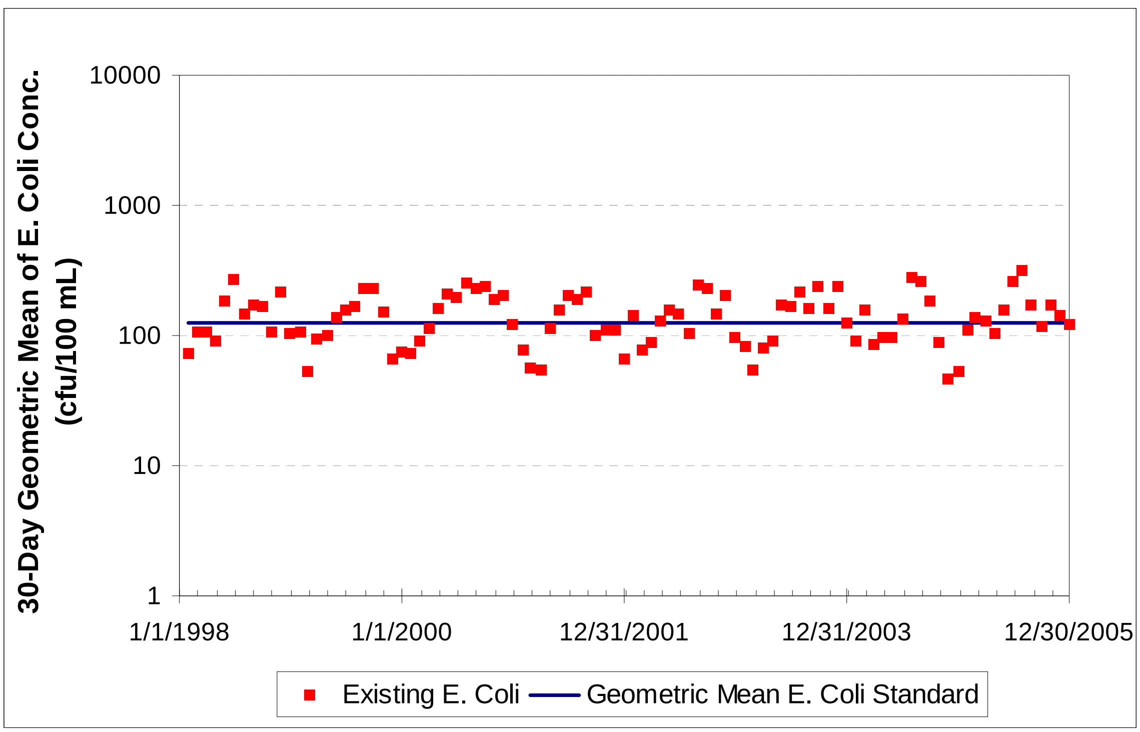

Figure 4-51: Smith River E. coli Geometric Mean Existing Conditions (Reach 44)

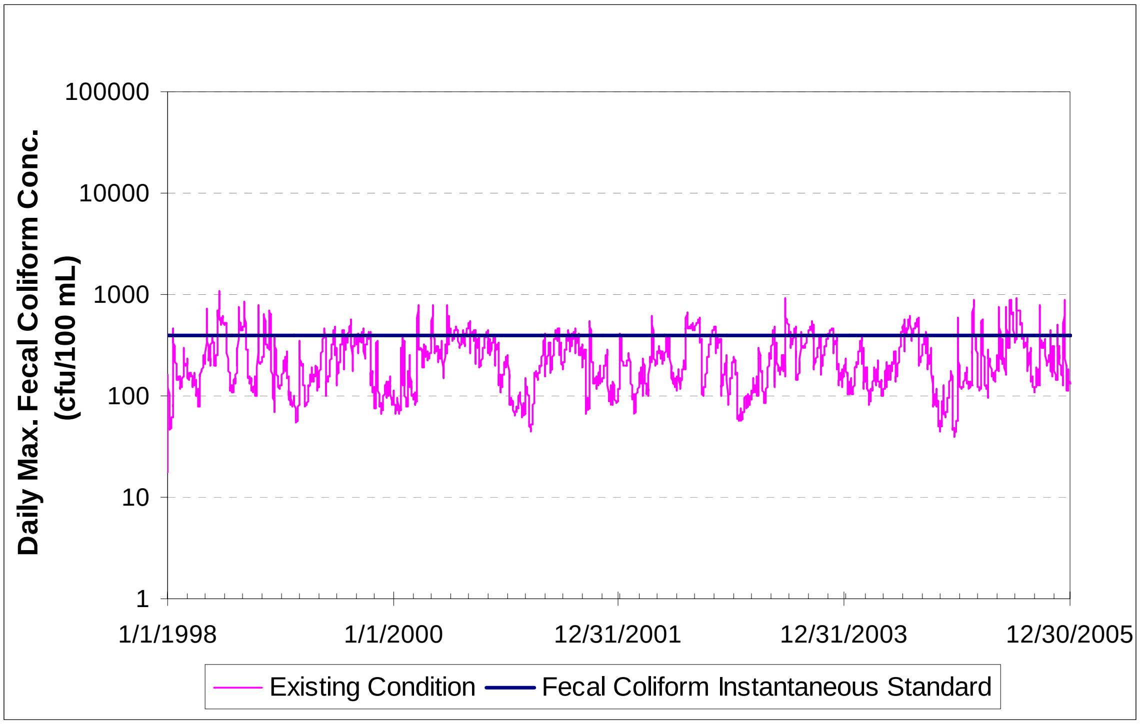

Figure 4-52: Smith River Fecal Coliform Instantaneous Existing Conditions (Reach 36)

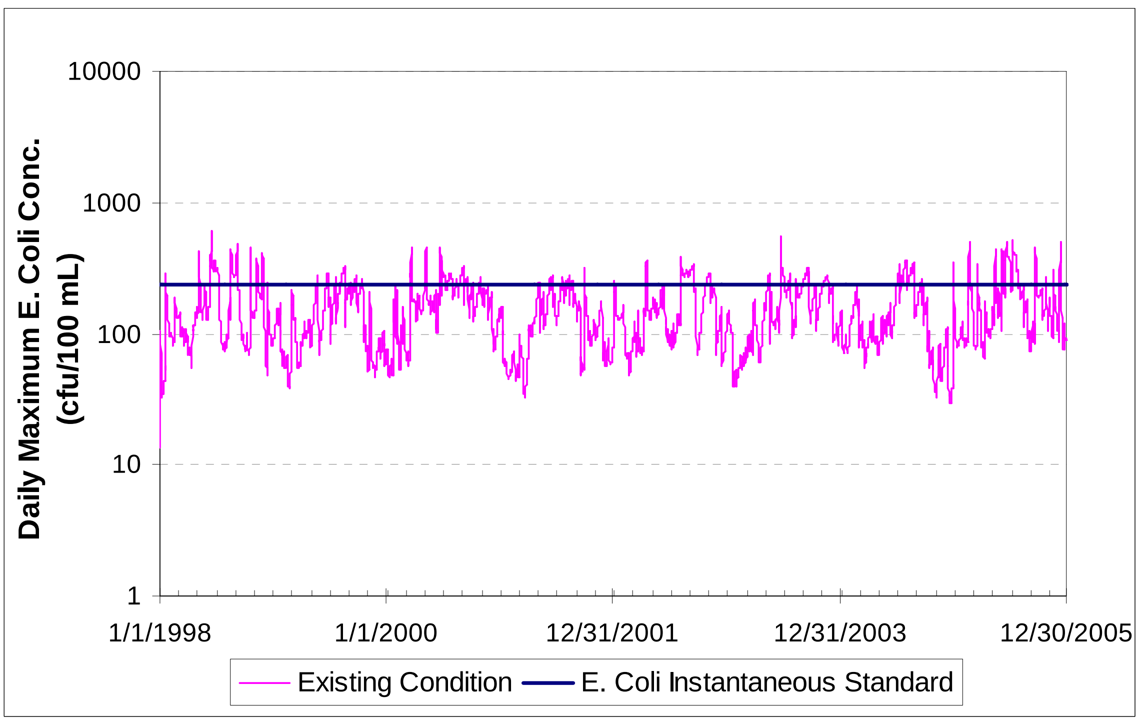

Figure 4-53: Smith River *E. coli* Instantaneous Existing Conditions (Reach 36)

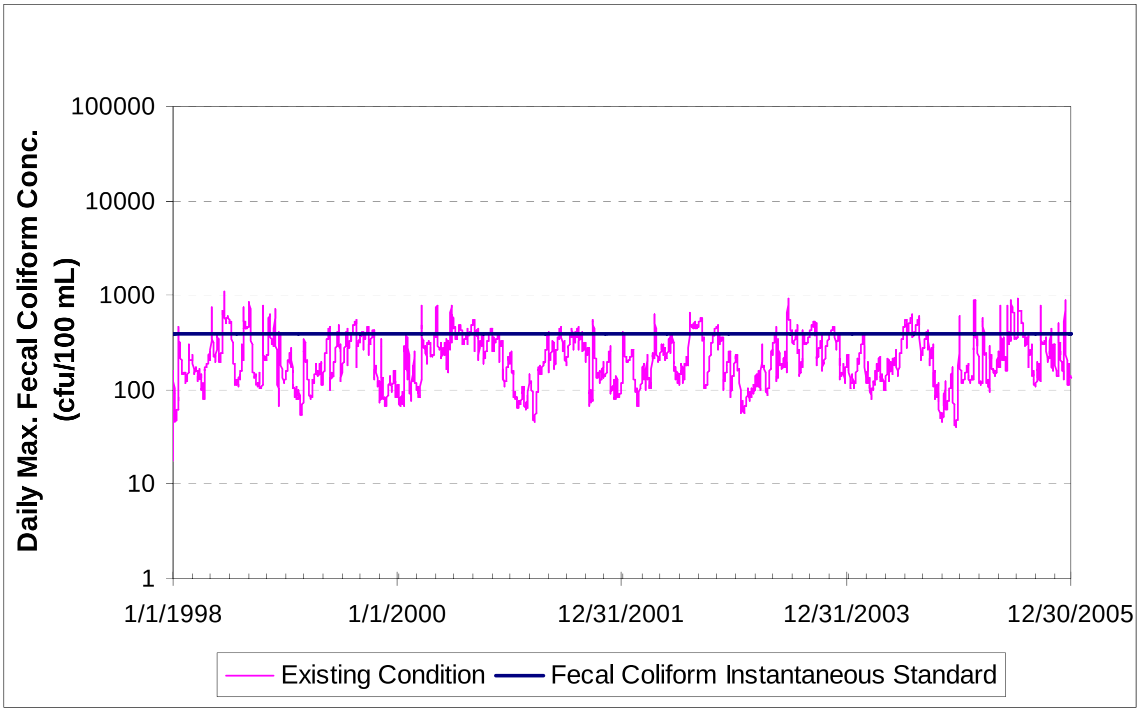

Figure 4-54: Smith River Fecal Coliform Instantaneous Existing Conditions (Reach 41)

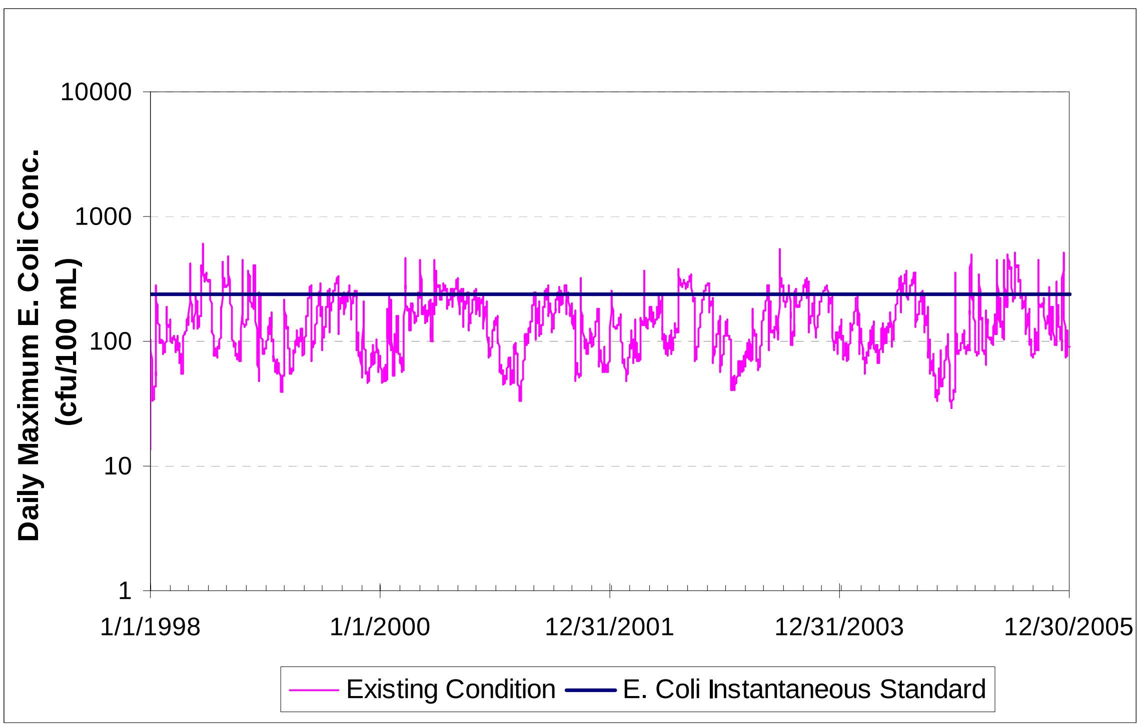

Figure 4-55: Smith River *E. coli* Instantaneous Existing Conditions (Reach 41)

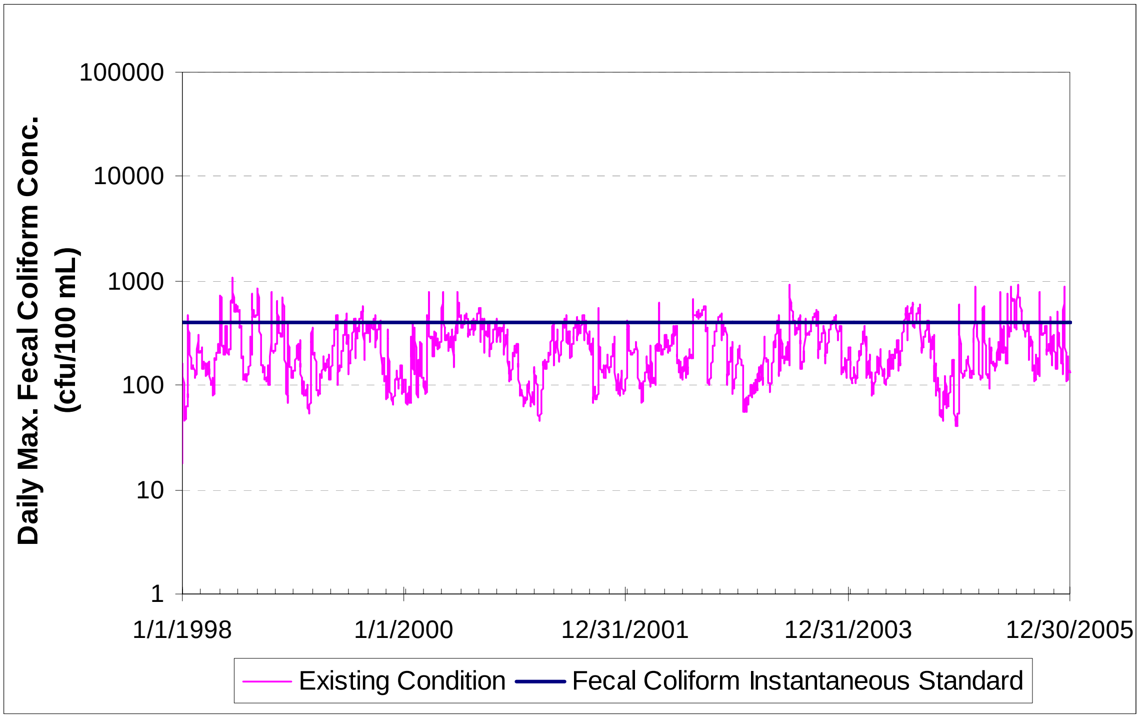

Figure 4-56: Smith River Fecal Coliform Instantaneous Existing Conditions (Reach 44)

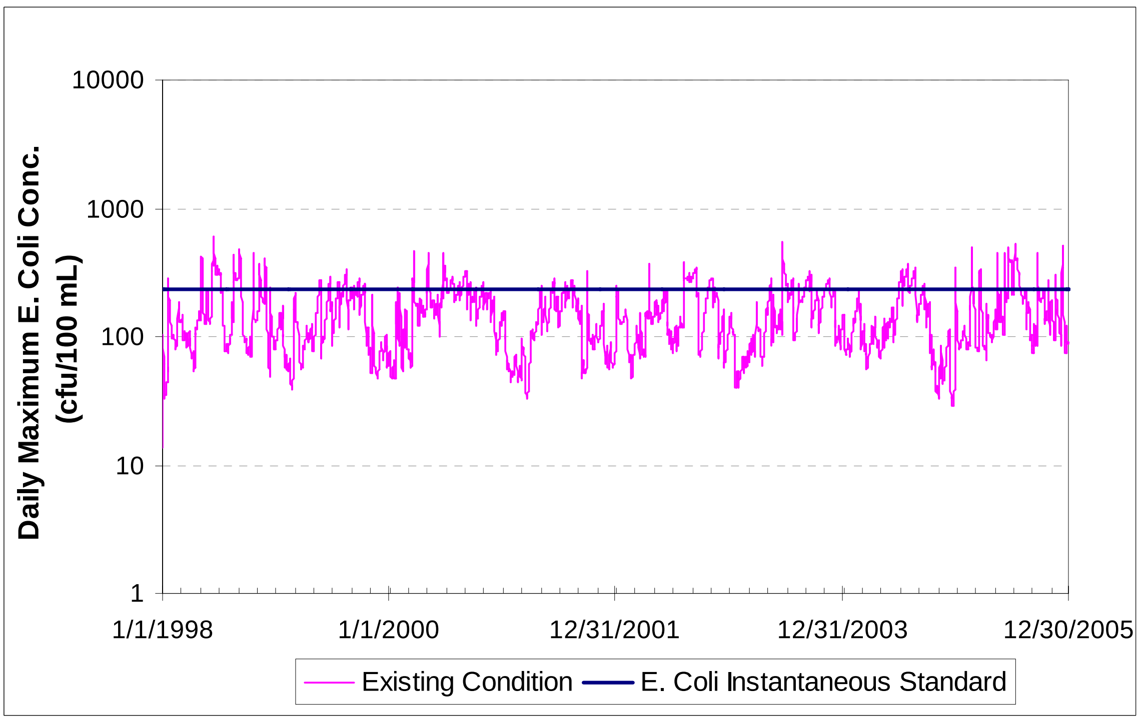

Figure 4-57: Smith River *E. coli* Instantaneous Existing Conditions (Reach 44)

Table 4-44: Smith River (Reach 36) Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	**8.90E+11**	**0.1%**
Cropland	**5.17E+11**	**0.1%**
Pasture	**5.37E+14**	**52.4%**
Low Density Residential	**8.88E+13**	**8.7%**
Medium Density Residential	**5.27E+13**	**5.1%**
High Density Residential	**4.01E+13**	**3.9%**
Commercial/Industrial	**1.14E+14**	**11.1%**
Failed Septic - direct deposition	**3.65E+12**	**0.4%**
Wildlife - direct deposition	**2.10E+13**	**2.1%**
Cattle - direct deposition	**1.10E+10**	**<0.1%**
Point Source	**1.66E+14**	**16.2%**
Total	**1.02E+15**	**100.0%**

Table 4-45: Smith River (Reach 36) *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	**4.48E+11**	**0.1%**
Cropland	**2.60E+11**	**0.1%**
Pasture	**2.71E+14**	**59.7%**
Low Density Residential	**4.47E+13**	**9.8%**
Medium Density Residential	**2.66E+13**	**5.9%**
High Density Residential	**2.02E+13**	**4.5%**
Commercial/Industrial	**5.73E+13**	**12.6%**
Failed Septic - direct deposition	**1.84E+12**	**0.4%**
Wildlife - direct deposition	**1.06E+13**	**2.3%**
Cattle - direct deposition	**5.52E+09**	**0.0%**
Point Source	**2.09E+13**	**4.6%**
Total	**4.54E+14**	**100.0%**

4.10.10 South Fork Mayo River

Under existing conditions, the instream concentration of bacteria in the South Fork Mayo River is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-58** shows the fecal coliform geometric mean existing conditions and **Figure 4-59** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-60** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-61** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in South Fork Mayo River is presented in **Table 4-46.** The corresponding *E. coli* loading is presented in **Table 4-47**. *E. coli* concentrations in the impaired South Fork Mayo River (Reach 80) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-46** and **Table 4-47** show that loading from commercial/industrial, pasture, and wildlife areas are the predominant sources of bacteria in the South Fork Mayo River watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife, failed septic systems, and straight pipes will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate. It should be noted that the point sources' existing-conditions bacteria loads are not included in **Tables 4-46 and 4-47** since existing fecal coliform concentrations were insignificant.

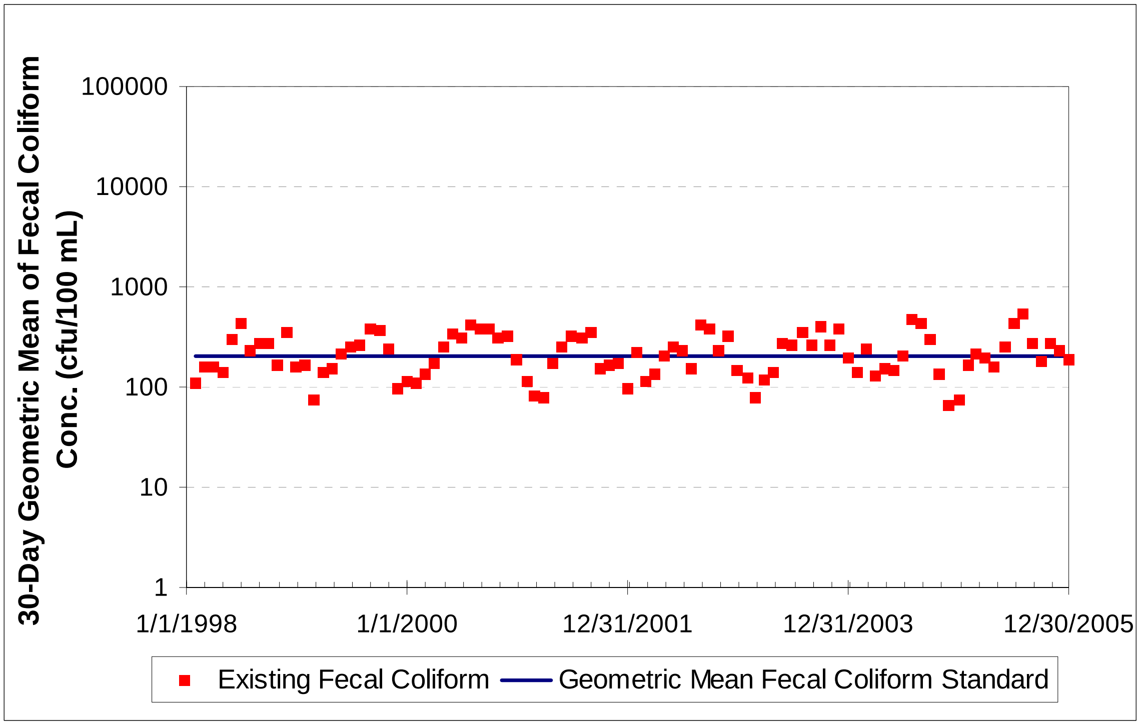

Figure 4-58: South Fork Mayo River Fecal Coliform Geometric Mean Existing Conditions

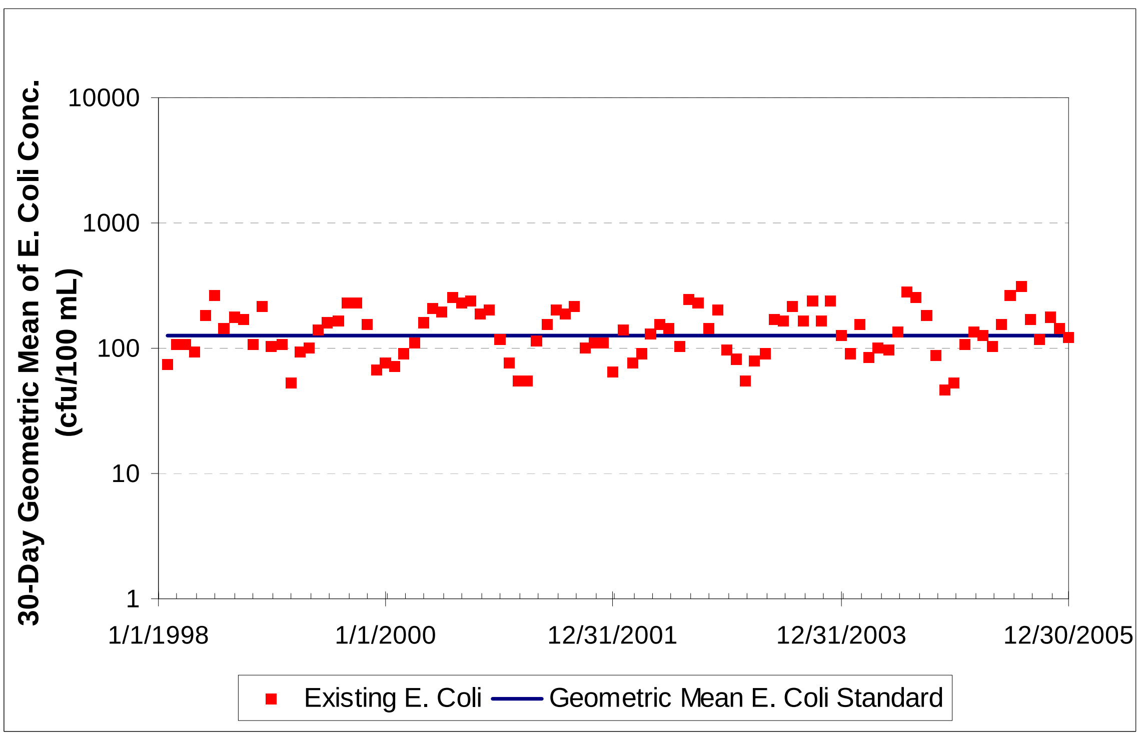

Figure 4-59: South Fork Mayo River E. coli Geometric Mean Existing Conditions

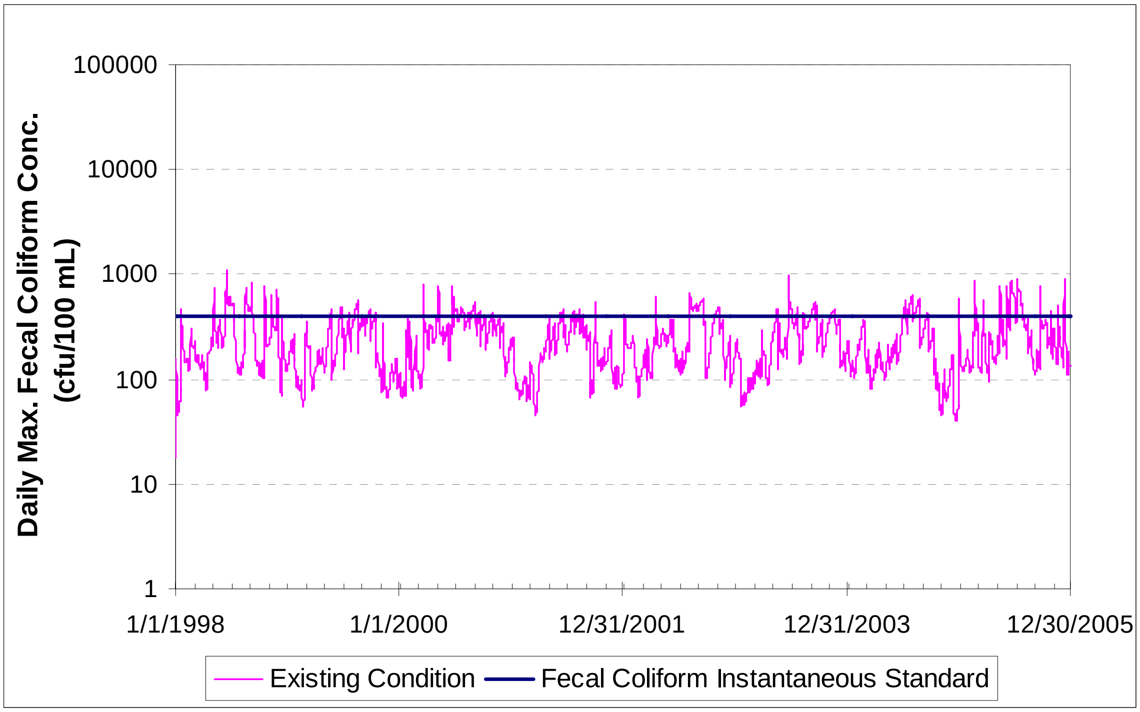

Figure 4-60: South Fork Mayo River Fecal Coliform Instantaneous Existing Conditions

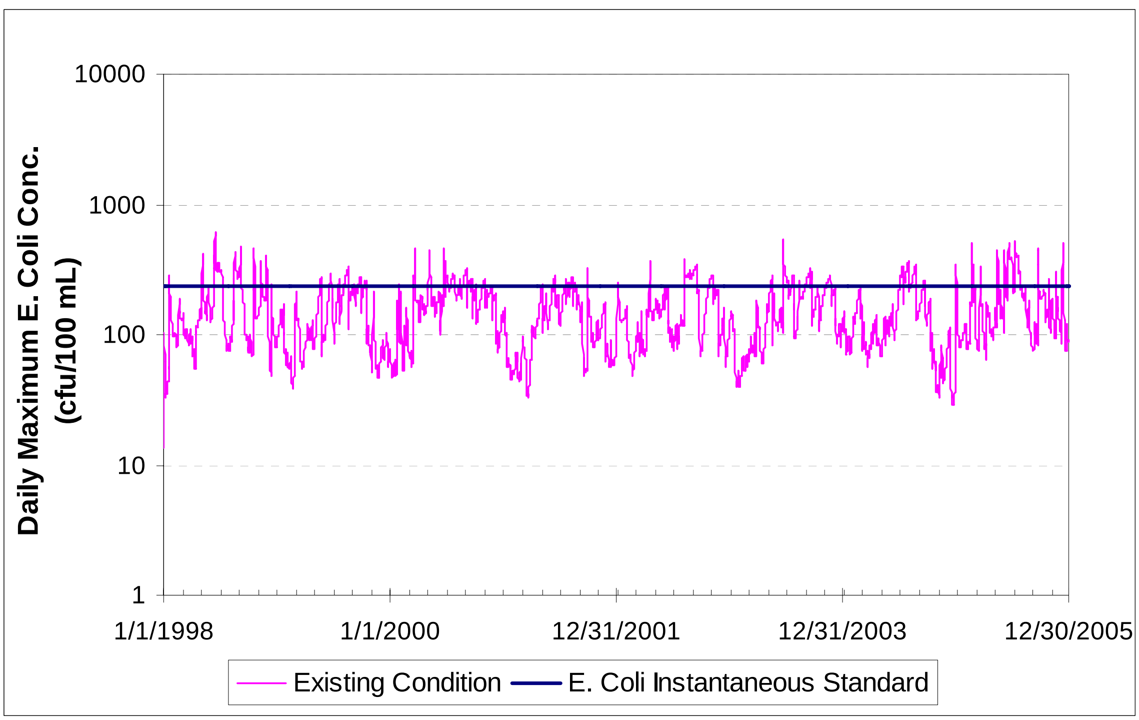

Figure 4-61: **South Fork Mayo River *E. coli* Instantaneous Existing Conditions**

Table 4-46: South Fork Mayo River Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	**3.30E+12**	**0.8%**
Cropland	**1.81E+12**	**0.4%**
Pasture	**2.31E+14**	**57.0%**
Low Density Residential	**2.96E+13**	**7.3%**
Medium Density Residential	**1.70E+13**	**4.2%**
High Density Residential	**2.31E+12**	**0.6%**
Commercial/Industrial	**2.80E+13**	**6.9%**
Failed Septic - direct deposition	**2.07E+13**	**5.1%**
Wildlife - direct deposition	**7.14E+13**	**17.6%**
Cattle - direct deposition	**1.15E+08**	**<0.1%**
Total	**4.05E+14**	**100.0%**

Table 4-47: South Fork Mayo River *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	**2.08E+12**	**0.8%**
Cropland	**1.14E+12**	**0.4%**
Pasture	**1.46E+14**	**57.0%**
Low Density Residential	**1.87E+13**	**7.3%**
Medium Density Residential	**1.07E+13**	**4.2%**
High Density Residential	**1.46E+12**	**0.6%**
Commercial/Industrial	**1.76E+13**	**6.9%**
Failed Septic - direct deposition	**1.30E+13**	**5.1%**
Wildlife - direct deposition	**4.50E+13**	**17.6%**
Cattle - direct deposition	**7.27E+07**	**<0.1%**
Total	**2.55E+14**	**100.0%**

4.10.11 Sandy Creek

Under existing conditions, the instream concentration of bacteria in the Sandy Creek is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-62** shows the fecal coliform geometric mean existing conditions and **Figure 4-63** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-64** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-65** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in Sandy Creek is presented in **Table 4-48.** The corresponding *E. coli* loading is presented in **Table 4-49**. *E. coli* concentrations in the impaired Sandy Creek (Reach 24) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-48** and **Table 4-49** show that loading from commercial/industrial, pasture, wildlife, and low density residential areas are the predominant sources of bacteria in the Sandy Creek watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife, failed septic systems, and straight pipes will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate. It should be noted that the point sources' existing-conditions bacteria loads are not included in **Tables 4-48 and 4-49** since existing fecal coliform concentrations were insignificant.

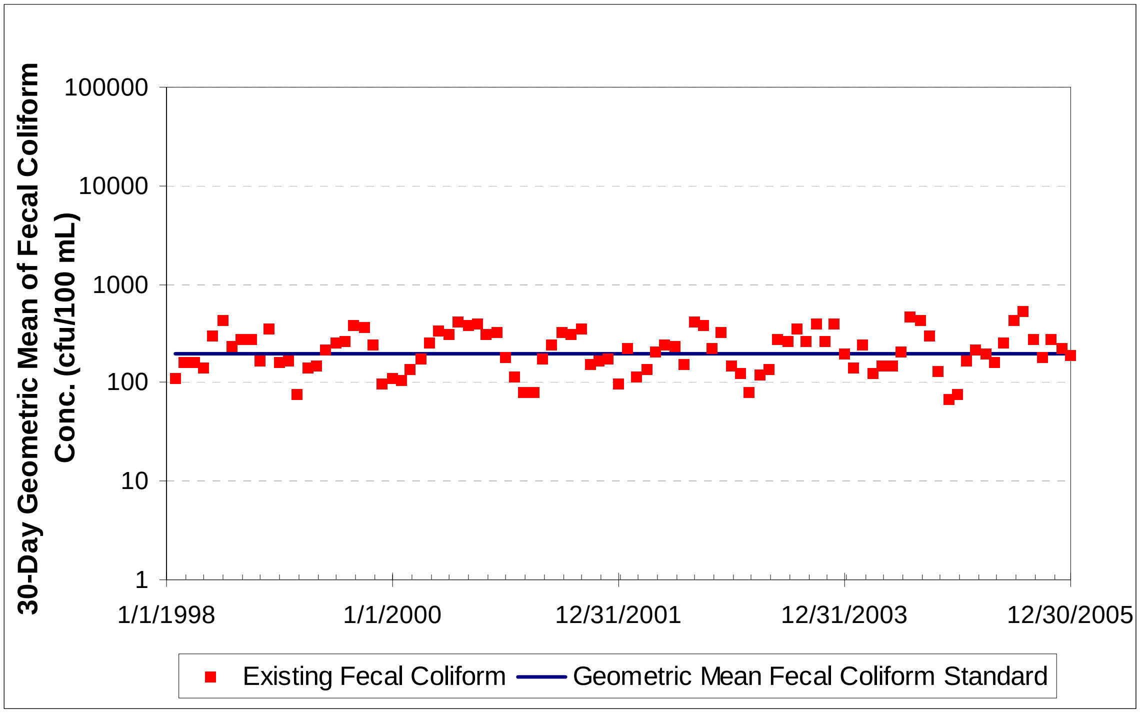

Figure 4-62: Sandy Creek Fecal Coliform Geometric Mean Existing Conditions

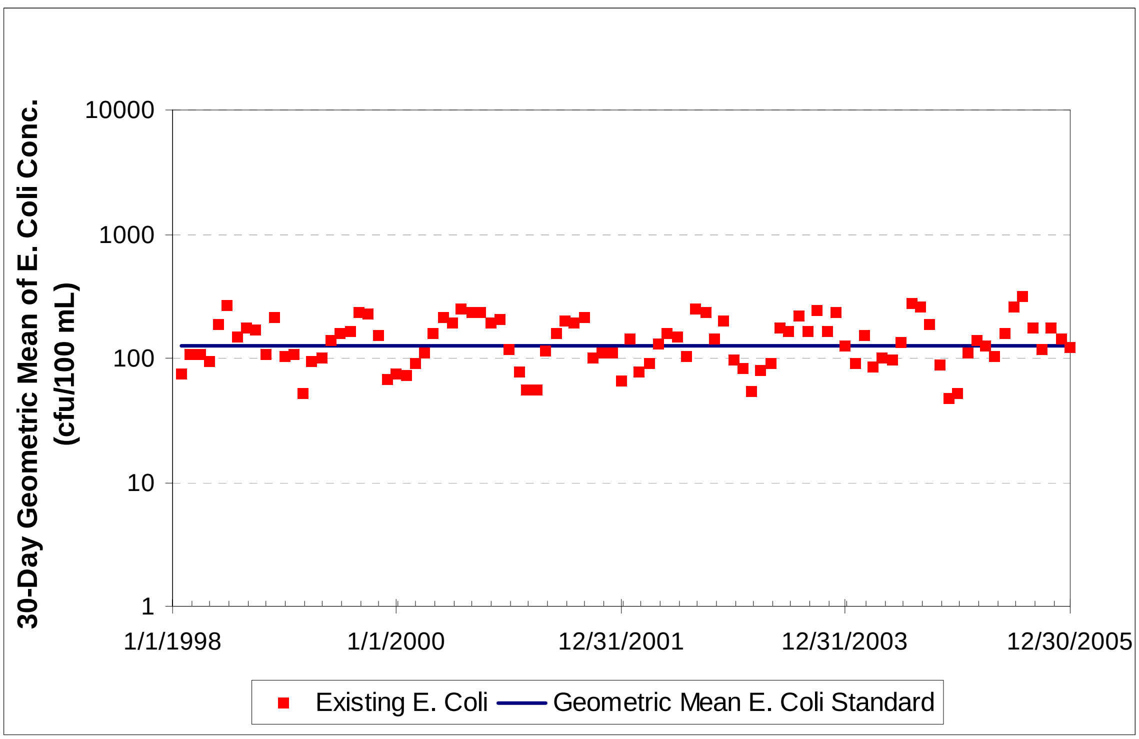

Figure 4-63: Sandy Creek E. coli Geometric Mean Existing Conditions

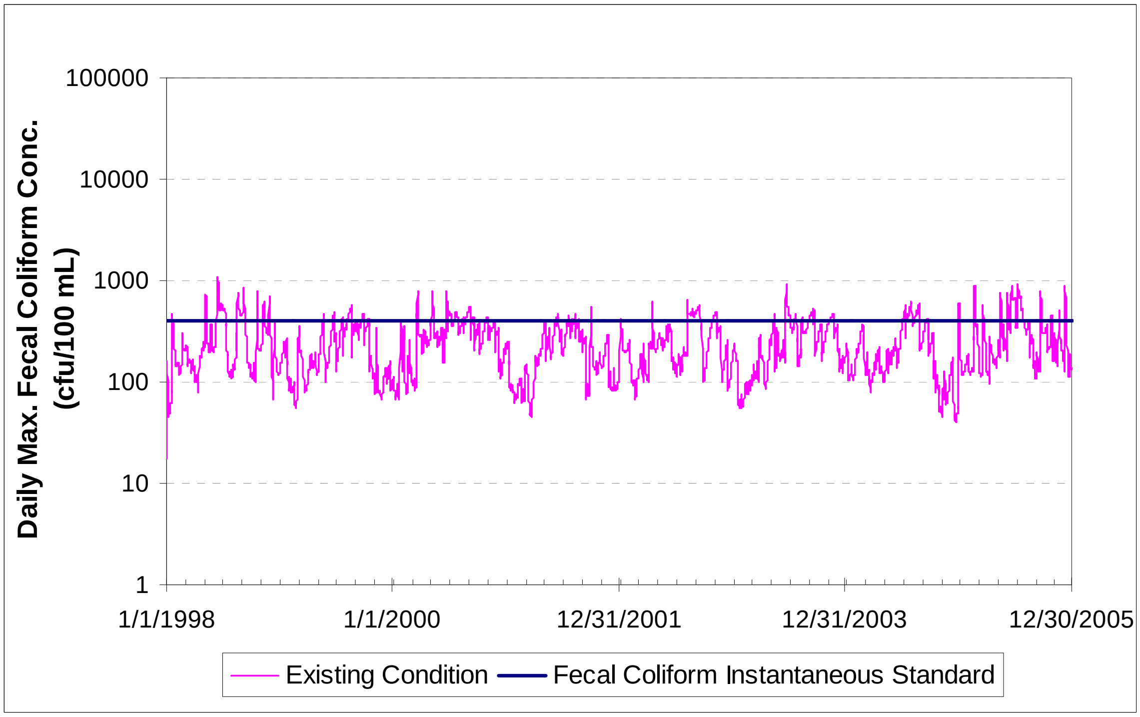

Figure 4-64: Sandy Creek Fecal Coliform Instantaneous Existing Conditions

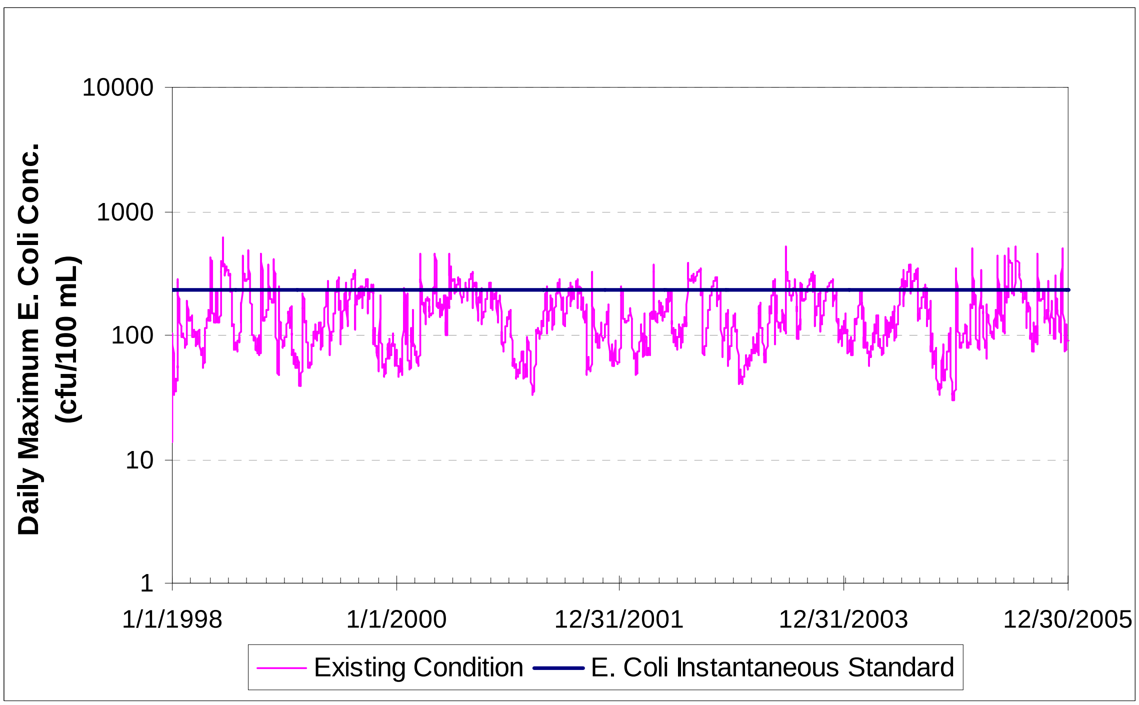

Figure 4-65: Sandy Creek *E. coli* Instantaneous Existing Conditions

Table 4-48: Sandy Creek Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	**2.29E+12**	**0.5%**
Cropland	**3.37E+12**	**0.7%**
Pasture	**3.05E+14**	**63.9%**
Low Density Residential	**7.13E+13**	**15.0%**
Medium Density Residential	**2.70E+13**	**5.7%**
High Density Residential	**3.09E+13**	**6.5%**
Commercial/Industrial	**2.38E+13**	**5.0%**
Failed Septic - direct deposition	**3.35E+12**	**0.7%**
Wildlife - direct deposition	**9.91E+12**	**2.1%**
Cattle - direct deposition	**1.69E+08**	**<0.1%**
Point Source	**1.04E+09**	**<0.1%**
Total	**4.77E+14**	**100.0%**

Table 4-49: Sandy Creek *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	**1.23E+12**	**0.5%**
Cropland	**1.80E+12**	**0.7%**
Pasture	**1.63E+14**	**63.9%**
Low Density Residential	**3.82E+13**	**15.0%**
Medium Density Residential	**1.44E+13**	**5.7%**
High Density Residential	**1.66E+13**	**6.5%**
Commercial/Industrial	**1.28E+13**	**5.0%**
Failed Septic - direct deposition	**1.80E+12**	**0.7%**
Wildlife - direct deposition	**5.31E+12**	**2.1%**
Cattle - direct deposition	**9.06E+07**	**<0.1%**
Point Source	**1.04E+09**	**<0.1%**
Total	**2.55E+14**	**100.0%**

4.10.12 Sandy River

Under existing conditions, the instream concentration of bacteria in the Sandy River is above both the fecal coliform and *E. coli* geometric mean and instantaneous standards for the majority of the time period. **Figure 4-66** shows the fecal coliform geometric mean existing conditions and **Figure 4-67** shows the *E. coli* geometric mean concentrations under existing conditions. **Figure 4-68** shows the fecal coliform instantaneous concentrations under existing conditions and **Figure 4-69** shows the *E. coli* instantaneous concentrations under existing conditions.

Distribution of the existing fecal coliform load by source in Sandy River is presented in **Table 4-50.** The corresponding *E. coli* loading is presented in **Table 4-51**. *E. coli* concentrations in the impaired Sandy River (Reach 26) segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-50** and **Table 4-51** show that loading from commercial/industrial, low density residential, and medium density residential areas are the predominant sources of bacteria in the Sandy River watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under dry weather conditions, the direct deposition load from wildlife, failed septic systems, and straight pipes will dominate. Under wet weather conditions, the non-point source loads from low-density residential and pasture areas will dominate.

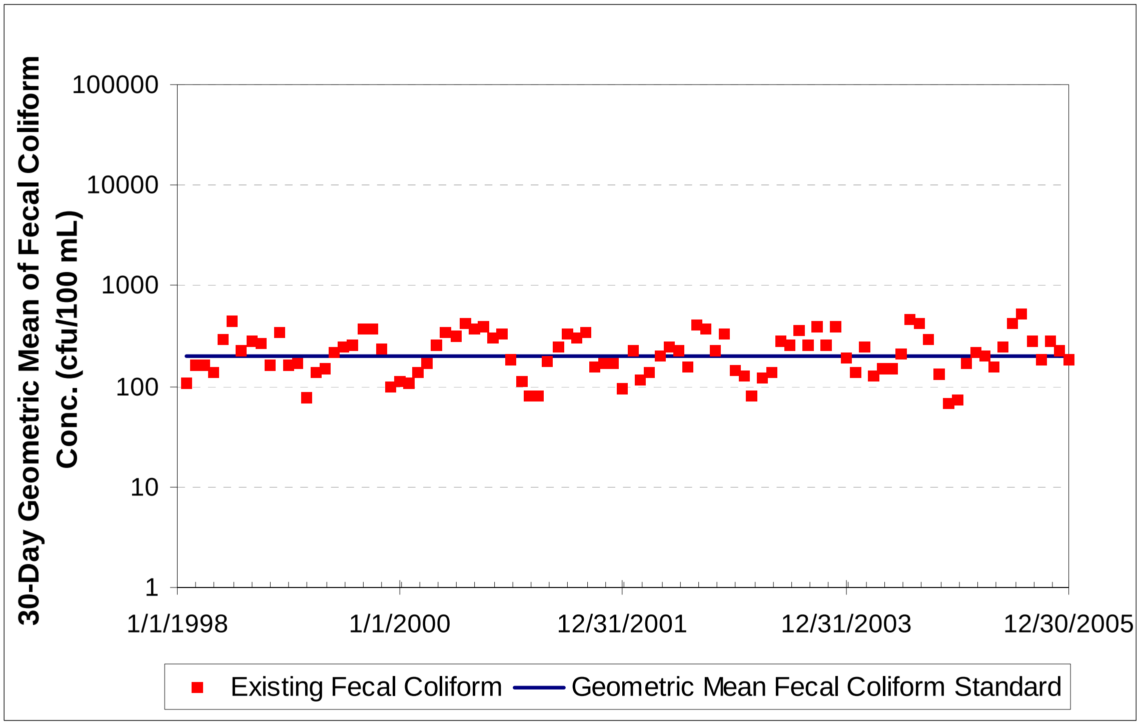

Figure 4-66: Sandy River Fecal Coliform Geometric Mean Existing Conditions

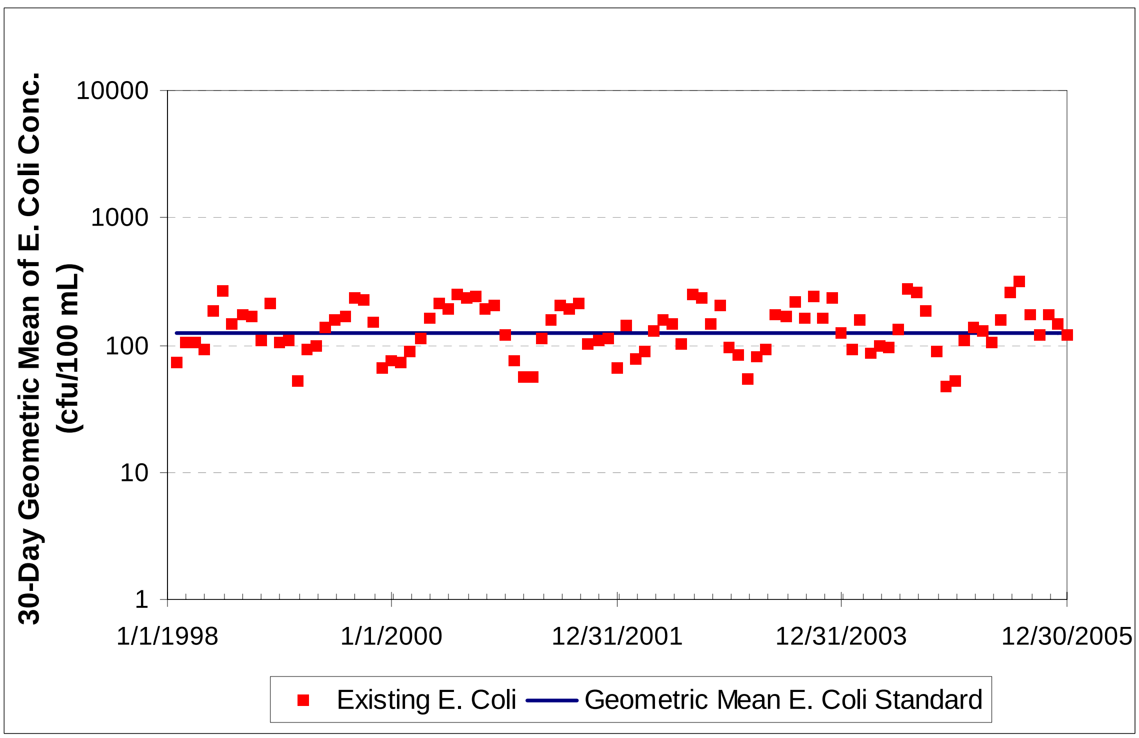

Figure 4-67: Sandy River E. coli Geometric Mean Existing Conditions

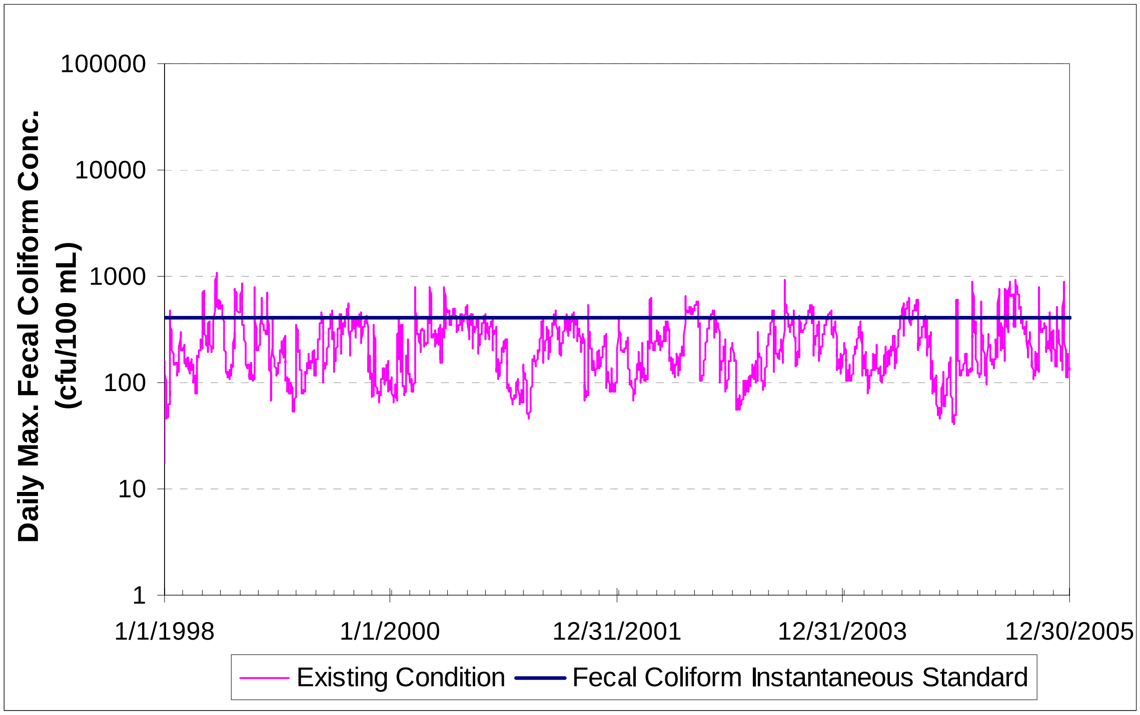

Figure 4-68: Sandy River Fecal Coliform Instantaneous Existing Conditions

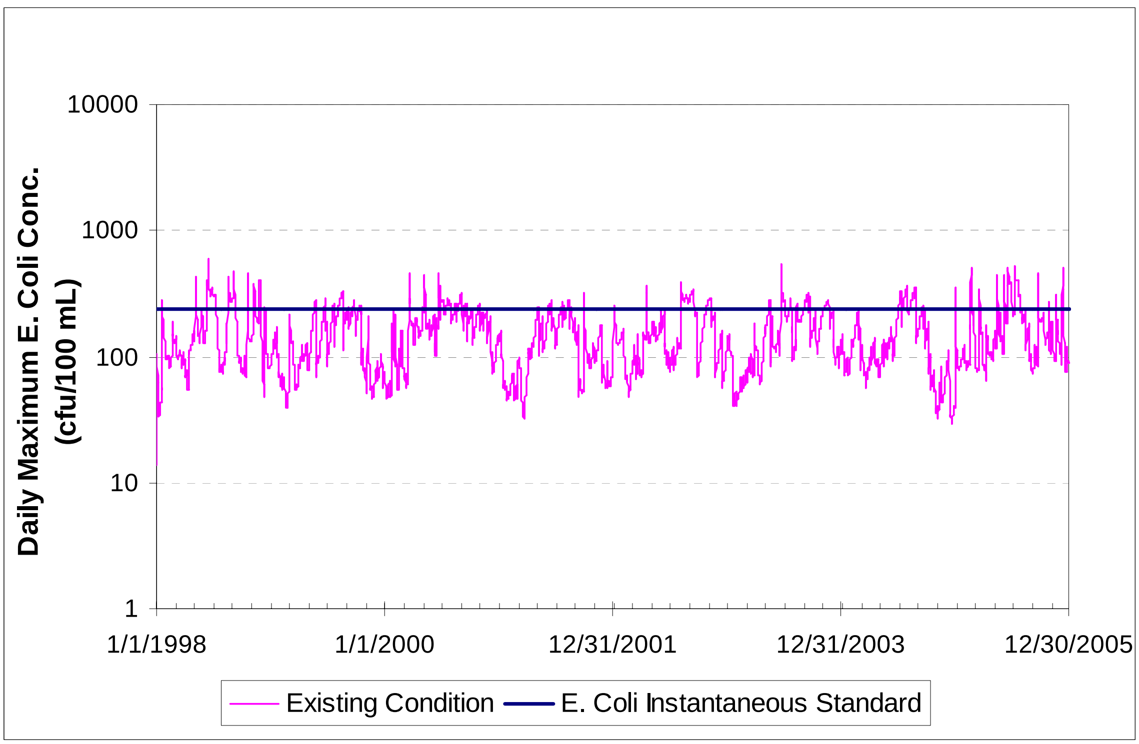

Figure 4-69: Sandy River *E. coli* Instantaneous Existing Conditions

Table 4-50: Sandy River Fecal Coliform Existing Load Distribution by Source

Source	Annual Average Fecal Coliform Loads	
	cfu/year	Percent (%)
Forest	**8.89E+12**	**0.6%**
Cropland	**2.16E+12**	**0.2%**
Pasture	**3.46E+14**	**24.4%**
Low Density Residential	**3.80E+14**	**26.9%**
Medium Density Residential	**2.27E+14**	**16.0%**
High Density Residential	**1.39E+14**	**9.8%**
Commercial/Industrial	**8.28E+13**	**5.8%**
Failed Septic - direct deposition	**4.58E+13**	**3.2%**
Wildlife - direct deposition	**1.83E+14**	**12.9%**
Cattle - direct deposition	**8.92E+09**	**<0.1%**
Point Source	**1.42E+12**	**0.1%**
Total	**1.42E+15**	**100.0%**

Table 4-51: Sandy River *E. coli* Existing Load Distribution by Source

Source	Annual Average *E. coli* Loads	
	cfu/year	Percent (%)
Forest	**5.02E+12**	**0.6%**
Cropland	**1.22E+12**	**0.2%**
Pasture	**1.95E+14**	**24.4%**
Low Density Residential	**2.15E+14**	**26.9%**
Medium Density Residential	**1.28E+14**	**16.0%**
High Density Residential	**7.84E+13**	**9.8%**
Commercial/Industrial	**4.67E+13**	**5.8%**
Failed Septic - direct deposition	**2.58E+13**	**3.2%**
Wildlife - direct deposition	**1.03E+14**	**13.0%**
Cattle - direct deposition	**5.03E+09**	**<0.1%**
Point Source	**2.17E+10**	**<0.1%**
Total	**7.99E+14**	**100.0%**

5.0 Allocation

Allocation analysis was the third stage in development for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, South Fork Mayo River, Sandy Creek, and Sandy River TMDLs. Its purpose was to develop the framework for reducing bacteria loading under the existing watershed conditions so water quality standards can be met. The TMDL represents the maximum amount of pollutant that the stream can receive without exceeding the water quality standard. The load allocations for the selected scenarios were calculated using the following equation:

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

Where,

WLA = wasteload allocation (point source contributions);

LA = load allocation (nonpoint 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.

5.1 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 and other uncertainties. According to EPA guidance (Guidance for Water Quality-Based Decisions: The TMDL Process, 1991), the MOS can be incorporated into the TMDL using two methods:

- Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or

- Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS was implicitly incorporated into this TMDL by using conservative estimates for all known factors which would affect bacteria loadings in the watershed. These known factors include animal populations, bacteria production rates, contributions to the stream, bacteria decay rates instream and on land, and others. By using conservative estimates, these factors would describe the worst-case scenario for the watershed which would be the highest instream bacteria concentrations that could happen in the watershed. By implicitly incorporating the MOS, the TMDLs are ensured to meet the monthly fecal coliform geometric mean standard of 200 cfu/100 ml and the instantaneous fecal coliform standard of 400 cfu/100 ml with 0% exceedance if the TMDL plan is followed. In terms of E. coli, incorporating an implicit MOS would result in TMDLs ensured to meet the monthly geometric mean standard of 126 cfu/100 ml and the instantaneous standard of 235 cfu/100 ml with zero exceedance if the TMDL plan is followed.

5.2 Sensitivity Analysis

The sensitivity analysis of the fecal coliform loadings and the waterbody response provides a better understanding of the watershed conditions that lead to the water quality standard violations, and provides insight and direction in developing the TMDL allocations and implementation. Based on the sensitivity analysis, several allocation scenarios were developed. For each scenario developed, the percent of days on which water quality conditions violate the monthly geometric mean standard and instantaneous standard for *E. coli* were calculated. The results of the sensitivity analysis are presented in Appendix F.

5.3 Allocation Scenario Development

Allocation scenarios were modeled using the calibrated HSPF model to adjust the existing bacteria loading conditions until the water quality standard was attained. The TMDLs developed for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, South Fork Mayo River, Sandy Creek, and Sandy River were based on the Virginia State Standard for *E. coli*. As detailed in Section 1.2, the *E. coli* standard 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* not exceed 235 cfu/100 ml.

According to the guidelines put forth by the DEQ (DEQ, 2003) 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:

$$\log_2 (C_{ec}) = -0.0172+0.91905*\log2(c_{fc})$$

Where C_{ec} is the concentration of *E. coli* in cfu/100 ml, and C_{fc} is the concentration of fecal coliform in cfu/100 ml.

The pollutant concentrations were simulated over the entire duration of a representative modeling period, and pollutant loads were adjusted until the standard was met. The pollutant loads were calculated at the outlet of each impaired segment and include the loads from all upstream reaches and WLAs. 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

Since the fecal coliform standards for Virginia and North Carolina are the same, the TMDL allocation scenarios modeled from the Virginia fecal coliform standards will meet both the Virginia and North Carolina water quality standards.

The following sections present the wasteload allocation (WLA) and load allocations (LA) for the thirteen impaired segments.

5.4 Wasteload Allocation Development

This section outlines the wasteload allocations (WLA) for each impaired segment. It presents the existing and allocated loads for each permitted (VPDES) facility contributing to the impaired segment.

The existing load for general domestic permits is based on the allowable flow rate of 1,000 gal/day and a maximum *E. coli* concentration of 126 cfu/100 ml. The allocated load for domestic sewage facilities is based on the actual design flow of the system as presented in **Table 3-17**. This load is computed by applying a factor of five to the actual design flow of the system to account for future growth. While the growth-expanded WLA is presented individually for each facility, it will be allocated to both new and existing facilities at the discretion of the permitting agency staff through permit issuances.

In general, the wasteload allocation for point sources under individual VPDES permits was set assuming that they were operating at five times their design flow at their permitted maximum average concentration. The factor of five was introduced as a conservative measure to account for potential growth. This growth-expanded allocation for the individual permitted facilities was calculated and presented based on the current design limits of existing permits in the watershed, but it will be allocated to both new and existing permits as needed on a first-come, first-served basis. All current permit limits remain in effect and can only be altered through the VADEQ permitting process. Allocation of bacteria loadings shall be determined at the discretion of DEQ staff.

Following DEQ guidance, wasteload allocations in watersheds without permitted facilities are not shown as zero. Rather, they are represented in the TMDL, expressed in terms of “less than” a number equal to or smaller than 1% of the Total Maximum Daily Load to account for future growth.

5.5 Load Allocation Development

The reduction of loading from nonpoint sources, including livestock and wildlife direct deposition, is incorporated into the load allocation. A number of load allocation scenarios were developed in order to determine the final TMDL load allocation. Bacteria loading and instream concentrations were estimated for each potential scenario using the HSPF model for the hydrologic period of January 1998 to December 2005. **Table 5-1** shows the typical load allocation scenarios that were run 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. The following is a brief summary of the key scenarios:

- Scenario 0 is the existing load, no reduction of any of the sources.
- Scenario 1 represents elimination of human sources (septic systems and straight pipes).
- Scenario 3 represents elimination of the human sources (septic systems and straight pipes) as well as the direct instream loading from livestock.
- Scenario 4 represents the direct instream loading from wildlife (all other sources are eliminated).
- Scenarios 8, 9, and 10 represent implementation scenarios for each reach and are further discussed in Chapter 6.

Table 5-1: Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, South Fork Mayo River, Sandy Creek, and Sandy River TMDL Load Allocation Scenarios

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%	50%	0%	0%	0%
3	100%	100%	0%	0%	0%
4	100%	100%	100%	100%	0%
5	100%	100%	0%	0%	50%
6	100%	100%	0%	0%	75%
7	100%	100%	95%	95%	75%

The estimated load reductions for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, South Fork Mayo River, Sandy Creek, and Sandy River from these allocation scenarios are presented separately in the following sections. In addition, the percent of days the 126 cfu/100ml *E. coli* geometric mean water quality standard and the 235 cfu/100ml *E. coli* instantaneous water quality standard were violated under each scenario are presented.

5.6 Dan River (VAC-L60R-01) TMDL

5.6.1 Dan River Wasteload Allocation

There are 33 facilities in Virginia discharging bacteria to Dan River. These facilities do not have a permit limit for bacteria. For this TMDL, the wasteload allocation for such facilities is to maintain discharge at the design flow limits and bacteria concentrations at the existing *E. coli* standard of 126 cfu/100mL. **Table 5-2** shows the loading from the permitted point source dischargers in Dan River. To account for future growth, the WLA was developed using 5 times the original allocation.

Table 5-2: Dan River Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VA0020362	9.55E+09	9.55E+09	3.48E+12	0%
VA0022705	2.43E+07	2.43E+07	8.89E+09	0%
VAG402052	2.15E+06	2.15E+06	7.84E+08	0%
VAG404018	2.15E+06	2.15E+06	7.84E+08	0%
VAG404039	2.15E+06	2.15E+06	7.84E+08	0%
VAG404043	2.15E+06	2.15E+06	7.84E+08	0%
VAG404067	1.43E+06	1.43E+06	5.23E+08	0%
VAG404095	4.77E+06	4.77E+06	1.74E+09	0%
VAG404104	4.77E+06	4.77E+06	1.74E+09	0%
VAG404108	4.77E+06	4.77E+06	1.74E+09	0%
VAG404112	4.77E+06	4.77E+06	1.74E+09	0%
VAG404119	4.77E+06	4.77E+06	1.74E+09	0%
VAG404121	2.15E+06	2.15E+06	7.84E+08	0%
VAG404123	1.43E+06	1.43E+06	5.23E+08	0%
VAG404127	4.77E+06	4.77E+06	1.74E+09	0%
VAG404138	2.15E+06	2.15E+06	7.84E+08	0%
VAG404160	2.15E+06	2.15E+06	7.84E+08	0%
VAG404163	4.77E+06	4.77E+06	1.74E+09	0%

Table 5-2: Dan River Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VAG404173	2.15E+06	2.15E+06	7.84E+08	0%
VAG404195	4.30E+06	4.30E+06	1.57E+09	0%
VAG407197	4.77E+06	4.77E+06	1.74E+09	0%
VAG407218	2.15E+06	2.15E+06	7.84E+08	0%
VAG407220	4.77E+06	4.77E+06	1.74E+09	0%
VAG407223	2.15E+06	2.15E+06	7.84E+08	0%
VAG407240	1.43E+06	1.43E+06	5.23E+08	0%
VAG407244	2.15E+06	2.15E+06	7.84E+08	0%
VAG407245	4.77E+05	4.77E+05	1.74E+08	0%
VAG407246	2.15E+06	2.15E+06	7.84E+08	0%
VAG407247	1.43E+06	1.43E+06	5.23E+08	0%
VPG100019	2.86E+06	2.86E+06	1.04E+09	0%
VPG100049	2.86E+06	2.86E+06	1.04E+09	0%
VPG100056	2.86E+06	2.86E+06	1.04E+09	0%
VPG120007	2.86E+06	2.86E+06	1.04E+09	0%
Total	**9.66E+09**	**9.66E+09**	**3.53E+12**	**0%**
Total (Future Growth)			**1.76E+13**	**-**

5.6.2 Dan River Load Allocation

The scenarios considered for Dan River load allocation are presented in **Table 5-3**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than 50% of the time.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 52 percent violation of the *E. coli* geometric mean standard and a 61 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in a 3 percent violation of the *E. coli* geometric mean standard and no violation of the *E. coli* instantaneous standard.
4. No violations of the *E. coli* geometric mean standard occurred in Dan River under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for Dan River. Under this scenario, complete elimination of the human sources (failed septic system s and straight pipes), livestock direct deposition, a 95 percent reduction of urban and agricultural nonpoint sources, and a 48 percent reduction of direct loading by wildlife are required.

Table 5-3: Dan River Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agri-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	59%	61%
1	100%	0%	0%	0%	0%	59%	61%
2	100%	50%	0%	0%	0%	56%	61%
3	100%	100%	0%	0%	0%	52%	61%
4	100%	100%	100%	100%	0%	3%	0%
5	100%	100%	0%	0%	50%	38%	61%
6	100%	100%	0%	0%	75%	28%	61%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	89%	89%	48%	3%	10%
9	100%	50%	50%	50%	0%	36%	52%
10	100%	75%	75%	75%	0%	2%	35%
11	100%	100%	95%	95%	48%	0%	0%

5.6.3 Dan River Allocation Plan and TMDL Summary

As shown in **Table 5-3**, Scenario 11 will meet 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml for Dan River. The requirements for this scenario are:

- 100 % reduction of the human sources (failed septic systems and straight pipes).
- 100 % reduction of the direct instream loading from livestock.
- 95% reduction of bacteria loading from agricultural and urban nonpoint sources.
- 48% reduction of the direct instream loading from wildlife.

Table 5-4 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. All point and nonpoint source loads presented in Table 5-4 aggregate the contributions from sources in Virginia and North Carolina. Relevant information about point and nonpoint sources located in North Carolina is discussed in Chapter 3. It may be worth noting here that point source loads presented in Table 5-2 include contributions from sources in Virginia only.

The monthly distribution of these loads is presented in Appendix E.

Table 5-4: Dan River Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	2.06E+13	2.06E+13	9.89E+10	0%
Cropland	3.37E+13	1.69E+12	8.10E+09	95%
Pasture	3.10E+15	1.55E+14	7.44E+11	95%
Low Density Residential	8.27E+14	4.14E+13	1.99E+11	95%
Medium Density Residential	4.33E+14	2.17E+13	1.04E+11	95%
High Density Residential	3.40E+14	1.70E+13	8.17E+10	95%
Commercial/Industrial	3.80E+14	1.90E+13	9.14E+10	95%
Failed Septic - direct deposition	1.43E+14	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	5.65E+14	2.94E+14	1.41E+12	48%
Cattle - direct deposition	4.73E+10	0.00E+00	0.00E+00	100%
Point Source	3.89E+13	1.95E+14	5.33E+11	0%
Total loads /Overall reduction	**5.88E+15**	**7.65E+14**	**3.27E+12**	**87%**

The TMDL for Dan River is presented in **Table 5-5**.

Table 5-5: Dan River Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
5.33E+11	**2.74E+12**	**Implicit**	**3.27E+12**

The resulting geometric mean and instantaneous E. coli concentrations under the TMDL allocation plan are presented in **Figure 5-1** and **Figure 5-2**. **Figure 5-1** shows the 30-day geometric mean *E. coli* concentrations after applying the allocations of Scenario 11, as well as geometric mean loading under existing conditions. **Figure 5-2** shows the instantaneous *E. coli* concentrations also under the allocations of Scenario 11 as well as the loading under existing conditions. For the Dan River, allocation Scenario 11 results in bacteria concentrations that are consistently below both the geometric mean and instantaneous standards for *E. coli*.

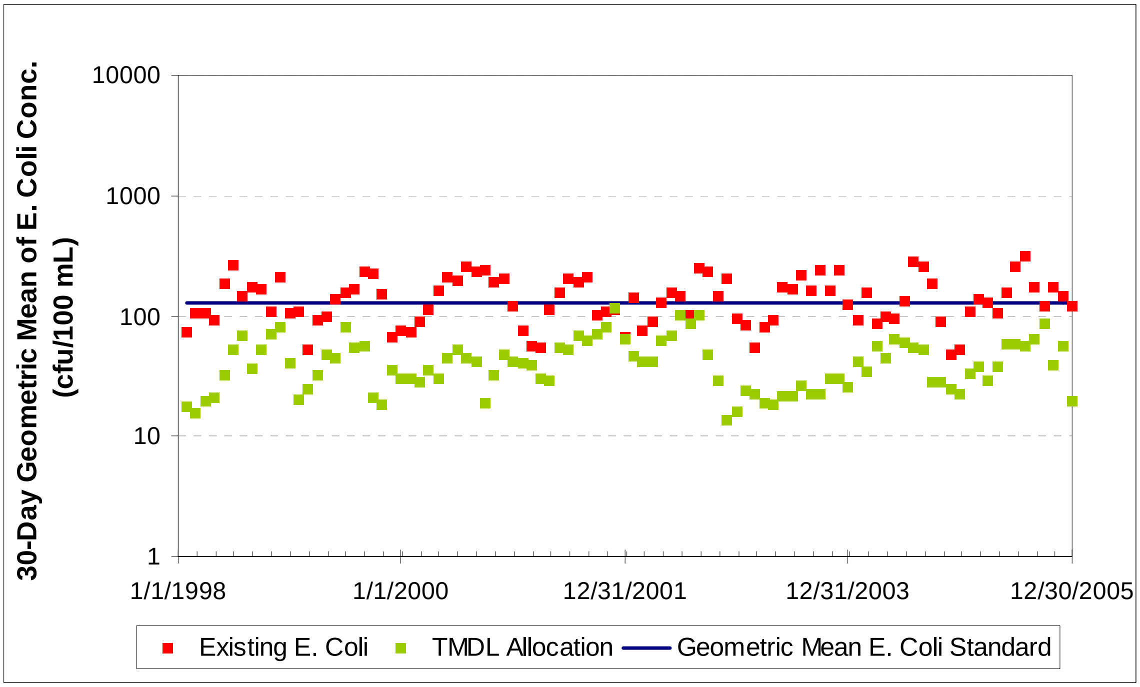

Figure 5-1: Dan River Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11 (Reach 2)

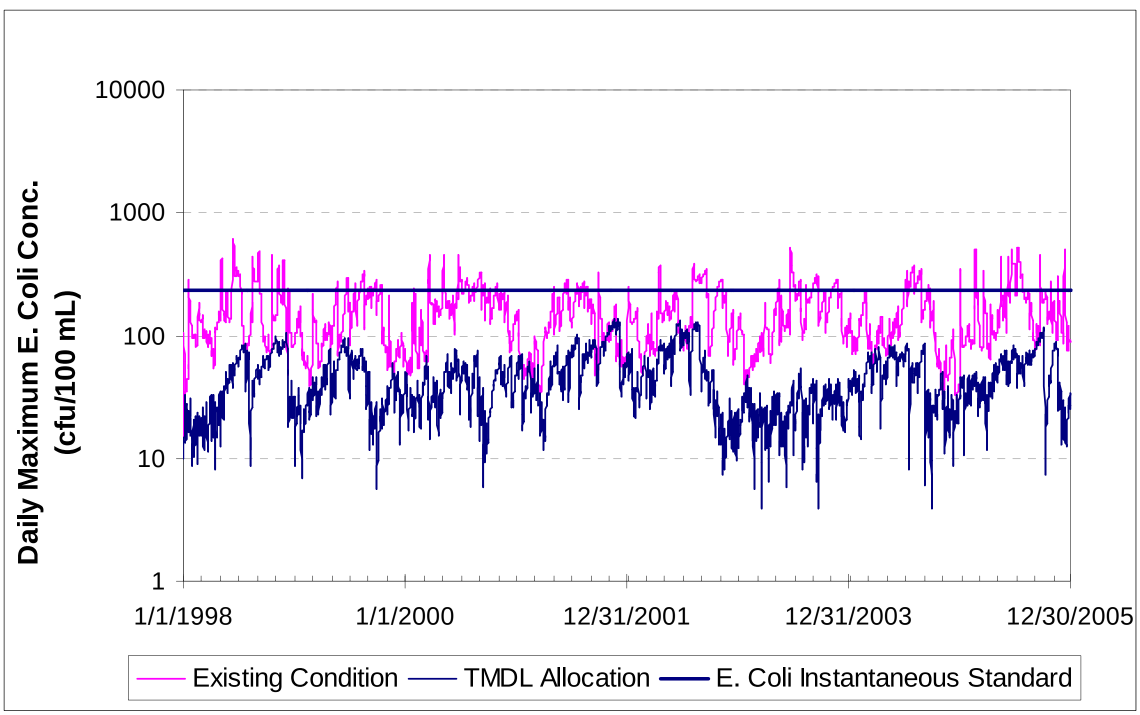

Figure 5-2: Dan River Instantaneous *E. coli* Concentrations under Allocation Scenario 11 (Reach 2)

5.7 Blackberry Creek (VAW-L52R-02) TMDL

5.7.1 Blackberry Creek Wasteload Allocation

There are no industrial or municipal permitted facilities currently discharging into Blackberry Creek.

5.7.2 Blackberry Creek Load Allocation

The scenarios considered for Blackberry Creek load allocation are presented in **Table 5-6**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than 40 percent of the time.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 31 percent violation of the *E. coli* geometric mean standard and a 42 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in no violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standards.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standards occurred in the Blackberry Creek under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for Blackberry Creek. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, a 92 percent reduction of urban and agricultural nonpoint sources, and no reduction of direct loading by wildlife are required.

Table 5-6: Blackberry Creek Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	42%	42%
1	100%	0%	0%	0%	0%	42%	42%
2	100%	50%	0%	0%	0%	38%	42%
3	100%	100%	0%	0%	0%	31%	42%
4	100%	100%	100%	100%	0%	0%	0%
5	100%	100%	0%	0%	50%	7%	42%
6	100%	100%	0%	0%	75%	0%	42%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	88%	88%	0%	2%	10%
9	100%	50%	50%	50%	0%	21%	35%
10	100%	75%	75%	75%	0%	0%	26%
11	100%	100%	92%	92%	0%	0%	0%

5.7.3 Blackberry Creek Allocation Plan and TMDL Summary

For Blackberry Creek, as shown in **Table 5-6**, Scenario 11 will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements for this scenario include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 92 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- No reduction of the direct instream loading from wildlife.

Table 5-7 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-7: Blackberry Creek Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	2.46E+11	2.46E+11	1.47E+09	0%
Cropland	7.06E+10	5.64E+09	3.37E+07	92%
Pasture	9.19E+12	7.36E+11	4.39E+09	92%
Low Density Residential	5.49E+12	4.39E+11	2.62E+09	92%
Medium Density Residential	1.06E+12	8.52E+10	5.08E+08	92%
Commercial/Industrial	2.81E+12	2.25E+11	1.34E+09	92%
Failed Septic - direct deposition	1.12E+12	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	4.98E+12	4.98E+12	2.97E+10	0%
Cattle - direct deposition	5.47E+07	0.00E+00	0.00E+00	100%
Point Source	0.00E+00	6.72E+10	1.84E+08	0%
Total loads /Overall reduction	**2.50E+13**	**6.78E+12**	**4.03E+10**	**73%**

The bacteria TMDL for Blackberry Creek is presented in **Table 5-8**.

Table 5-8: Blackberry Creek Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
1.84E+08	**4.01E+10**	**Implicit**	**4.03E+10**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan for the Blackberry Creek are presented in **Figure 5-3** and **Figure 5-4.** **Figure 5-3** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-4** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11 as well as existing conditions.

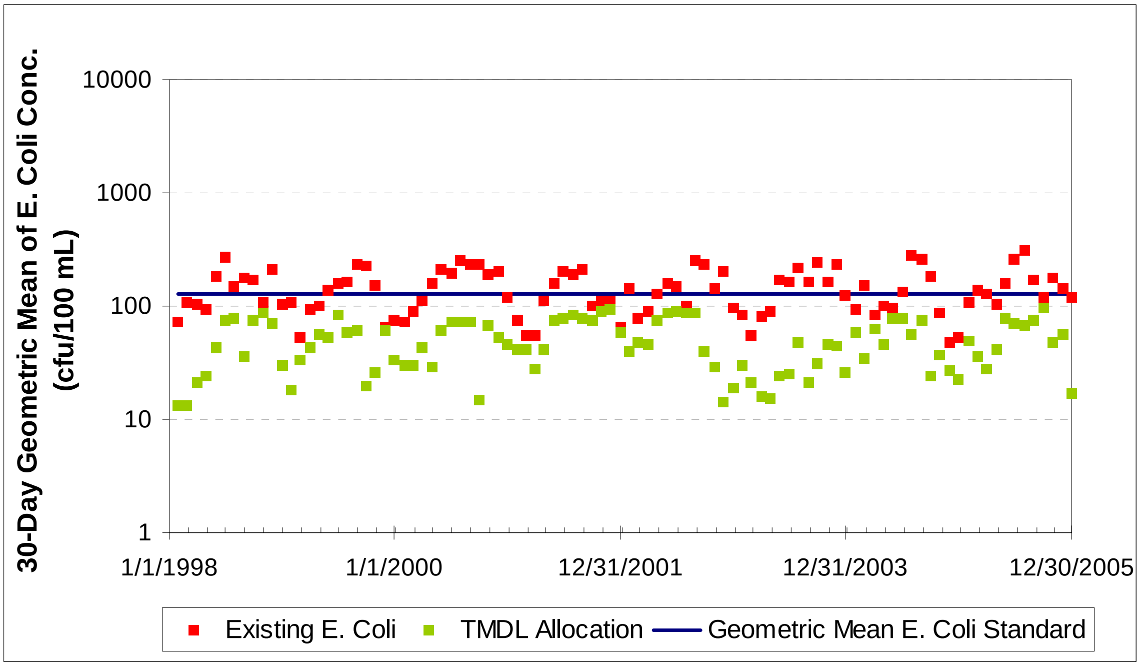

Figure 5-3: Blackberry Creek Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

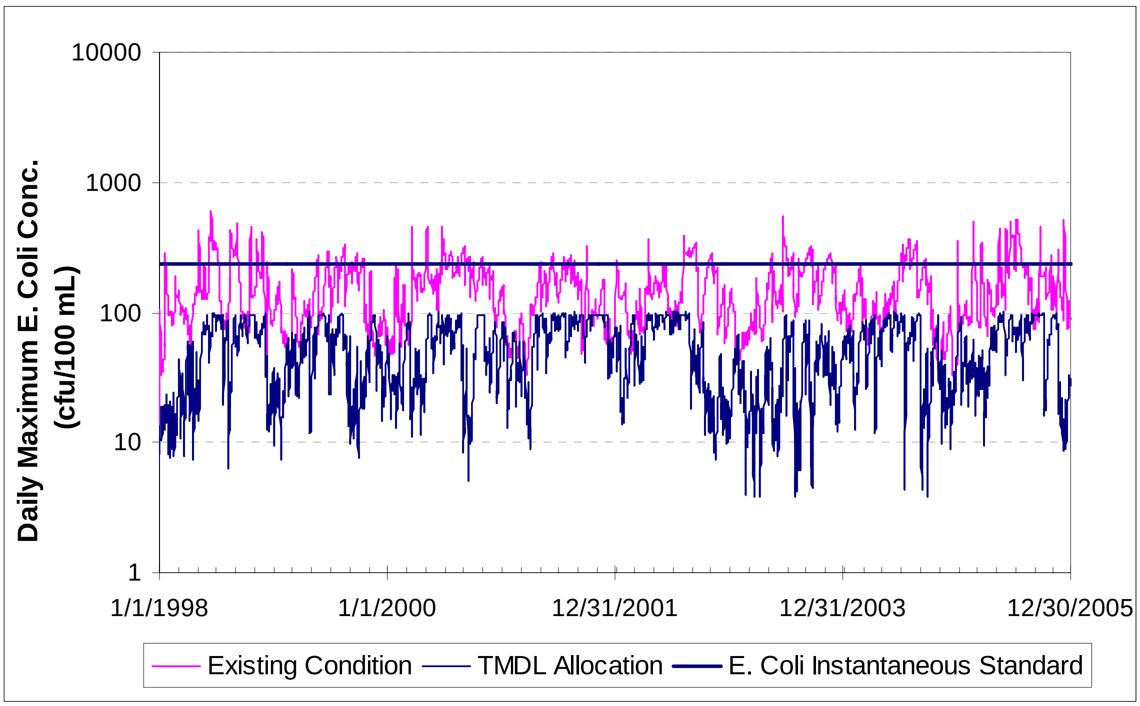

Figure 5-4: Blackberry Creek Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.8 Byrds Branch (VAC-L62R-04) TMDL

5.8.1 Byrds Branch Wasteload Allocation

There is one facility in the Byrds Branch watershed permitted to discharge bacteria (see Chapter 4). For this TMDL, the wasteload allocation for permitted facilities is to maintain discharge at the design flow limits and bacteria concentrations at their permitted levels of 126 cfu/100mL. **Table 5-9** shows the loading from the permitted point source dischargers in the watershed. To account for future growth, the WLA was developed using 5 times the original allocation.

Table 5-9: Byrds Branch Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VPG100029	2.86E+06	2.86E+06	1.04E+09	0%
Total (Future Growth)			**5.21E+09**	**-**

5.8.2 Byrds Branch Load Allocation

The scenarios considered for the Byrds Branch load allocation are presented in **Table 5-10**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated most of the time.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 40 percent violation of the *E. coli* geometric mean standard and a 35 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in a 22 percent violation of the *E. coli* geometric mean standard and no violation of the *E. coli* instantaneous standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standards occurred in the Byrds Branch under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for Byrds Branch Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, and 95 percent reduction of urban and agricultural nonpoint sources, and a 39 percent reduction of direct loading by wildlife are required.

Table 5-10: Byrds Branch Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	53%	100%
1	100%	0%	0%	0%	0%	53%	100%
2	100%	50%	0%	0%	0%	47%	100%
3	100%	100%	0%	0%	0%	40%	35%
4	100%	100%	100%	100%	0%	22%	0%
5	100%	100%	0%	0%	50%	13%	32%
6	100%	100%	0%	0%	75%	0%	32%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	85%	85%	39%	2%	10%
9	100%	50%	50%	50%	0%	36%	32%
10	100%	75%	75%	75%	0%	0%	16%
11	100%	100%	95%	95%	39%	0%	0%

5.8.3 Byrds Branch Allocation Plan and TMDL Summary

For Byrds Branch, as shown in **Table 5-10**, Scenario 11 will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements for this scenario include:

- 100 percent from cattle and failed septics
- 100 percent reduction of the direct instream loading from livestock.
- 95 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- 39 percent reduction of the direct instream loading from wildlife.

Table 5-11 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-11: Byrds Branch Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	3.61E+10	3.61E+10	2.13E+08	0%
Cropland	6.76E+10	3.38E+09	2.00E+07	95%
Pasture	3.96E+12	1.98E+11	1.17E+09	95%
Low Density Residential	7.70E+10	3.85E+09	2.27E+07	95%
Commercial/Industrial	3.54E+11	1.77E+10	1.05E+08	95%
Failed Septic - direct deposition	3.69E+11	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	8.90E+11	5.43E+11	3.21E+09	39%
Cattle - direct deposition	5.06E+06	0.00E+00	0.00E+00	100%
Point Source	1.04E+09	5.21E+09	1.43E+07	0%
Total loads /Overall reduction	**5.76E+12**	**8.07E+11**	**4.75E+09**	**86%**

The bacteria TMDL for Byrds Branch is presented in **Table 5-12.**

Table 5-12: Byrds Branch Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
1.43E+07	**4.74E+09**	**Implicit**	**4.75E+09**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan for Byrds Branch are presented in **Figure 5-5** and **Figure 5-6.** **Figure 5-5** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-6** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

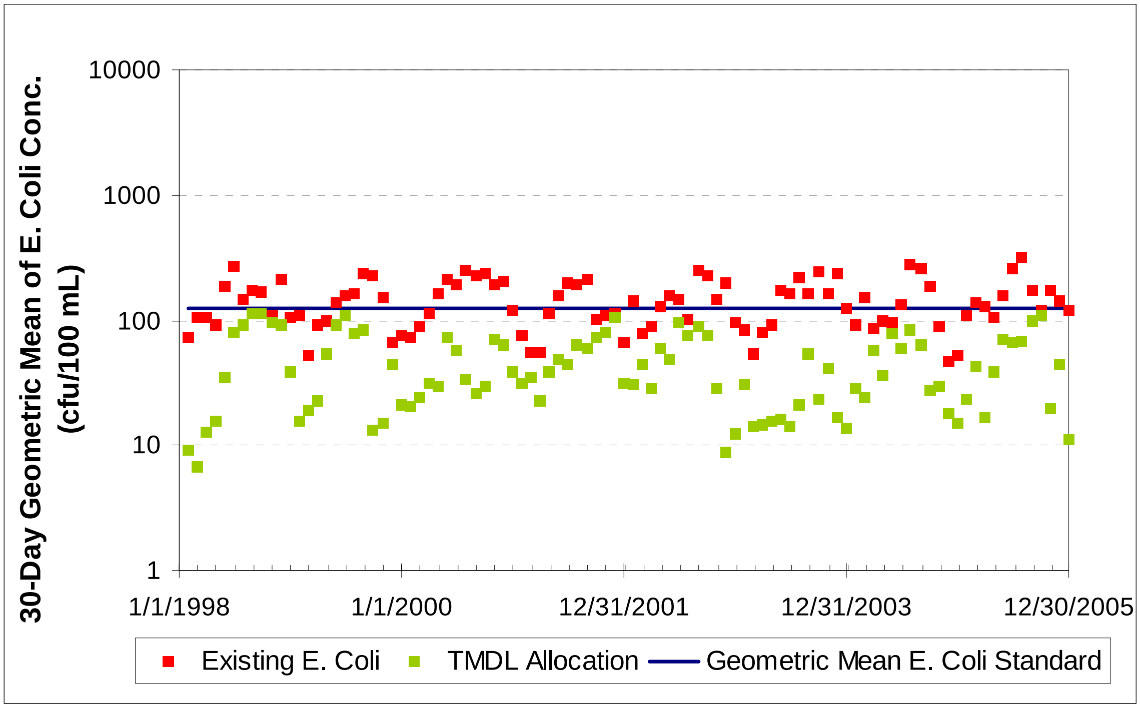

Figure 5-5: Byrds Branch Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

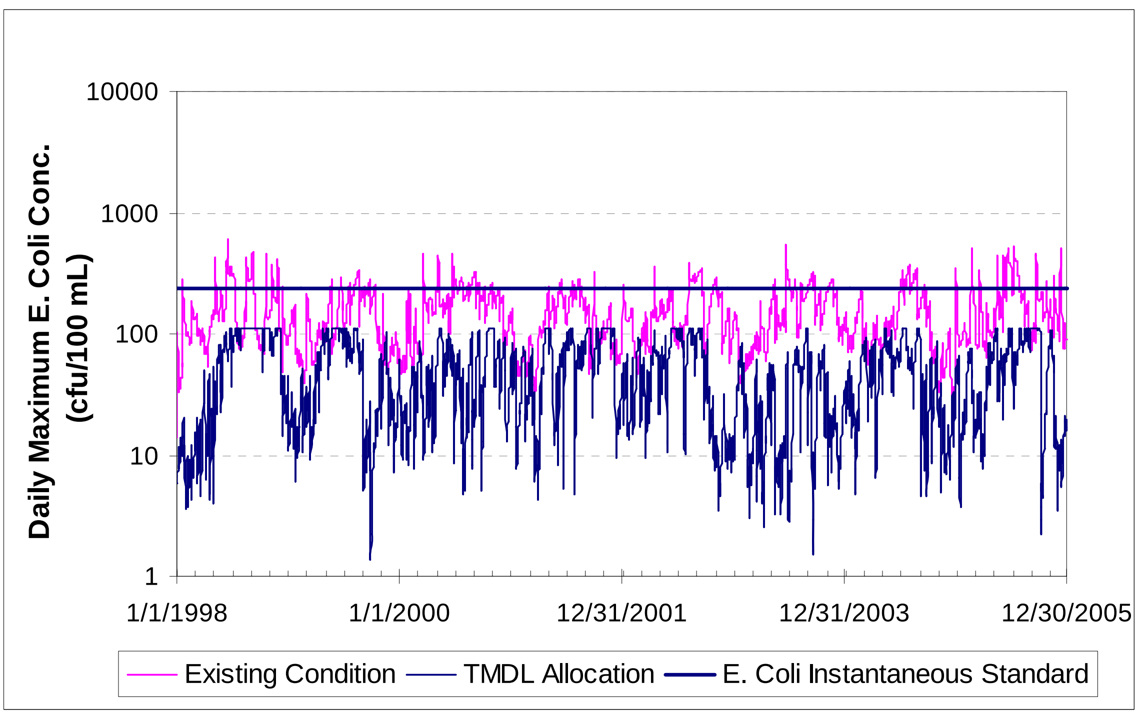

Figure 5-6: Byrds Branch Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.9 Double Creek (VAC-L62R-03) TMDL

5.9.1 Double Creek Wasteload Allocation

There are no industrial or municipal permitted facilities currently discharging into Double Creek.

5.9.2 Double Creek Load Allocation

The scenarios considered for Double Creek load allocation are presented in **Table 5-13**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than 30 percent of the time in the Double Creek.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 18 percent violation of this standard in the Double Creek and a 32 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in no violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the Double Creek under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the Double Creek. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, an 86 percent reduction of urban nonpoint sources and agricultural nonpoint sources, and no reduction of direct loading by wildlife are required.

Table 5-13: Double Creek Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	34%	32%
1	100%	0%	0%	0%	0%	34%	32%
2	100%	50%	0%	0%	0%	30%	32%
3	100%	100%	0%	0%	0%	18%	32%
4	100%	100%	100%	100%	0%	0%	0%
5	100%	100%	0%	0%	50%	0%	32%
6	100%	100%	0%	0%	75%	0%	32%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	79%	79%	0%	0%	7%
9	100%	50%	50%	50%	0%	4%	23%
10	100%	75%	75%	75%	0%	0%	7%
11	100%	100%	86%	86%	0%	0%	0%

5.9.3 Double Creek Allocation Plan and TMDL Summary

As shown in **Table 5-13**, Scenario 11 for the Double Creek, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 86 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- No reduction of the direct instream loading from wildlife.

Table 5-14 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-14: Double Creek Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	2.05E+11	2.05E+11	1.22E+09	0%
Cropland	3.15E+11	4.41E+10	2.61E+08	86%
Pasture	1.74E+13	2.43E+12	1.44E+10	86%
Low Density Residential	1.25E+12	1.75E+11	1.04E+09	86%
Commercial/Industrial	1.04E+12	1.46E+11	8.63E+08	86%
Failed Septic - direct deposition	1.71E+12	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	4.54E+12	4.54E+12	2.69E+10	0%
Cattle - direct deposition	3.11E+07	0.00E+00	0.00E+00	100%
Point Source	0.00E+00	7.54E+10	2.07E+08	0%
Total loads /Overall reduction	**2.64E+13**	**7.61E+12**	**4.49E+10**	**71%**

The bacteria TMDL for the Double Creek is presented in **Table 5-15**.

Table 5-15: Double Creek Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
2.07E+08	**4.47E+10**	**Implicit**	**4.49E+10**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-7 and Figure 5-8**. **Figure 5-7** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-8** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

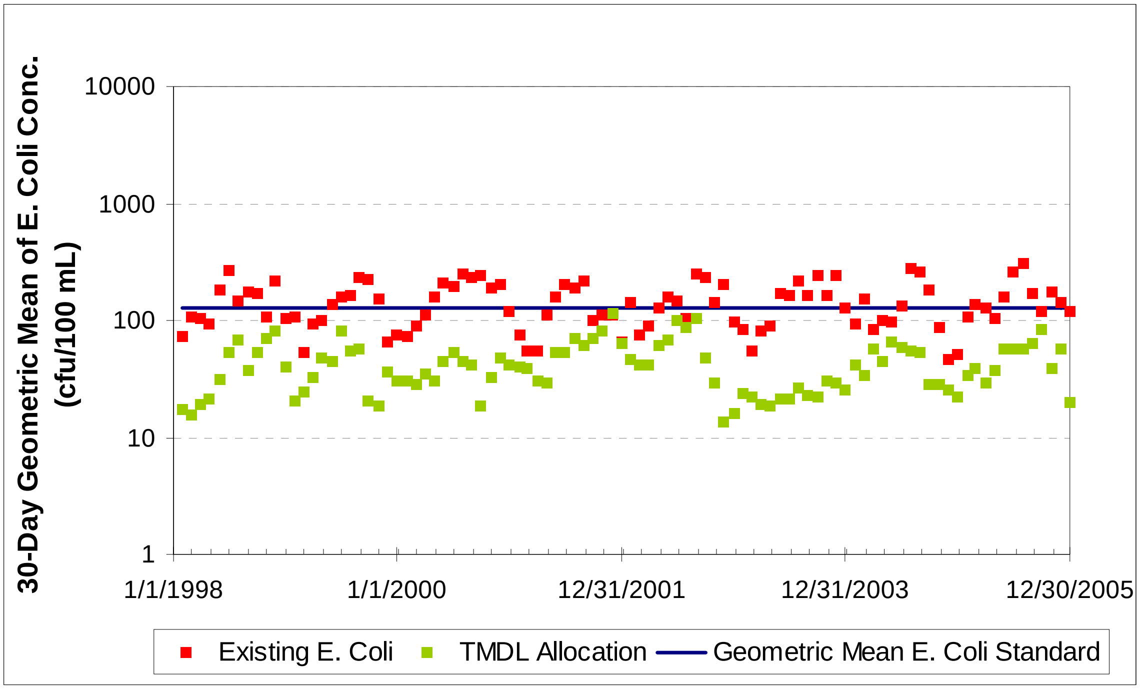

Figure 5-7: Double Creek Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

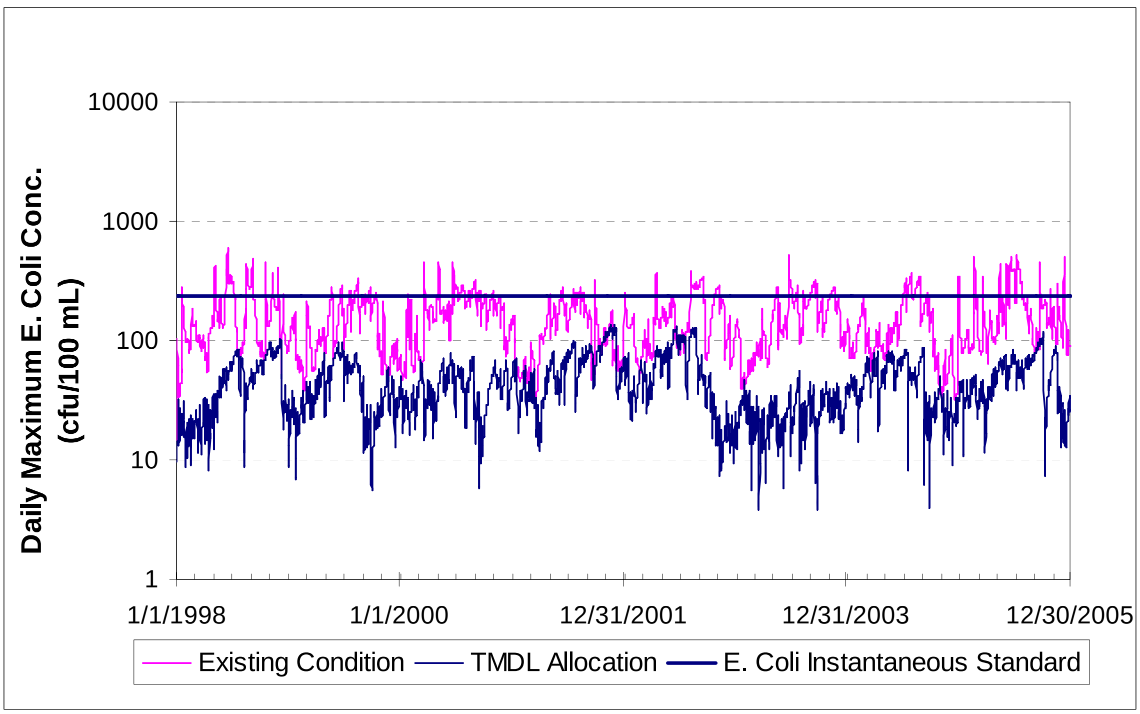

Figure 5-8: Double Creek Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.10 Fall Creek (VAC-L61R-01) TMDL

5.10.1 Fall Creek Wasteload Allocation

There is one facility in the Fall Creek watershed permitted to discharge bacteria (see Chapter 4). For this TMDL, the wasteload allocation for permitted facilities is to maintain discharge at the design flow limits and bacteria concentrations at their permitted levels of 126 cfu/100mL. **Table 5-16** shows the loading from the permitted point source dischargers in the watershed. To account for future growth, the WLA was developed using 5 times the original allocation.

Table 5-16: Fall Creek Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VA0027685	4.96E+07	4.96E+07	1.81E+10	0%
Total (Future Growth)			**9.06E+10**	**-**

5.10.2 Fall Creek Load Allocation

The scenarios considered for Fall Creek load allocation are presented in **Table 5-17**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than 50 percent of the time in the Fall Creek.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 33 percent violation of this standard in the Fall Creek and a 52 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in no violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the Fall Creek under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the Fall Creek. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, a 97 percent reduction of urban and agricultural nonpoint sources, and no reduction of direct loading by wildlife are required.

Table 5-17: Fall Creek Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	51%	52%
1	100%	0%	0%	0%	0%	51%	52%
2	100%	50%	0%	0%	0%	45%	52%
3	100%	100%	0%	0%	0%	33%	52%
4	100%	100%	100%	100%	0%	0%	0%
5	100%	100%	0%	0%	50%	13%	52%
6	100%	100%	0%	0%	75%	4%	52%
7	100%	100%	95%	95%	75%	0%	7%
8	100%	100%	94%	94%	0%	1%	10%
9	100%	50%	50%	50%	0%	24%	39%
10	100%	75%	75%	75%	0%	0%	32%
11	100%	100%	97%	97%	0%	0%	0%

5.10.3 Fall Creek Allocation Plan and TMDL Summary

As shown in **Table 5-17**, Scenario 11 for the Fall Creek, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 97 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- No reduction of the direct instream loading from wildlife.

Table 5-18 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-18: Fall Creek Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	3.72E+11	3.64E+11	2.08E+09	0%
Cropland	1.02E+12	3.00E+10	1.71E+08	97%
Pasture	4.51E+13	6.09E+11	3.48E+09	97%
Low Density Residential	6.25E+13	1.84E+12	1.05E+10	97%
Medium Density Residential	3.88E+13	1.14E+12	6.51E+09	97%
High Density Residential	1.98E+13	5.82E+11	3.32E+09	97%
Commercial/Industrial	8.54E+12	2.56E+12	1.46E+10	97%
Failed Septic - direct deposition	3.25E+12	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	1.07E+13	1.04E+13	5.96E+10	0%
Cattle - direct deposition	6.97E+09	0.00E+00	0.00E+00	100%
Point Source	1.81E+10	9.06E+10	2.48E+08	0%
Total loads /Overall reduction	**1.90E+14**	**1.64E+13**	**1.00E+11**	**91.4%**

The bacteria TMDL for the Fall Creek is presented in **Table 5-19**.

Table 5-19: Fall Creek Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
2.48E+08	**1.00E+11**	**Implicit**	**1.01E+11**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-9 and Figure 5-10**. **Figure 5-9** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-10** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

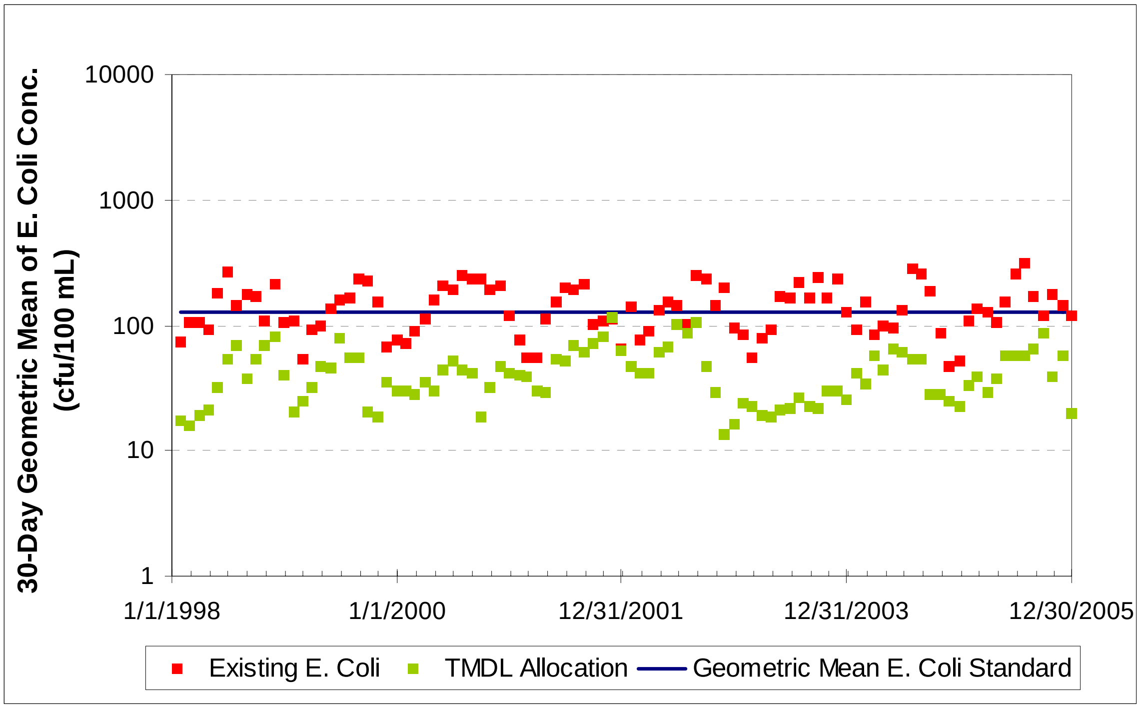

Figure 5-9: Fall Creek Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

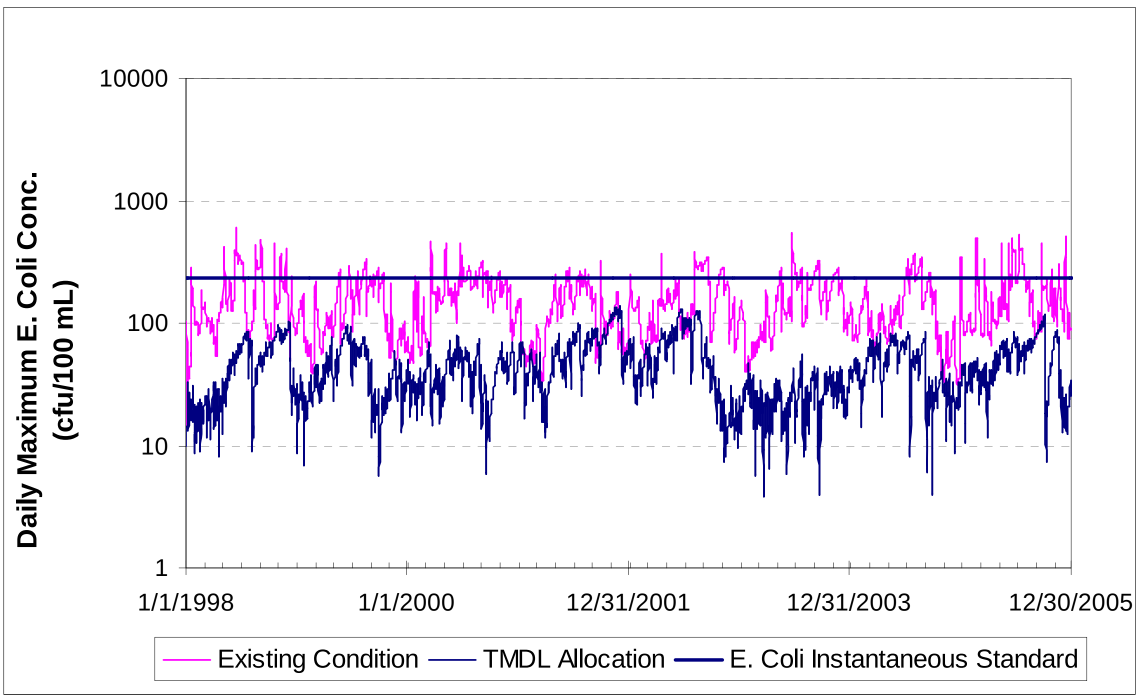

Figure 5-10: Fall Creek Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.11 Leatherwood Creek (VAW-L56R-01) TMDL

5.11.1 Leatherwood Creek Wasteload Allocation

There is one facility in the Leatherwood Creek watershed permitted to discharge bacteria (see Chapter 4). For this TMDL, the wasteload allocation for permitted facilities is to maintain discharge at the design flow limits and bacteria concentrations at their permitted levels of 126 cfu/100mL. **Table 5-20** shows the loading from the permitted point source dischargers in the watershed. To account for future growth, the WLA was developed using 5 times the original allocation.

Table 5-20: Leatherwood Creek Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VA0060445	1.91E+08	1.91E+08	6.97E+10	0%
Total (Future Growth)			**3.48E+11**	**-**

5.11.2 Leatherwood Creek Load Allocation

The scenarios considered for Leatherwood Creek load allocation are presented in **Table 5-21**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than 40 percent of the time in the Leatherwood Creek.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 41 percent violation of this standard in the Leatherwood Creek and a 42 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in a 9 percent violation of this standard in the Leatherwood Creek and no violation of the *E. coli* instantaneous standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the Leatherwood Creek under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the Leatherwood Creek. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, a 97 percent reduction of urban and agricultural nonpoint sources, and a 24 percent reduction of direct loading by wildlife are required.

Table 5-21: Leatherwood Creek Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	45%	45%
1	100%	0%	0%	0%	0%	45%	45%
2	100%	50%	0%	0%	0%	43%	42%
3	100%	100%	0%	0%	0%	41%	42%
4	100%	100%	100%	100%	0%	9%	0%
5	100%	100%	0%	0%	50%	17%	42%
6	100%	100%	0%	0%	75%	2%	42%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	89%	89%	24%	4%	10%
9	100%	50%	50%	50%	0%	35%	39%
10	100%	75%	75%	75%	0%	0%	29%
11	100%	100%	97%	97%	24%	0%	0%

5.11.3 Leatherwood Creek Allocation Plan and TMDL Summary

As shown in **Table 5-21**, Scenario 11 for the Leatherwood Creek, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 97 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- 24 percent reduction of the direct instream loading from wildlife.

Table 5-22 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-22: Leatherwood Creek Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	1.08E+12	1.08E+12	5.34E+09	0%
Cropland	2.03E+11	6.09E+09	3.02E+07	97%
Pasture	6.49E+13	1.95E+12	9.65E+09	97%
Low Density Residential	3.05E+13	9.14E+11	4.53E+09	97%
Medium Density Residential	8.52E+12	2.56E+11	1.27E+09	97%
High Density Residential	2.47E+12	7.42E+10	3.68E+08	97%
Commercial/Industrial	7.78E+12	2.34E+11	1.16E+09	97%
Failed Septic - direct deposition	4.53E+12	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	2.31E+13	1.76E+13	8.72E+10	24%
Cattle - direct deposition	3.14E+08	0.00E+00	0.00E+00	100%
Point Source	6.97E+10	3.48E+11	9.55E+08	0%
Total loads /Overall reduction	**1.43E+14**	**2.24E+13**	**1.11E+11**	**84%**

The bacteria TMDL for the Leatherwood Creek is presented in **Table 5-23**.

Table 5-23: Leatherwood Creek Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
9.55E+08	**1.10E+11**	**Implicit**	**1.11E+11**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-11 and Figure 5-12**. **Figure 5-11** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-12** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

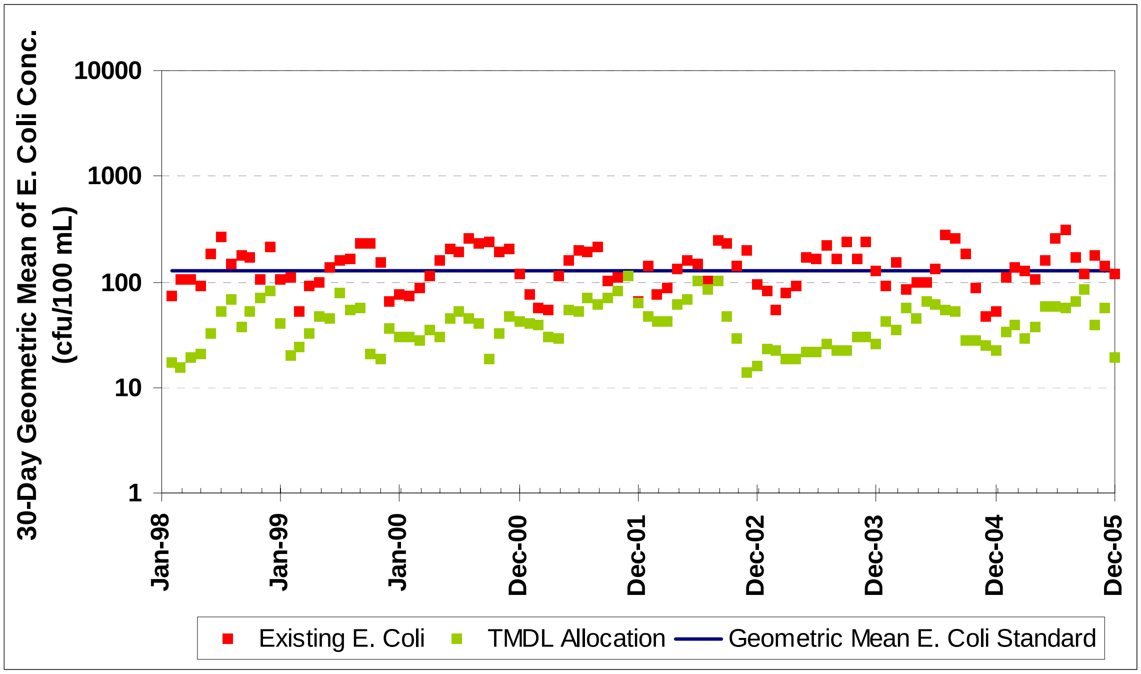

Figure 5-11: Leatherwood Creek Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

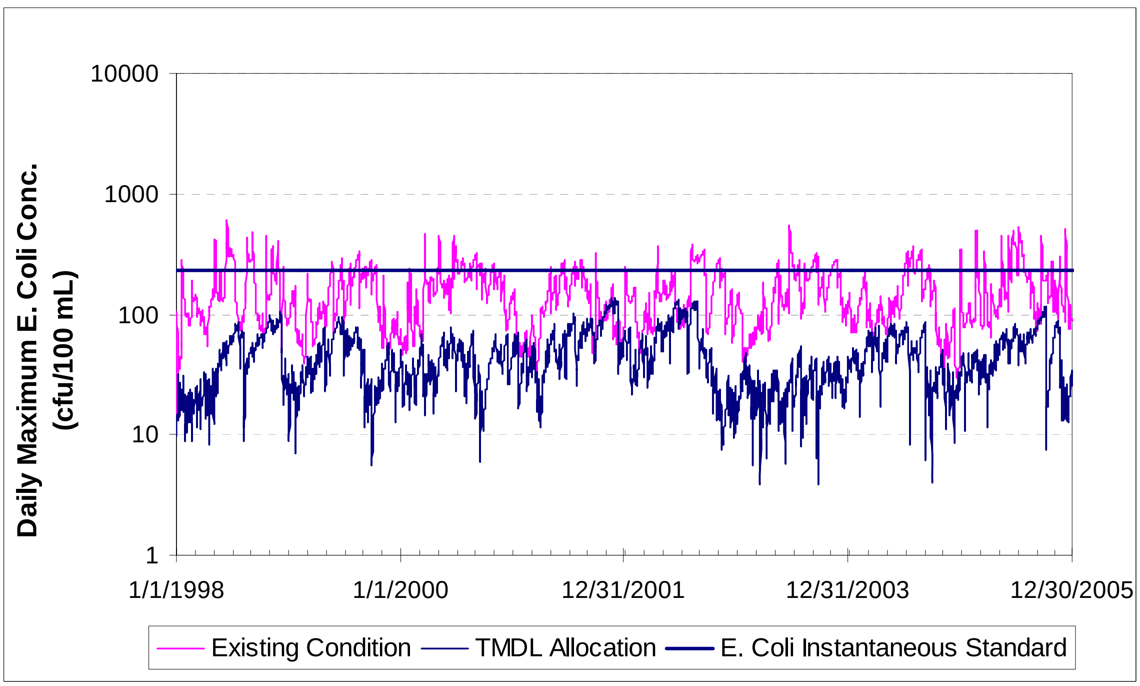

Figure 5-12: Leatherwood Creek Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.12 Marrowbone Creek (VAW-L55R-01) TMDL

5.12.1 Marrowbone Creek Wasteload Allocation

There are no industrial or municipal permitted facilities currently discharging into Marrowbone Creek.

5.12.2 Marrowbone Creek Load Allocation

The scenarios considered for Marrowbone Creek load allocation are presented in **Table 5-24**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than 40 percent of the time in the Marrowbone Creek.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 40 percent violation of this standard in the Marrowbone Creek and a 45 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in a 2 percent violation of this standard in the Marrowbone Creek and no violation of the *E. coli* instantaneous standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the Marrowbone Creek under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the Marrowbone Creek. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, a 95 percent reduction of urban and agricultural nonpoint sources, and a 9 percent reduction of direct loading by wildlife are required.

Table 5-24: Marrowbone Creek Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	45%	48%
1	100%	0%	0%	0%	0%	45%	48%
2	100%	50%	0%	0%	0%	43%	48%
3	100%	100%	0%	0%	0%	40%	45%
4	100%	100%	100%	100%	0%	2%	0%
5	100%	100%	0%	0%	50%	13%	45%
6	100%	100%	0%	0%	75%	2%	45%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	91%	91%	9%	4%	10%
9	100%	50%	50%	50%	0%	32%	39%
10	100%	75%	75%	75%	0%	0%	32%
11	100%	100%	95%	95%	9%	0%	0%

5.12.3 Marrowbone Creek Allocation Plan and TMDL Summary

As shown in **Table 5-24**, Scenario 11 for the Marrowbone Creek, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 95 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- 9 percent reduction of the direct instream loading from wildlife.

Table 5-25 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-25: Marrowbone Creek Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	4.42E+11	4.42E+11	2.47E+09	0%
Cropland	4.13E+10	2.06E+09	1.15E+07	95%
Pasture	2.13E+13	1.06E+12	5.94E+09	95%
Low Density Residential	1.79E+13	8.95E+11	4.99E+09	95%
Medium Density Residential	1.10E+13	5.51E+11	3.08E+09	95%
High Density Residential	8.79E+12	4.39E+11	2.45E+09	95%
Commercial/Industrial	3.77E+12	1.88E+11	1.05E+09	95%
Failed Septic - direct deposition	1.82E+12	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	9.37E+12	8.52E+12	4.76E+10	9%
Cattle - direct deposition	1.32E+08	0.00E+00	0.00E+00	100%
Point Source	0.00E+00	1.21E+11	3.32E+08	0%
Total loads /Overall reduction	**7.44E+13**	**1.22E+13**	**6.79E+10**	**84%**

The bacteria TMDL for the Marrowbone Creek is presented in **Table 5-26**.

Table 5-26: Marrowbone Creek Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
3.32E+08	**6.76E+10**	**Implicit**	**6.79E+10**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-13 and Figure 5-14**. **Figure 5-13** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-14** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

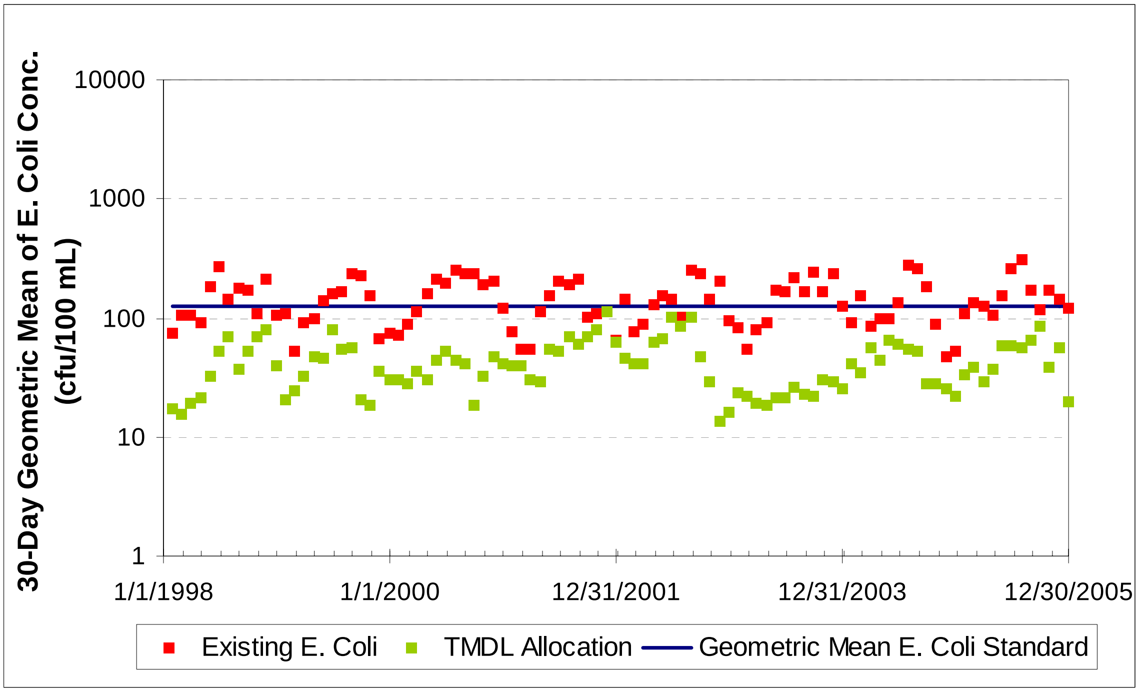

Figure 5-13: Marrowbone Creek Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

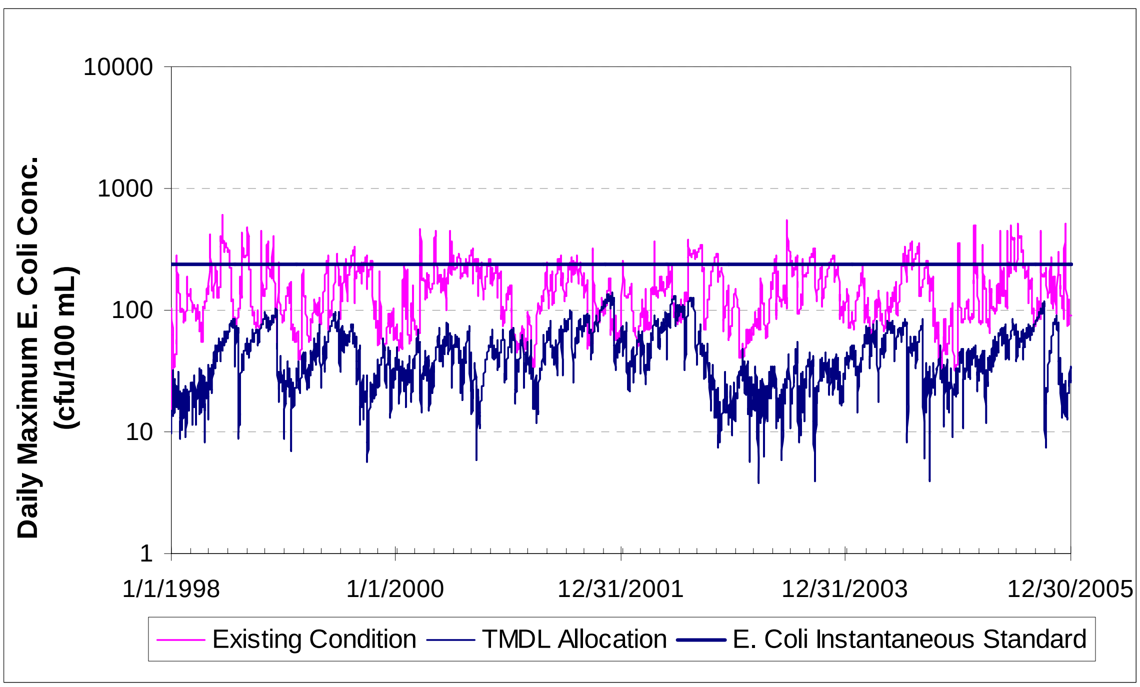

Figure 5-14: Marrowbone Creek Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.13 North Fork Mayo River (VAW-L46R-01) TMDL

5.13.1 North Fork Mayo River Wasteload Allocation

There is one facility in the North Fork Mayo River watershed permitted to discharge bacteria (see Chapter 4). For this TMDL, the wasteload allocation for permitted facilities is to maintain discharge at the design flow limits and bacteria concentrations at their permitted levels of 126 cfu/100mL. **Table 5-27** shows the loading from the permitted point source dischargers in the watershed. To account for future growth, the WLA was developed using 5 times the original allocation.

Table 5-27: North Fork Mayo River Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VA0023558	1.34E+08	1.34E+08	4.88E+10	0%
Total (Future Growth)			**2.44E+11**	-

5.13.2 North Fork Mayo River Load Allocation

The scenarios considered for North Fork Mayo River load allocation are presented in **Table 5-28**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than 25 percent of the time in the North Fork Mayo River.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 20 percent violation of this standard in the North Fork Mayo River and a 39 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in no violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the North Fork Mayo River under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the North Fork Mayo River. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, a 89 percent reduction of urban and agricultural nonpoint sources, and no reduction of direct loading by wildlife are required.

Table 5-28: North Fork Mayo River Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	28%	42%
1	100%	0%	0%	0%	0%	28%	42%
2	100%	50%	0%	0%	0%	26%	39%
3	100%	100%	0%	0%	0%	20%	39%
4	100%	100%	100%	100%	0%	0%	0%
5	100%	100%	0%	0%	50%	2%	35%
6	100%	100%	0%	0%	75%	0%	32%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	83%	83%	0%	2%	10%
9	100%	50%	50%	50%	0%	8%	29%
10	100%	75%	75%	75%	0%	0%	13%
11	100%	100%	89%	89%	0%	0%	0%

5.13.3 North Fork Mayo River Allocation Plan and TMDL Summary

As shown in **Table 5-28**, Scenario 11 for the North Fork Mayo River, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 89 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- No reduction of the direct instream loading from wildlife.

Table 5-29 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-29: North Fork Mayo River Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	1.70E+12	1.70E+12	1.11E+10	0%
Cropland	6.07E+11	6.68E+10	4.37E+08	89%
Pasture	9.57E+13	1.05E+13	6.89E+10	89%
Low Density Residential	1.49E+13	1.64E+12	1.07E+10	89%
Medium Density Residential	5.76E+12	6.34E+11	4.15E+09	89%
High Density Residential	3.48E+11	3.83E+10	2.50E+08	89%
Commercial/Industrial	1.11E+13	1.22E+12	7.97E+09	89%
Failed Septic - direct deposition	9.15E+12	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	3.51E+13	3.51E+13	2.30E+11	0%
Cattle - direct deposition	2.44E+08	0.00E+00	0.00E+00	100%
Point Source	4.88E+10	2.44E+11	6.68E+08	0%
Total loads /Overall reduction	**1.75E+14**	**5.12E+13**	**3.34E+11**	**71%**

The bacteria TMDL for the North Fork Mayo River is presented in **Table 5-30**.

Table 5-30: North Fork Mayo River Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
6.68E+08	**3.33E+11**	**Implicit**	**3.34E+11**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-15 and Figure 5-16**. **Figure 5-15** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-16** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

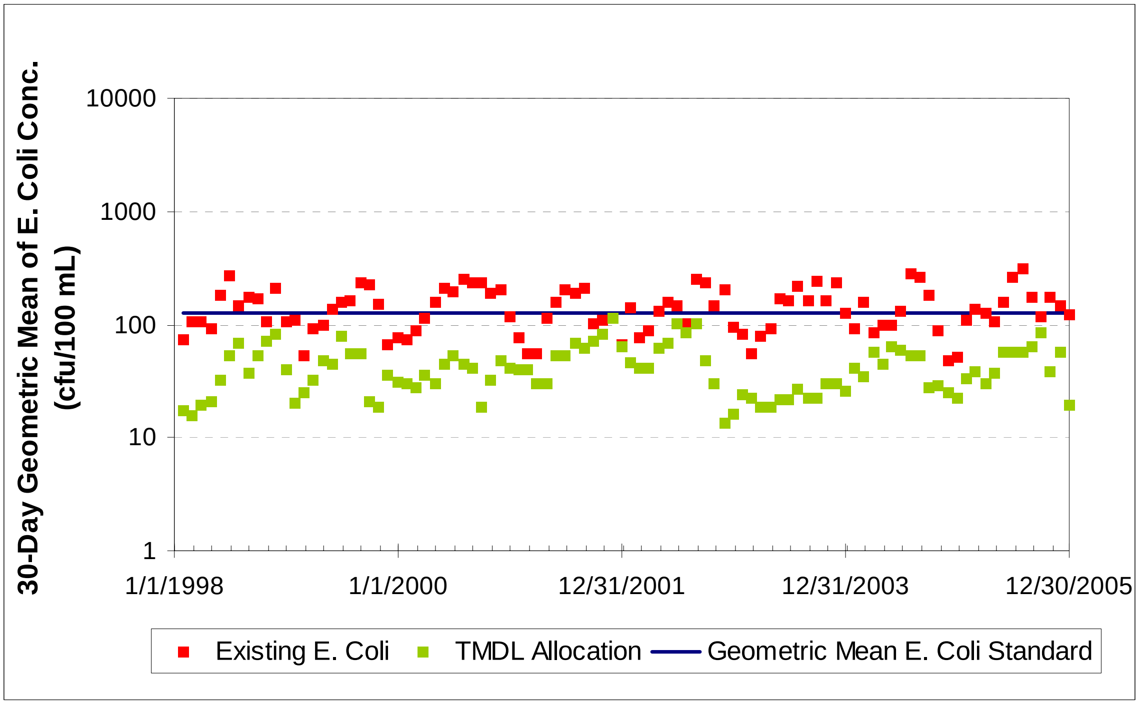

Figure 5-15: North Fork Mayo River Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

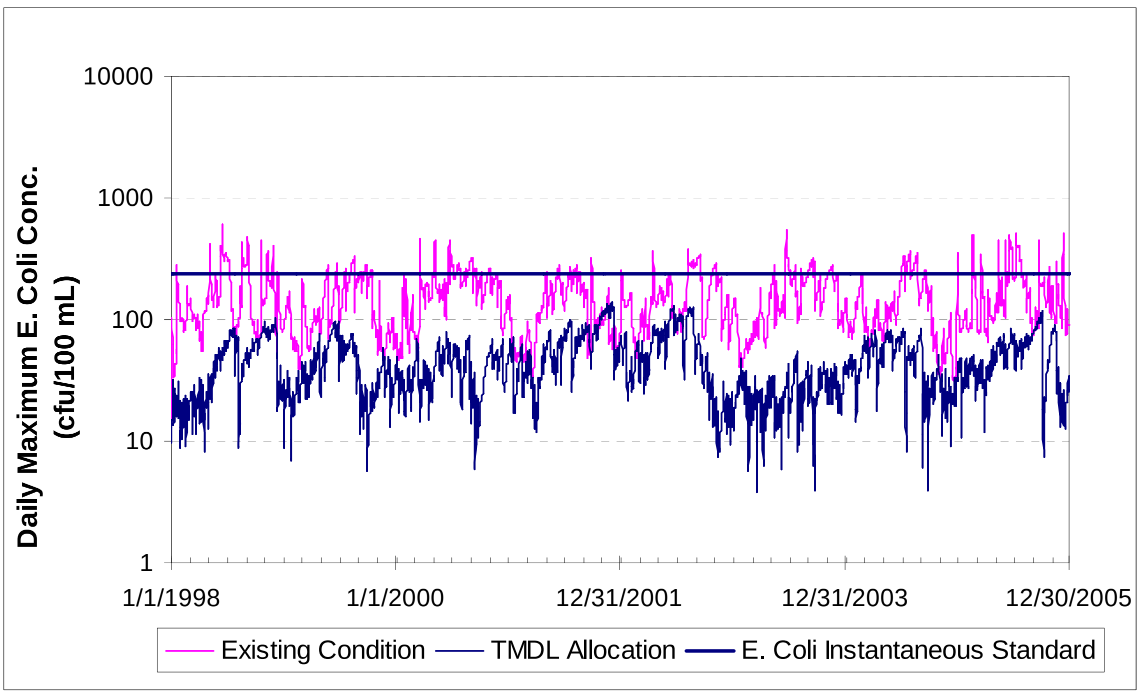

Figure 5-16: North Fork Mayo River Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.14 Smith River (VAW-L54R-01) TMDL

5.14.1 Smith River Wasteload Allocation

There are 2 facilities in the Smith River watershed permitted to discharge bacteria (see Chapter 4). For this TMDL, the wasteload allocation for permitted facilities is to maintain discharge at the design flow limits and bacteria concentrations at their permitted levels of 126 cfu/100mL. **Table 5-31** shows the loading from the permitted point source dischargers in the watershed. To account for future growth, the WLA was developed using 5 times the original allocation.

Table 5-31: Smith River (VAW-L54R-01) Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VA0025305	3.82E+10	3.82E+10	1.39E+13	0%
VA0069345	1.91E+10	1.91E+10	6.97E+12	0%
Total	**5.73E+10**	**5.73E+10**	**2.09E+13**	**0%**
Total (Future Growth)			**1.05E+14**	**-**

5.14.2 Smith River (VAW-L54R-01) Load Allocation

The scenarios considered for Smith River (Reach 36) load allocation are presented in **Table 5-32.** The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than forty percent of the time in the Smith River.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 43 percent violation of this standard in the Smith River and a 48 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in no violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the Smith River under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the Smith River. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, a 96 percent reduction of urban and agricultural nonpoint sources, and a 64 percent reduction of direct loading by wildlife are required.

Table 5-32: Smith River (VAW-L54R-01) Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	44%	48%
1	100%	0%	0%	0%	0%	44%	48%
2	100%	50%	0%	0%	0%	43%	48%
3	100%	100%	0%	0%	0%	43%	48%
4	100%	100%	100%	100%	0%	0%	0%
5	100%	100%	0%	0%	50%	27%	48%
6	100%	100%	0%	0%	75%	21%	48%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	89%	89%	64%	0%	6%
9	100%	50%	50%	50%	0%	25%	35%
10	100%	75%	75%	75%	0%	2%	26%
11	100%	100%	96%	96%	64%	0%	0%

5.14.3 Smith River (VAW-L54R-01) Allocation Plan and TMDL Summary

As shown in **Table 5-32**, Scenario 11 for the Smith River, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 96 percent reduction of bacteria loading from agricultural and urban nonpoint sources.

- 64 percent reduction of the direct instream loading from wildlife.

Table 5-33 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-33: Smith River (VAW-L54R-01) Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	4.48E+11	4.48E+11	2.93E+09	0%
Cropland	2.60E+11	1.04E+10	6.82E+07	96%
Pasture	2.71E+14	1.08E+13	7.08E+10	96%
Low Density Residential	4.47E+13	1.79E+12	1.17E+10	96%
Medium Density Residential	2.66E+13	1.06E+12	6.95E+09	96%
High Density Residential	2.02E+13	8.07E+11	5.28E+09	96%
Commercial/Industrial	5.73E+13	2.29E+12	1.50E+10	96%
Failed Septic - direct deposition	1.84E+12	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	1.06E+13	3.81E+12	2.49E+10	64%
Cattle - direct deposition	5.52E+09	0.00E+00	0.00E+00	100%
Point Source	2.09E+13	1.05E+14	2.86E+11	0%
Total loads /Overall reduction	**4.54E+14**	**1.26E+14**	**4.24E+11**	**77%**

The bacteria TMDL for the Smith River is presented in **Table 5-34**.

Table 5-34: Smith River (VAW-L54R-01) Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
2.86E+11	**1.38E+11**	**Implicit**	**4.24E+11**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-17 and Figure 5-18**. **Figure 5-17** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-18** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

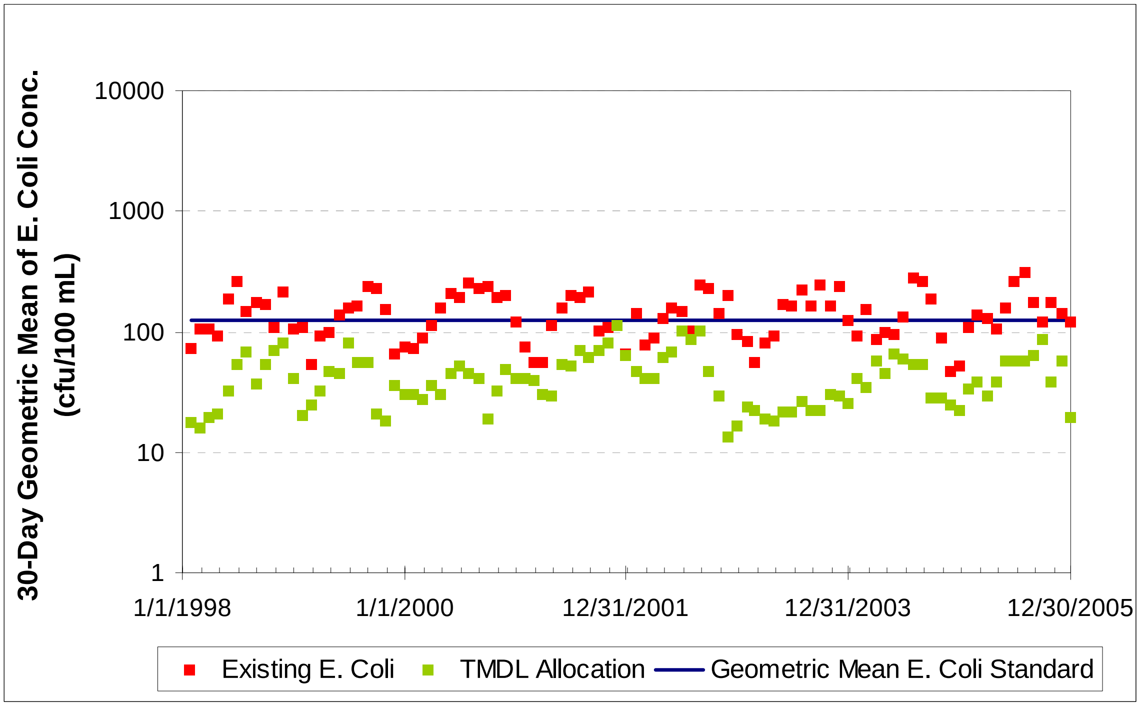

Figure 5-17: Smith River (VAW-L54R-01) Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

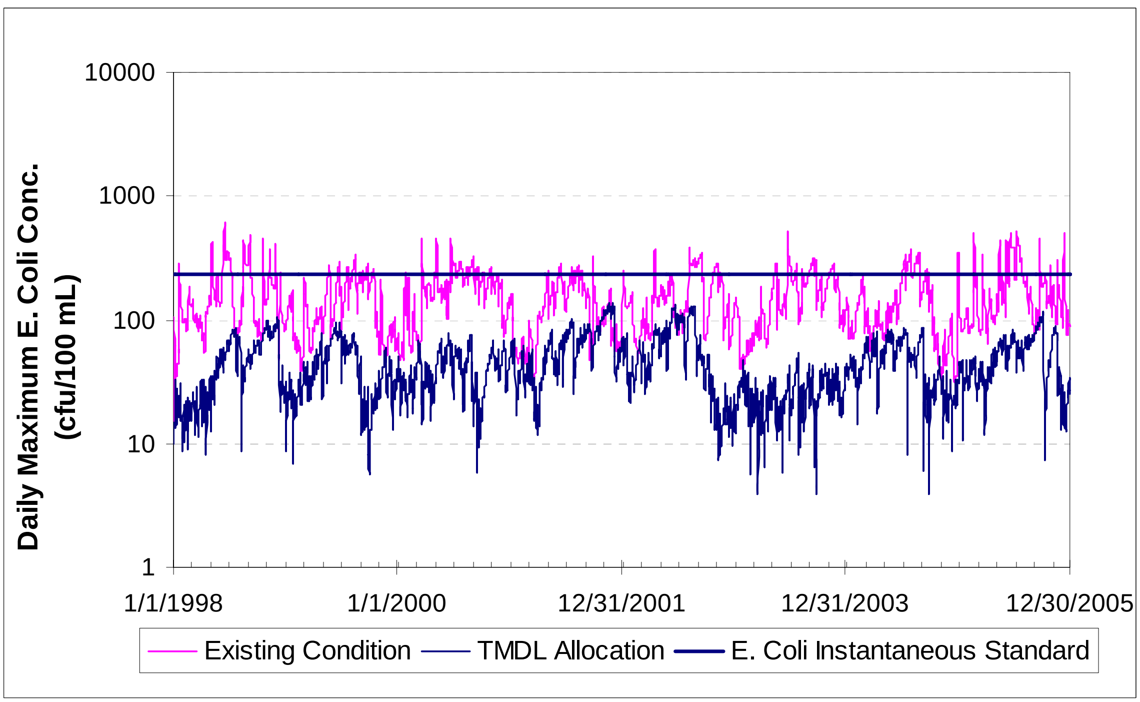

Figure 5-18: Smith River (VAW-L54R-01) Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.15 Smith River (VAW-L53R-01) TMDL

5.15.1 Smith River Wasteload Allocation

There are 4 facilities in this portion of the Smith River watershed permitted to discharge bacteria (see Chapter 4). For this TMDL, the wasteload allocation for permitted facilities is to maintain discharge at the design flow limits and bacteria concentrations at their permitted levels of 126 cfu/100mL. **Table 5-35** shows the loading from the permitted point source dischargers in the watershed. To account for future growth, the WLA was developed using 5 times the original allocation.

Table 5-35: Smith River (VAW-L53R-01) Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VA0029858	2.86E+08	2.86E+08	1.05E+11	0%
VA0090174	4.77E+07	4.77E+07	1.74E+10	0%
VA0090280	1.53E+08	1.53E+08	5.58E+10	0%
VAG402049	2.86E+06	2.86E+06	1.04E+09	0%
Total	**4.90E+08**	**4.90E+08**	**1.79E+11**	**0%**
Total (Future Growth)			**8.94E+11**	**-**

5.15.2 Smith River (VAW-L53R-01) Load Allocation

The scenarios considered for Smith River (Reach 42) load allocation are presented in **Table 5-36**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than 40 percent of the time in the Smith River.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 28 percent violation of this standard in the Smith River and a 45 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in no violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the Smith River under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the Smith River. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, a 96 percent reduction of urban and agricultural nonpoint sources, and a 64 percent reduction of direct loading by wildlife are required.

Table 5-36: Smith River (VAW-L53R-01) Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	35%	45%
1	100%	0%	0%	0%	0%	35%	45%
2	100%	50%	0%	0%	0%	32%	45%
3	100%	100%	0%	0%	0%	28%	45%
4	100%	100%	100%	100%	0%	0%	0%
5	100%	100%	0%	0%	50%	14%	42%
6	100%	100%	0%	0%	75%	9%	42%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	89%	89%	64%	0%	10%
9	100%	50%	50%	50%	0%	10%	35%
10	100%	75%	75%	75%	0%	0%	26%
11	100%	100%	96%	96%	64%	0%	0%

5.15.3 Smith River (VAW-L53R-01) Allocation Plan and TMDL Summary

As shown in **Table 5-36**, Scenario 11 for the Smith River, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 96 percent reduction of bacteria loading from agricultural and urban nonpoint sources.

- 64 percent reduction of the direct instream loading from wildlife.

Table 5-37 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-37: Smith River (VAW-L53R-01) Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	5.45E+12	5.45E+12	3.57E+10	0%
Cropland	1.32E+12	5.29E+10	3.47E+08	96%
Pasture	2.12E+14	8.48E+12	5.55E+10	96%
Low Density Residential	2.33E+14	9.33E+12	6.11E+10	96%
Medium Density Residential	1.39E+14	5.57E+12	3.64E+10	96%
High Density Residential	8.52E+13	3.41E+12	2.23E+10	96%
Commercial/Industrial	5.07E+13	2.03E+12	1.33E+10	96%
Failed Septic - direct deposition	2.81E+13	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	1.12E+14	4.05E+13	2.65E+11	64%
Cattle - direct deposition	5.47E+09	0.00E+00	0.00E+00	100%
Point Source	1.79E+11	8.94E+11	2.45E+09	0%
Total loads /Overall reduction	**8.68E+14**	**7.57E+13**	**4.92E+11**	**91%**

The bacteria TMDL for the Smith River is presented in **Table 5-38**.

Table 5-38: Smith River (VAW-L53R-01) Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
2.45E+09	**4.89E+11**	**Implicit**	**4.92E+11**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-19 and Figure 5-20**. **Figure 5-19** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-20** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

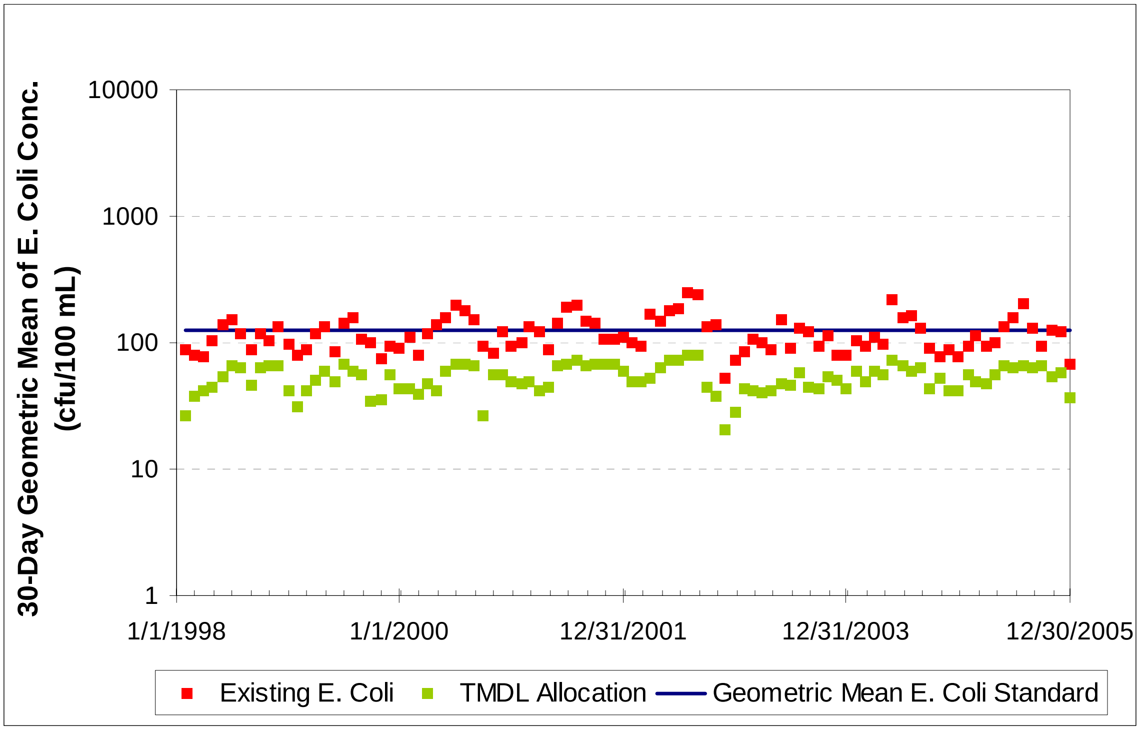

Figure 5-19: Smith River (VAW-L53R-01) Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

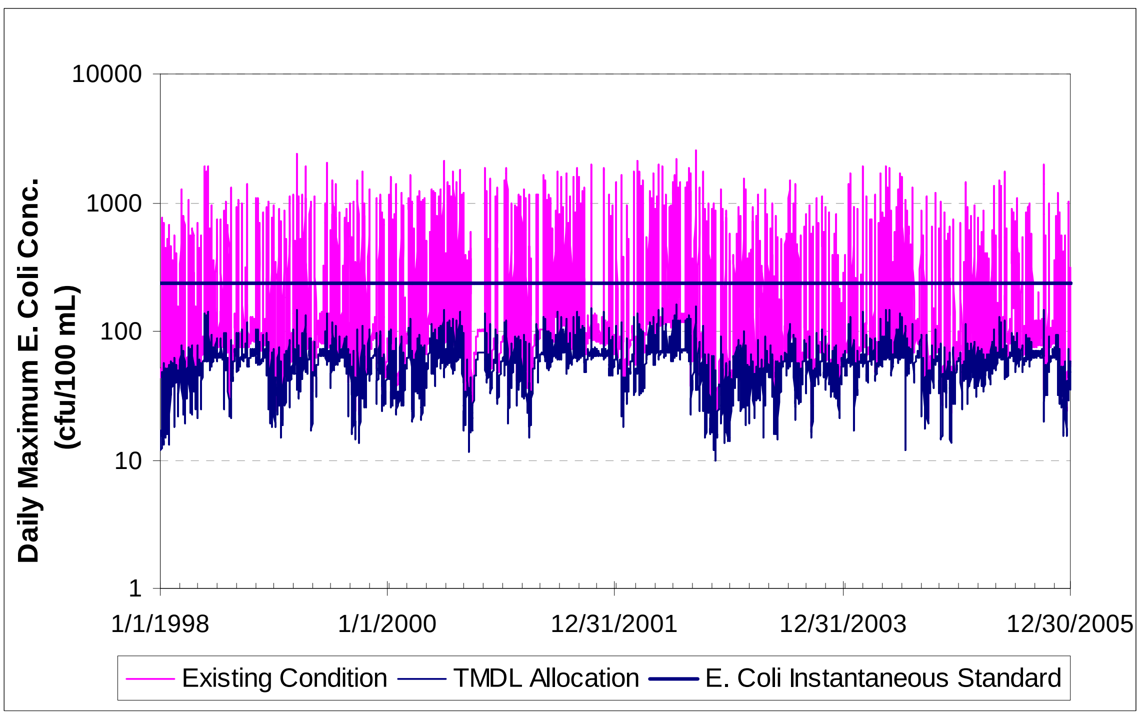

Figure 5-20: Smith River (VAW-L53R-01) Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.16 South Fork Mayo River (VAW-L45R-01) TMDL

5.16.1 South Fork Mayo River Wasteload Allocation

There are no industrial or municipal permitted facilities currently discharging into the South Fork Mayo River.

5.16.2 South Fork Mayo River Load Allocation

The scenarios considered for South Fork Mayo River load allocation are presented in **Table 5-39**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated more than 35 percent of the time in the South Fork Mayo River.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 27 percent violation of this standard in the South Fork Mayo River and a 45 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in no violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the South Fork Mayo River under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the South Fork Mayo River. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, a 97.9 percent reduction of urban and agricultural nonpoint sources, and no reduction of direct loading by wildlife are required.

Table 5-39: South Fork Mayo River Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	38%	45%
1	100%	0%	0%	0%	0%	38%	45%
2	100%	50%	0%	0%	0%	30%	45%
3	100%	100%	0%	0%	0%	27%	45%
4	100%	100%	100%	100%	0%	0%	0%
5	100%	100%	0%	0%	50%	4%	39%
6	100%	100%	0%	0%	75%	0%	35%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	87%	87%	0%	4%	7%
9	100%	50%	50%	50%	0%	16%	29%
10	100%	75%	75%	75%	0%	0%	26%
11	100%	100%	97.9%	97.9%	0%	0%	0%

5.16.3 South Fork Mayo River Allocation Plan and TMDL Summary

As shown in **Table 5-39**, Scenario 11 for the South Fork Mayo River, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 97.9 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- No reduction of the direct instream loading from wildlife.

Table 5-40 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-40: South Fork Mayo Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	2.08E+12	2.08E+12	1.36E+10	0%
Cropland	1.14E+12	2.40E+10	1.57E+08	98%
Pasture	1.46E+14	3.06E+12	2.00E+10	98%
Low Density Residential	1.87E+13	3.92E+11	2.57E+09	98%
Medium Density Residential	1.07E+13	2.25E+11	1.47E+09	98%
High Density Residential	1.46E+12	3.06E+10	2.00E+08	98%
Commercial/Industrial	1.76E+13	3.70E+11	2.42E+09	98%
Failed Septic - direct deposition	1.30E+13	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	4.50E+13	4.50E+13	2.95E+11	0%
Cattle - direct deposition	7.27E+07	0.00E+00	0.00E+00	100%
Point Source	0.00E+00	5.12E+11	1.40E+09	0%
Total loads /Overall reduction	**2.55E+14**	**5.17E+13**	**3.37E+11**	**80%**

The bacteria TMDL for the South Fork Mayo River is presented in **Table 5-41**.

Table 5-41: South Fork Mayo River Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
1.40E+09	**3.35E+11**	**Implicit**	**3.37E+11**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-21 and Figure 5-22**. **Figure 5-21** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-22** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

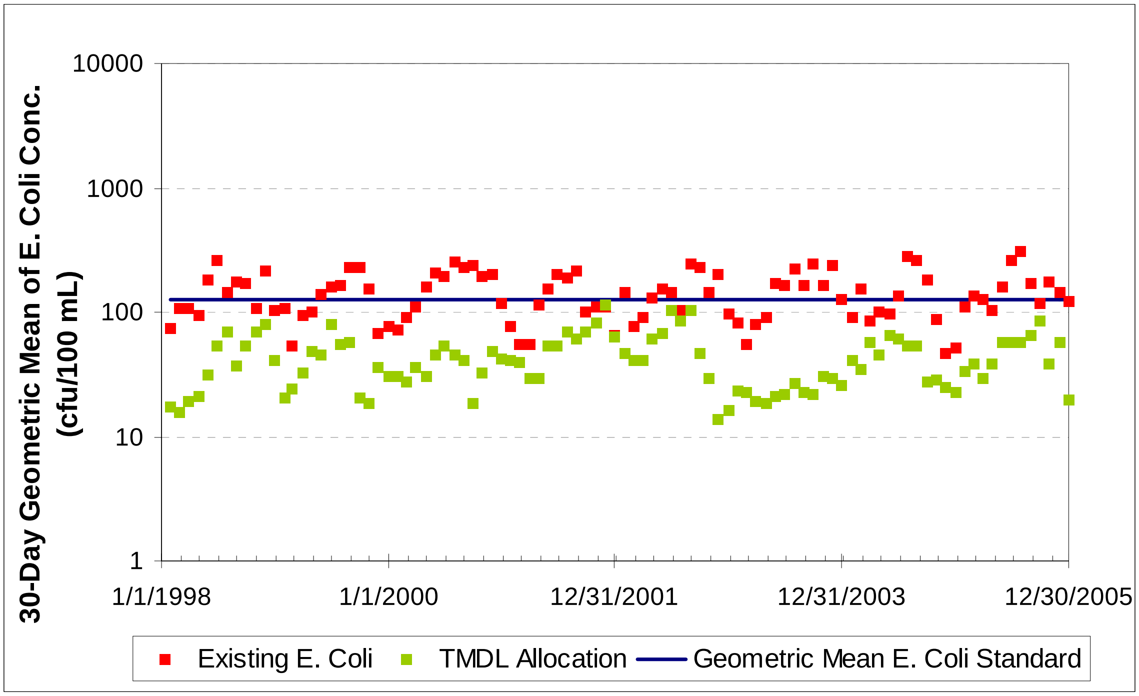

Figure 5-21: South Fork Mayo River Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

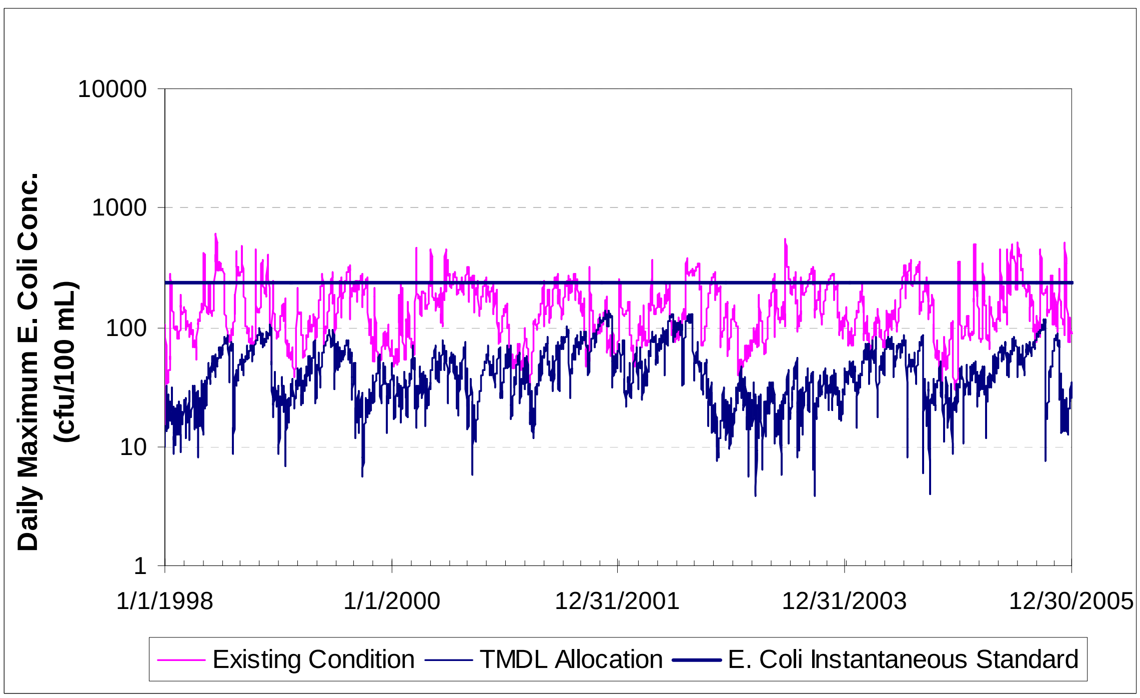

Figure 5-22: South Fork Mayo River Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.17 Sandy Creek (VAC-L59R-01) TMDL

5.17.1 Sandy Creek Wasteload Allocation

There is one facility in the Sandy Creek watershed permitted to discharge bacteria (see Chapter 4). For this TMDL, the wasteload allocation for permitted facilities is to maintain discharge at the design flow limits and bacteria concentrations at their permitted levels of 126 cfu/100mL. **Table 5-42** shows the loading from the permitted point source dischargers in the watershed. To account for future growth, the WLA was developed using 5 times the original allocation.

Table 5-42: Sandy Creek Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VPG100139	2.86E+06	2.86E+06	1.04E+09	0%
Total (Future Growth)			**5.21E+09**	**-**

5.17.2 Sandy Creek Load Allocation

The scenarios considered for Sandy Creek load allocation are presented in **Table 5-43**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated mo re than 40 percent of the time in the Sandy Creek.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 36 percent violation of this standard in the Sandy Creek and a 39 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in a 5 percent violation of this standard in the Sandy Creek and no violation of the *E. coli* instantaneous standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the Sandy Creek under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the Sandy Creek. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes) and livestock direct deposition, a 97 percent reduction of urban nonpoint sources and agricultural nonpoint sources, and a 13 percent reduction of direct loading by wildlife are required.

Table 5-43: Sandy Creek Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	45%	39%
1	100%	0%	0%	0%	0%	45%	39%
2	100%	50%	0%	0%	0%	39%	39%
3	100%	100%	0%	0%	0%	36%	39%
4	100%	100%	100%	100%	0%	5%	0%
5	100%	100%	0%	0%	50%	9%	39%
6	100%	100%	0%	0%	75%	0%	39%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	90%	90%	13%	2%	10%
9	100%	50%	50%	50%	0%	29%	32%
10	100%	75%	75%	75%	0%	0%	23%
11	100%	100%	97%	97%	13%	0%	0%

5.17.3 Sandy Creek Allocation Plan and TMDL Summary

As shown in **Table 5-43**, Scenario 11 for the Sandy Creek, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 97 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- 13 percent reduction of the direct instream loading from wildlife.

Table 5-44 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-44: Sandy Creek Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	1.23E+12	1.23E+12	8.02E+09	0%
Cropland	1.80E+12	5.41E+10	3.54E+08	97%
Pasture	1.63E+14	4.90E+12	3.21E+10	97%
Low Density Residential	3.82E+13	1.15E+12	7.51E+09	97%
Medium Density Residential	1.44E+13	4.33E+11	2.84E+09	97%
High Density Residential	1.66E+13	4.97E+11	3.25E+09	97%
Commercial/Industrial	1.28E+13	3.83E+11	2.51E+09	97%
Failed Septic - direct deposition	1.80E+12	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	5.31E+12	4.62E+12	3.02E+10	13%
Cattle - direct deposition	9.06E+07	0.00E+00	0.00E+00	100%
Point Source	1.04E+09	5.21E+09	1.43E+07	0%
Total loads /Overall reduction	**2.55E+14**	**1.33E+13**	**8.68E+10**	**95%**

The bacteria TMDL for the Sandy Creek is presented in **Table 5-45**.

Table 5-45: Sandy Creek Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
1.43E+07	**8.68E+10**	**Implicit**	**8.68E+10**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-23 and Figure 5-24**. **Figure 5-23** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-24** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

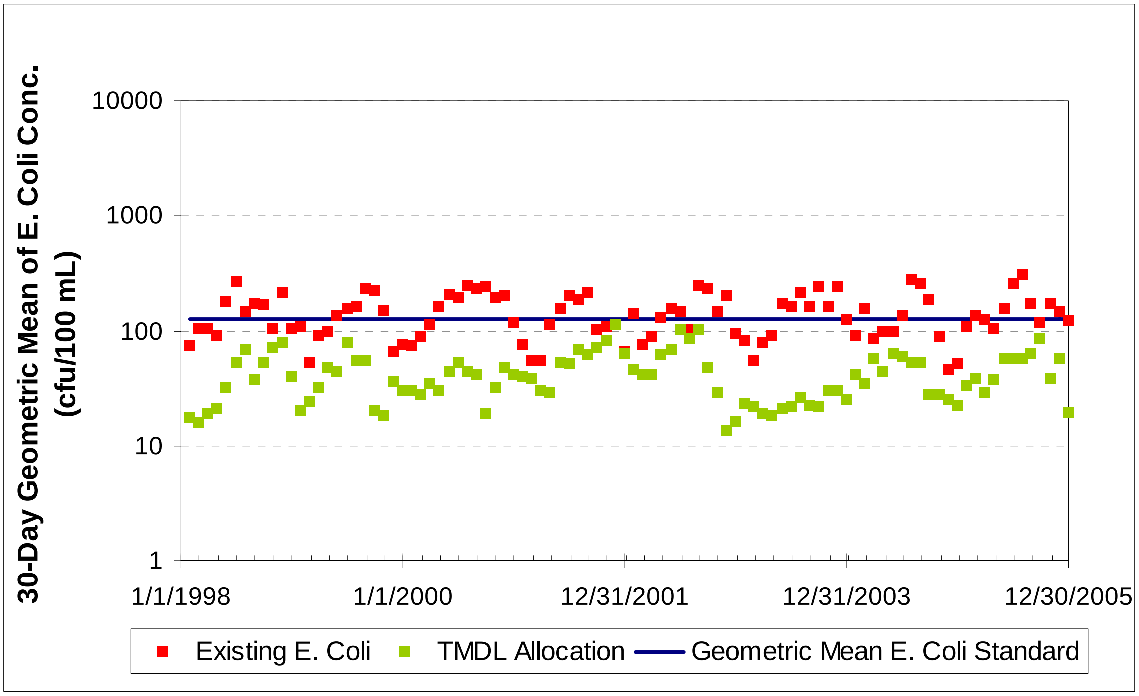

Figure 5-23: Sandy Creek Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

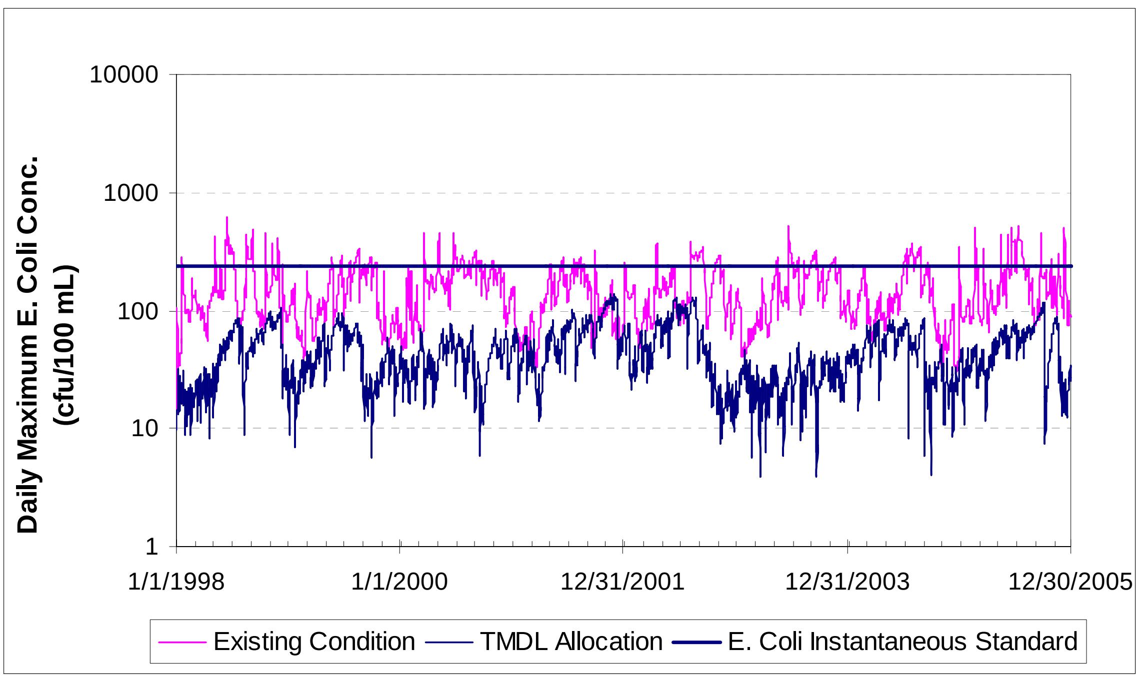

Figure 5-24: Sandy Creek Instantaneous *E. coli* Concentrations under Allocation Scenario 11

5.18 Sandy River (VAC-L58R-01) TMDL

5.18.1 Sandy River Wasteload Allocation

There are two facilities in the Sandy River watershed permitted to discharge bacteria (see Chapter 4). For this TMDL, the wasteload allocation for permitted facilities is to maintain discharge at the design flow limits and bacteria concentrations at their permitted levels of 126 cfu/100mL. **Table 5-46** shows the loading from the permitted point source dischargers in the watershed. To account for future growth, the WLA was developed using 5 times the original allocation.

Table 5-46: Sandy River Wasteload Allocation for *E. coli*

Point Source	Existing Load (cfu/day)	Allocated Load (cfu/day)	Allocated Load (cfu/year)	Percent Reduction
VA0027693	5.73E+07	5.73E+07	2.09E+10	0%
VAG402053	2.15E+06	2.15E+06	7.84E+08	0%
Total	**5.94E+07**	**5.94E+07**	**2.17E+10**	**0%**
Total (Future Growth)			**1.08E+11**	**-**

5.18.2 Sandy River Load Allocation

The scenarios considered for Sandy River load allocation are presented in **Table 5-47**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality standard was violated most of the time in the Sandy River.
2. In Scenario 3, elimination of the human sources (failed septic systems and straight pipes) and the livestock direct instream loading resulted in a 42 percent violation of this standard in the Sandy River and a 42 percent violation of the *E. coli* instantaneous standard.
3. In Scenario 4, eliminating all sources except direct instream loading from wildlife resulted in a 19 percent violation of this standard in the Sandy River and no violation of the *E. coli* instantaneous standard.
4. No violations of either the *E. coli* geometric mean standard or the instantaneous *E. coli* standard occurred in the Sandy River under Scenario 11.

Therefore, Scenario 11 was chosen as the final TMDL load allocation scenario for the Sandy River. Under this scenario, complete elimination of the human sources (failed septic systems and straight pipes), livestock direct deposition, a 97 percent reduction of urban and agricultural nonpoint sources, a 42 percent reduction of direct loading by wildlife are required.

Table 5-47: Sandy River Load Reductions under 30-Day Geometric Mean and Instantaneous Standards for *E. coli*

Scenario	Failed Septic & Pipes	Direct Livestock	NPS (Agric-cultural)	NPS (Urban)	Direct Wildlife	*E. coli* Percent violation of GM standard 126 #/100ml	*E. coli* Percent violation of Inst. standard 235 #/100ml
0	0%	0%	0%	0%	0%	53%	100%
1	100%	0%	0%	0%	0%	53%	100%
2	100%	50%	0%	0%	0%	47%	100%
3	100%	100%	0%	0%	0%	42%	42%
4	100%	100%	100%	100%	0%	19%	0%
5	100%	100%	0%	0%	50%	20%	39%
6	100%	100%	0%	0%	75%	4%	39%
7	100%	100%	95%	95%	75%	0%	0%
8	100%	100%	92%	92%	42%	2%	10%
9	100%	50%	50%	50%	0%	38%	35%
10	100%	75%	75%	75%	0%	0%	26%
11	100%	100%	97%	97%	42%	0%	0%

5.18.3 Sandy River Allocation Plan and TMDL Summary

As shown in **Table 5-47**, Scenario 11 for the Sandy River, will meet the 30-day *E. coli* geometric mean water quality standard of 126 cfu/100 ml and the instantaneous water quality standard of 235 cfu/100ml. The requirements necessary to met Scenario 11 include:

- 100 percent reduction of the human sources (failed septic systems and straight pipes).
- 100 percent reduction of the direct instream loading from livestock.
- 97percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- 42 percent reduction of the direct instream loading from wildlife.

Table 5-48 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source. The monthly distribution of these loads is presented in Appendix E.

Table 5-48: Sandy River Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Annual Average *E. coli* Loads (cfu/yr)		Allocation (cfu/day)	Percent Reduction (%)
	Existing	Future		
Forest	5.02E+12	5.02E+12	3.28E+10	0%
Cropland	1.22E+12	3.65E+10	2.39E+08	97%
Pasture	1.95E+14	5.85E+12	3.83E+10	97%
Low Density Residential	2.15E+14	6.44E+12	4.22E+10	97%
Medium Density Residential	1.28E+14	3.84E+12	2.51E+10	97%
High Density Residential	7.84E+13	2.35E+12	1.54E+10	97%
Commercial/Industrial	4.67E+13	1.40E+12	9.17E+09	97%
Failed Septic - direct deposition	2.58E+13	0.00E+00	0.00E+00	100%
Wildlife - direct deposition	1.03E+14	6.00E+13	3.93E+11	42%
Cattle - direct deposition	5.03E+09	0.00E+00	0.00E+00	100%
Point Source	2.17E+10	1.08E+11	2.97E+08	0%
Total loads /Overall reduction	**7.99E+14**	**8.50E+13**	**5.56E+11**	**89%**

The bacteria TMDL for the Sandy River is presented in **Table 5-49**.

Table 5-49: Sandy River Bacteria TMDL (cfu/day) for *E. coli*

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
2.97E+08	**5.56E+11**	**Implicit**	**5.56E+11**

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-25 and Figure 5-26**. **Figure 5-25** shows the 30-day geometric mean *E. coli* concentrations after applying allocation Scenario 11, as well as geometric mean concentrations under existing conditions. **Figure 5-26** shows the instantaneous *E. coli* concentrations after applying allocation Scenario 11.

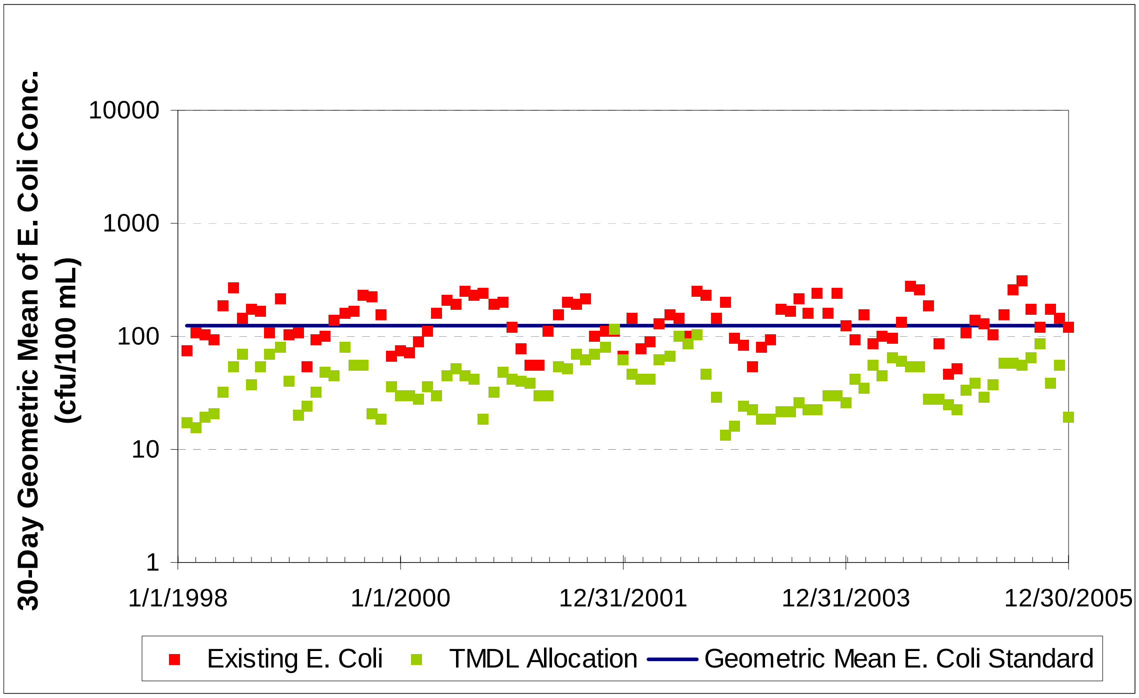

Figure 5-25: Sandy River Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 11

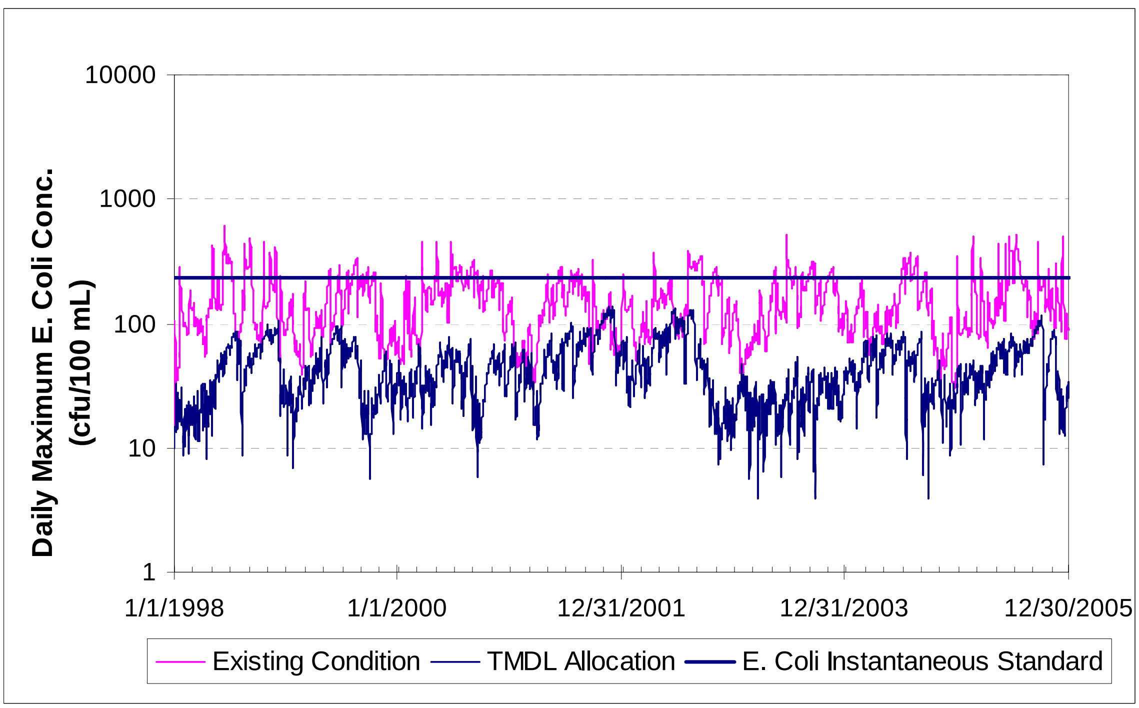

Figure 5-26: Sandy River Instantaneous E. coli Concentrations under Allocation Scenario 11

6.0 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. The measures for non point source reductions, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/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.

6.1 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. This has been shown 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. This component could be implemented through education on septic tank pump-outs as well as a septic system repair/replacement program and the use of alternative waste treatment systems.

In urban areas, reducing the human bacteria loading from leaking sewer lines could be accomplished through a sanitary sewer inspection and management program. Other BMPs that might be appropriate for controlling urban wash-off from parking lots and roads and that could be readily implemented 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. While specific goals for BMP implementation will be established as part of the implementation plan development, the following stage 1 scenarios are targeted at controllable, anthropogenic bacteria sources and can serve as starting points for targeting BMP implementation activities.

6.2 Stage 1 Scenarios

The goal of the stage 1 scenarios is to reduce the bacteria loadings from controllable sources (excluding wildlife) such that violations of the single sample maximum criterion (235 cfu/100mL) are less than 10 percent. The stage 1 scenarios were generated with the same model setup as was used for the TMDL allocation scenarios. A margin of safety was not used in determining the stage 1 scenarios. It was estimated for modeling purposes that there are 405 straight pipes in the watershed. If straight pipes are found during the implementation process, they should be eliminated as soon as possible since they would be illegally discharging fecal bacteria into Bacteria TMDLs for Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River watersheds and their tributaries.

Three allocation scenarios are presented in **Tables 6-1 to 6-13** for Bacteria TMDLs for Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, South Fork Mayo River, Sandy Creek, Sandy River, and Smith River Watersheds respectively. Scenario 1 represents the required load reduction that will not exceed the instantaneous standard by more than 10% violation. Scenarios 2 and 3 represent the implementation of BMPs and management strategies such as livestock exclusion from streams, alternative water, manure storage, riparian buffers, and pet waste control that can be readily put in place in the watershed.

Table 6-1: Dan River (Segment VAC-L60R-01) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	89%	89%	48%	3%	10%
2	100%	50%	50%	50%	0%	36%	52%
3	100%	75%	75%	75%	0%	2%	35%

Table 6-2: Blackberry Creek (Segment VAW-L52R-02) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	88%	88%	0%	2%	10%
2	100%	50%	50%	50%	0%	21%	35%
3	100%	75%	75%	75%	0%	0%	26%

Table 6-3: Byrds Branch (Segment VAC-L62R-04) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	85%	85%	39%	2%	10%
2	100%	50%	50%	50%	0%	36%	32%
3	100%	75%	75%	75%	0%	0%	16%

Table 6-4: Double Creek (Segment VAC-L62R-03) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	79%	79%	0%	0%	7%
2	100%	50%	50%	50%	0%	4%	23%
3	100%	75%	75%	75%	0%	0%	7%

Table 6-5: Fall Creek (Segment VAC-L61R-01) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	94%	94%	0%	1%	10%
2	100%	50%	50%	50%	0%	24%	39%
3	100%	75%	75%	75%	0%	0%	32%

Table 6-6: Leatherwood Creek (Segment VAW-L56R-01) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	89%	89%	24%	4%	10%
2	100%	50%	50%	50%	0%	35%	39%
3	100%	75%	75%	75%	0%	0%	29%

Table 6-7: Marrowbone Creek (Segment VAW-L55R-01) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	91%	91%	9%	4%	10%
2	100%	50%	50%	50%	0%	32%	39%
3	100%	75%	75%	75%	0%	0%	32%

Table 6-8: North Fork Mayo River (Segment VAW-L46R-01) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	83%	83%	0%	2%	10%
2	100%	50%	50%	50%	0%	8%	29%
3	100%	75%	75%	75%	0%	0%	13%

Table 6-9 Smith River (Segment VAW-L54R-01) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	89%	89%	64%	0%	6%
2	100%	50%	50%	50%	0%	25%	35%
3	100%	75%	75%	75%	0%	2%	26%

Table 6-10: Smith River (Segment VAW-L53R-01) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	violation of GM standard 126 #/100ml	violation of Inst. standard 235 #/100ml
1	100%	100%	89%	89%	64%	0%	10%
2	100%	50%	50%	50%	0%	10%	35%
3	100%	75%	75%	75%	0%	0%	26%

Table 6-11: South Fork Mayo River (Segment VAW-L45R-01) Watershed Stage 1 Scenarios							
Scenario	**Failed Septics & Pipes**	**Direct Livestock**	**NPS (Agricultural)**	**NPS (Urban)**	**Direct Wildlife**	**violation of GM standard 126 #/100ml**	**violation of Inst. standard 235 #/100ml**
1	100%	100%	87%	87%	0%	4%	7%
2	100%	50%	50%	50%	0%	16%	29%
3	100%	75%	75%	75%	0%	0%	26%

Table 6-12 Sandy Creek (Segment VAC-L59R-01) Watershed Stage 1 Scenarios							
Scenario	**Failed Septics & Pipes**	**Direct Livestock**	**NPS (Agricultural)**	**NPS (Urban)**	**Direct Wildlife**	**violation of GM standard 126 #/100ml**	**violation of Inst. standard 235 #/100ml**
1	100%	100%	90%	90%	13%	2%	10%
2	100%	50%	50%	50%	0%	29%	32%
3	100%	75%	75%	75%	0%	0%	23%

Table 6-13: Sandy River (Segment VAC-L58R-01) Watershed Stage 1 Scenarios							
Scenario	**Failed Septics & Pipes**	**Direct Livestock**	**NPS (Agricultural)**	**NPS (Urban)**	**Direct Wildlife**	**violation of GM standard 126 #/100ml**	**violation of Inst. standard 235 #/100ml**
1	100%	100%	92%	92%	42%	2%	10%
2	100%	50%	50%	50%	0%	38%	35%
3	100%	75%	75%	75%	0%	0%	26%

6.3 Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the watershed. Currently, there are several ongoing restoration and management efforts in the watershed. These efforts include but are not limited to the Dan River Watershed Protection Plan, Roanoke River Basinwide Water Quality Plan, Philpott Source Water Protection Plan, and the Project Management Plan for Philpott Lake, Virginia (Section 216) Feasibility Study.

The Dan River Watershed Protection Plan was prepared by the Piedmont Land Conservancy via a grant from the North Carolina Clean Water Management Trust Fund. The purpose of the plan is to guide conservation efforts in the Upper Dan River watershed by identifying high-priority restoration and protection areas. It seeks to assist the Dan River Watershed Partnership, an association of nonprofit groups, local businesses, and government agencies, by identifying opportunities to increase the level of coordination between the various stakeholder groups within the watershed.

The Roanoke River Basinwide Water Quality Plan is overseen by the North Carolina Division of Water Quality and is an application of the concept of Basinwide Water Quality Planning to the Roanoke River. This approach seeks to identify water quality problems and restore full designated use to impaired waters, identify and protect high value waters, and protect currently unimpaired segments against future threats. To date, the North Carolina Division of Water Quality has authored three documents providing an update on the state of Basinwide Water Quality Planning in the Roanoke River basin. The first such document was released in 1996, the second in 2001, and the third in 2006. These documents describe the biophysical properties of the Roanoke River system, its main water quality problems, and the various restoration and water quality initiatives that are underway within the basin.

The Philpott Source Water Protection Plan is lead by a committee composed of members of local governments and nonprofits. Its goal is to provide the Henry County Public Service Administration with a plan to reduce the potential contamination of its water sources, and to protect the public health. The Philpott Source Water Protection Plan has suggested various strategies for a management plan that would be able to assist the Henry County Public Service Administration with this goal, such as a household hazardous waste collection day, public education, conservation easements, and a contingency plan.

The Project Management Plan for Philpott Lake, Virginia (Section 216) Feasibility Study, prepared by the US Army Corps of Engineers, will provide recommendations to Congress on the advisability of modifying the Philpott Dam structures and operations for the improvement of the environment and public interest. The goal of the Management Plan is to manage the Philpott Dam, and subsequently the Smith River, to sustainably balance the natural resources and economic uses of the dam and reservoir. Participating on the project is a Water Quality Work Group, whose responsibility it is to identify water quality problems created by the operation of the Philpott Dam and to evaluate ways to change the operations to improve water quality conditions. The Feasility Study is projected to be completed and approved by January 2011. More information is available at http://www.saw.usace.army.mil/philpott_216/main.htm.

Further contributions are made by the Dan River Basin Association, whose mission is to preserve and promote the natural and cultural resources of the Dan River Basin. The Dan River Basin Association is a nonprofit organization established in 2002 by citizens of both Virginia and North Carolina. Direct contributions to the water quality of the watershed are made through stream monitoring in addition to stewardship, recreation, and education efforts. Representatives of the Dan River Basin Association have actively participated throughout the TMDL development.

6.4 Reasonable Assurance for Implementation

6.4.1 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. The purpose, location, parameters, frequency, and duration of the monitoring will be determined by the DEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders. 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 details of the follow-up monitoring will be outlined in the Annual Water Monitoring Plan prepared by each DEQ Regional Office. Other agency personnel, watershed stakeholders, etc. may provide input on the Annual Water Monitoring Plan. These recommendations must be made to the DEQ regional TMDL coordinator by September 30 of each year.

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. Ancillary monitoring by citizens’, watershed groups, local government, or universities is an option that may be used in such cases. An effort should be made to ensure that ancillary monitoring follows 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/cmonitor/.

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 deemed 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 absolute minimum requirement is two consecutive samples (one in the spring and one in the fall) in a one year period each scoring greater than 60 VSCI. And finally an EPA approved state change of Water Quality Standards with data showing waters meet the newly established narrative, criterion or both.

6.4.2 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). All such permits should be submitted to EPA for review.

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. Requirements of the permit process should not be duplicated 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

6.4.3 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.

Part of the Dan River watershed is covered by the MS4 permits VAR040018 (City of Danville) and VAR040003 (VDOT Danville Urban Area). The permits state, under Part II.A., that the "permittee must develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act and the State Water Control Law."

The permit also contains a TMDL clause that states: "If a TMDL is approved for any waterbody into which the small MS4 discharges, the Board will review the TMDL to determine whether the TMDL includes requirements for control of stormwater discharges. If discharges from the MS4 are not meeting the TMDL allocations, the Board will notify the permittee of that finding and may require that the Stormwater Management Program required in Part II be modified to implement the TMDL within a timeframe consistent with the TMDL." ("Board" means the Soil and Water Conservation Board).

6.4.4 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.

6.4.5 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.

7.0 Public Participation

The development of the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, South Fork Mayo River, Sandy Creek, and Sandy River bacteria TMDLs would not have been possible without public participation. Due to the size of the Dan River watershed, public participation opportunities were available in both the upper and lower parts of the watershed (covering the DEQ's West Central and South Central regions, respectively). One technical advisory committee (TAC) meeting was held in the upper part of the Dan River watershed (including Smith River, Blackberry Creek, Leatherwood Creek, North Fork Mayo River and South Fork Mayo River) and two in the lower part of the watershed (including Dan River, Byrds Branch, Double Creek, Fall Creek, Sandy Creek and Sandy River). Two public meetings were held in the upper Dan River watershed and two public meetings where held in the lower Dan River the watershed. The following is a summary of the meetings.

Lower Dan River watershed meetings:

TAC Meeting No. 1: The first TAC meeting was held on May 8, 2007 at the South Boston Public Library in South Boston, Virginia to present and review the steps and the data used in the development of the bacteria TMDLs for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, South Fork Mayo River, Sandy Creek, and Sandy River listed segments.

TAC Meeting No. 2: The second TAC meeting was held on October 2, 2007 at the Danville Science Center in Danville, Virginia to discuss the preliminary source assessment for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, South Fork Mayo River, Sandy Creek, and Sandy River watersheds.

Public Meeting No. 1: The first public meeting was held on August 9, 2007 at the Danville Community College in Danville, Virginia to present the process for TMDL development of the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, South Fork Mayo River, Sandy Creek, and Sandy River bacteria impaired segments. Also presented was the potential bacteria sources data throughout the watershed as well as the data required for TMDL development. Eight people attended the meeting. Copies of the presentation were available for public distribution. This meeting was publicly noticed in the *Virginia Register* and real estate signs announcing the meeting were posted near the impaired waterways. No written comments were received during the 30-day comment period.

Public Meeting No. 2: The second public meeting was held on January 31, 2008 at the Mary Bethune Complex Building in Halifax, Virginia to present the process for TMDL development, final bacteria source assessments, and final TMDLs for the Dan River, Blackberry Creek, Byrds Branch, Double Creek, Fall Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, South Fork Mayo River, Sandy Creek, and Sandy River bacteria impaired segments. Nineteen people attended the meeting. Copies of the presentation were available for public distribution. This meeting was publicly noticed in the *Virginia Register* and real estate signs announcing the meeting were posted near the impaired waterways. No written comments were received during the 30-day comment period.

Upper Dan River Watershed meetings:

TAC Meeting No. 1: The first TAC meeting was held on May 30, 2007 at the Henry County Administrative Building in Martinsville, Virginia to present and review the steps and the data used in the development of the bacteria TMDLs for Blackberry Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, and South Fork Mayo River listed segments. In addition, development of the benthic macroinvertebrate TMDL on the Smith River was discussed. Twenty people attended this meeting.

Public Meeting No. 1: The first public meeting was held on August 8, 2007 at the Henry County Administrative Building in Martinsville, Virginia to discuss bacteria impairments and present the process for TMDL development in the West Central DEQ Region for the Blackberry Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, and South Fork Mayo River bacteria impaired segments. Nineteen people attended the meeting. Copies of the presentation were available for public distribution. This meeting was publicly noticed in the *Virginia Register* and real estate signs announcing the meeting were posted near the impaired waterways. Also discussed at this meeting was the benthic macroinvertebrate impairment on the Smith River.

Public Meeting No. 2: The second public meeting was held on March 27, 2008 at the Henry County Administrative Building in Martinsville, Virginia to present the process for TMDL development, final bacteria source assessments, and final TMDLs in the West Central DEQ Region for the Blackberry Creek, Leatherwood Creek, Marrowbone Creek, North Fork Mayo River, Smith River, and South Fork Mayo River bacteria impaired segments. Nine people attended the meeting. Copies of the presentation were available for public distribution. This meeting was publicly noticed in the *Virginia Register* and real estate signs announcing the meeting were posted near the impaired waterways. Four comments were received and addressed during the 30-day comment period.

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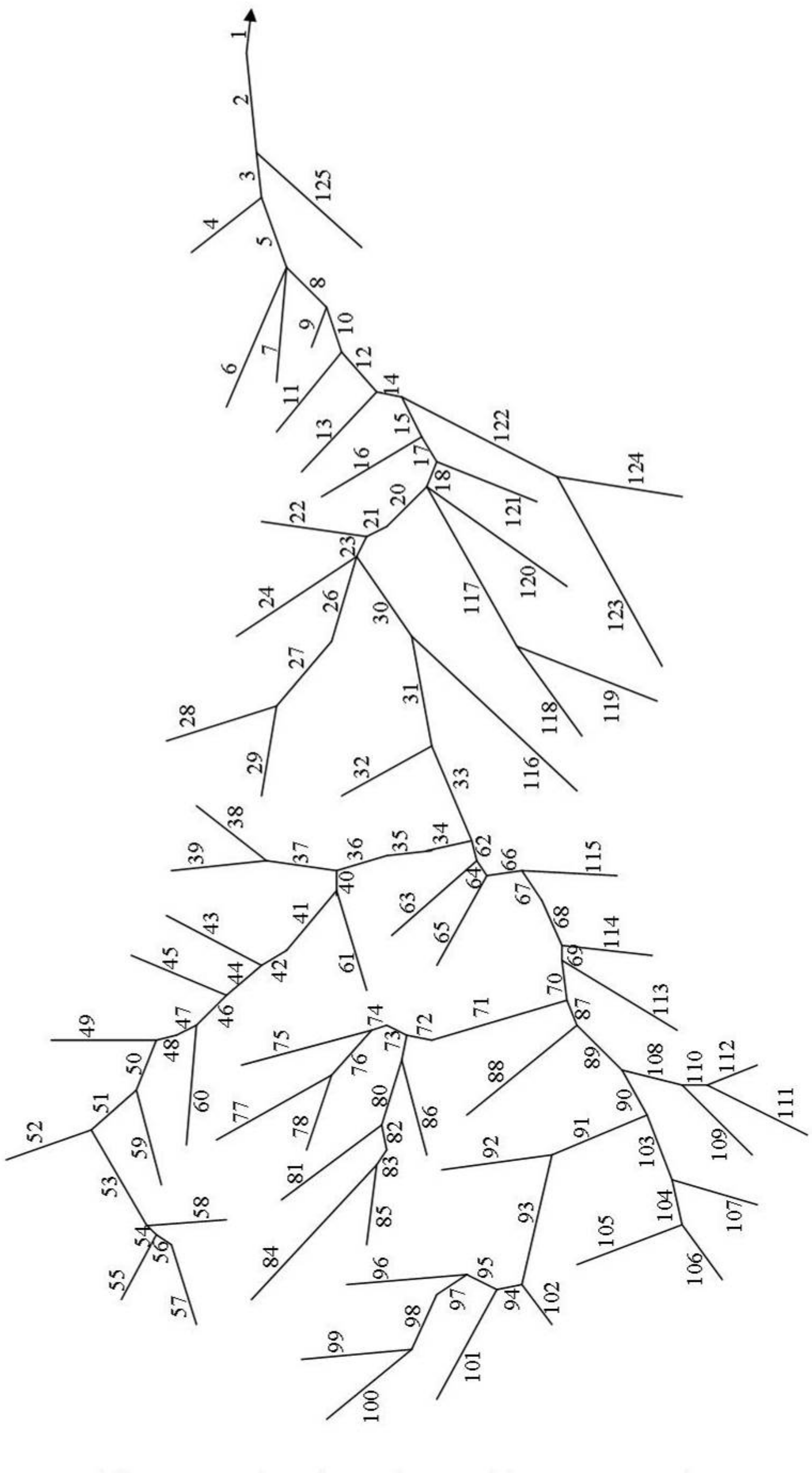
APPENDIX A:

Model Representation of Stream Reach Networks



Model Representation of Dan River Model Stream Network

APPENDIX B:

Livestock and Wildlife Inventories by Subwatershed

Table B-1: Livestock Inventory by Subwatershed

Sub-watershed	Beef Cows	Milk Cows	Hogs and Pigs	Sheep and Lambs	Chickens	Horses
1	293	0	230	3	961	19
2	698	0	547	6	2,288	45
3	138	0	108	1	452	9
4	691	0	542	6	2,265	44
5	356	0	279	3	1,166	23
6	1,361	68	740	18	2,839	110
7	365	2	275	3	1,142	24
8	239	0	188	2	784	15
9	67	0	52	1	219	4
10	587	10	444	6	2,042	61
11	291	26	104	5	340	27
12	595	27	349	7	3,669	46
13	358	49	45	8	6	39
14	79	9	19	2	47	8
15	77	16	10	2	3,930	7
16	348	48	42	7	762	38
17	55	10	6	1	2,003	5
18	19	4	2	0	1,074	2
19	3	1	0	0	184	0
20	42	6	5	1	282	5
21	53	12	6	1	3,072	5
22	589	80	72	13	0	64
23	0	0	0	0	0	0
24	565	77	69	12	0	62
25	0	0	0	0	0	0
26	83	11	10	2	0	9
27	833	114	101	18	0	91
28	688	84	75	14	5	77
29	435	43	38	8	9	51
30	168	25	20	4	1,144	18
31	760	83	163	25	695	142
32	734	81	131	21	429	121
33	559	28	235	33	1,525	201
34	130	7	54	8	353	47
35	234	2	17	4	125	42
36	235	0	0	2	17	33
37	193	0	0	1	14	27
38	299	8	1	2	22	41
39	325	6	0	2	23	45

Table B-1: Livestock Inventory by Subwatershed

Sub-watershed	Beef Cows	Milk Cows	Hogs and Pigs	Sheep and Lambs	Chickens	Horses
40	44	0	0	0	3	6
41	135	0	0	1	10	19
42	104	0	0	1	7	15
43	257	4	0	2	19	36
44	253	0	0	2	18	36
45	326	26	2	2	24	43
46	135	0	0	1	10	19
47	47	0	0	0	3	7
48	37	0	0	0	3	5
49	406	115	9	1	30	46
50	168	12	2	1	10	18
51	320	96	10	1	21	30
52	408	112	9	6	64	46
53	779	104	24	13	37	44
54	12	1	0	0	0	1
55	280	28	7	7	27	18
56	96	10	3	2	3	4
57	448	48	15	7	13	21
58	311	33	10	5	9	15
59	468	50	15	8	14	22
60	194	7	2	2	11	21
61	337	0	0	2	27	48
62	41	2	17	2	112	15
63	370	14	113	16	744	111
64	18	1	7	1	48	6
65	348	18	146	20	948	125
66	277	14	116	16	754	99
67	76	4	32	4	209	27
68	356	18	150	21	972	128
69	22	1	9	1	59	8
70	58	3	24	3	159	21
71	776	45	334	51	4,006	283
72	81	2	14	2	94	19
73	26	0	0	0	3	4
74	37	0	0	0	3	5
75	303	0	0	2	22	43
76	89	1	0	1	6	12
77	831	76	23	13	30	50
78	285	30	9	5	9	13
79	22	0	3	1	33	4
80	210	18	6	3	8	13
81	332	35	11	6	10	15
82	50	5	2	1	1	2
83	20	2	1	0	1	1
84	988	105	32	16	30	46

Table B-1: Livestock Inventory by Subwatershed						
Sub-watershed	**Beef Cows**	**Milk Cows**	**Hogs and Pigs**	**Sheep and Lambs**	**Chickens**	**Horses**
85	429	46	18	8	277	23
86	171	22	59	17	3,590	48
87	53	3	22	3	144	19
88	397	34	188	37	5,789	155
89	249	21	119	24	3,749	98
90	73	11	42	12	2,637	33
91	166	24	95	26	5,997	74
92	272	40	156	43	9,835	121
93	269	40	154	43	9,741	120
94	86	13	49	14	3,119	38
95	34	5	20	5	1,235	15
96	391	45	53	17	2,673	48
97	30	4	17	5	1,079	13
98	214	26	44	13	2,488	37
99	540	58	20	10	161	27
100	1,460	213	47	24	898	67
101	882	214	121	34	7,661	94
102	107	16	62	17	3,892	48
103	252	31	100	34	6,212	173
104	122	16	56	18	3,471	75
105	122	18	70	19	4,420	55
106	302	34	99	38	6,068	236
107	130	10	15	13	798	139
108	189	14	90	16	2,144	73
109	105	9	16	11	872	108
110	17	2	8	2	412	13
111	186	13	4	16	0	224
112	164	22	119	13	2,608	174
113	393	20	165	23	1,071	141
114	587	30	246	34	1,601	211
115	370	19	155	22	1,010	133
116	1,030	62	413	58	6,187	353
117	329	66	47	8	17,115	40
118	320	16	134	19	873	115
119	676	42	269	38	4,458	230
120	396	86	44	8	22,954	37
121	205	44	23	4	11,842	19
122	317	68	38	6	18,126	29
123	478	95	69	12	24,802	58
124	363	79	40	7	21,027	33
125	930	0	729	8	3,048	60
Total	**38,529**	**3,605**	**10,373**	**1,278**	**268,597**	**6,987**

Table B-2: Wildlife Inventory

Sub-watershed	Deer	Raccoon	Muskrat	Beaver	Goose	Mallard	Wood Duck	Wild Turkey
1	373	382	1,651	180	32	1	1	79
2	950	987	4,265	465	81	3	3	202
3	194	203	878	96	17	1	1	41
4	880	901	3,892	425	75	3	3	187
5	453	464	2,003	219	39	1	1	96
6	1,901	1,912	8,261	901	162	6	5	404
7	471	480	2,076	226	40	2	1	100
8	305	312	1,347	147	26	1	1	65
9	85	87	377	41	7	0	0	18
10	861	875	3,780	412	73	3	2	183
11	433	430	1,860	203	37	1	1	92
12	900	910	3,934	429	77	3	3	191
13	575	565	2,440	266	49	2	2	122
14	123	122	525	57	10	0	0	26
15	265	269	1,163	127	23	1	1	56
16	654	643	2,777	303	56	2	2	139
17	160	162	700	76	14	1	0	34
18	69	70	302	33	6	0	0	15
19	12	12	52	6	1	0	0	3
20	160	156	676	74	14	0	0	34
21	551	541	2,339	255	47	2	2	117
22	1,123	1,099	4,750	518	96	3	3	239
23	148	142	614	67	13	0	0	31
24	971	952	4,113	449	83	3	3	207
25	7	6	27	3	1	0	0	1
26	278	270	1,169	127	24	1	1	59
27	1,341	1,317	5,689	621	114	4	4	285
28	1,181	1,169	5,053	551	101	4	3	251
29	830	832	3,594	392	71	3	2	177
30	579	566	2,446	267	49	2	2	123
31	1,295	1,262	5,456	595	110	4	4	276
32	1,273	1,250	5,401	589	108	4	4	271
33	1,063	1,023	4,421	482	91	3	3	226
34	248	238	1,029	112	21	1	1	53
35	596	611	2,639	288	51	2	2	127
36	629	651	2,812	307	54	2	2	134
37	518	535	2,314	252	44	2	2	110
38	805	834	3,604	393	69	3	2	171

Table B-2: Wildlife Inventory

Sub-watershed	Deer	Raccoon	Muskrat	Beaver	Goose	Mallard	Wood Duck	Wild Turkey
39	875	906	3,915	427	74	3	3	186
40	118	122	527	57	10	0	0	25
41	499	514	2,220	242	42	2	2	106
42	343	354	1,529	167	29	1	1	73
43	763	788	3,406	372	65	3	2	162
44	679	702	3,033	331	58	2	2	144
45	886	922	3,984	435	75	3	3	188
46	362	375	1,619	177	31	1	1	77
47	125	130	560	61	11	0	0	27
48	98	102	440	48	8	0	0	21
49	1,142	1,208	5,222	570	97	4	3	243
50	409	423	1,826	199	35	1	1	87
51	839	886	3,830	418	72	3	2	178
52	982	1,005	4,344	474	84	3	3	209
53	1,460	1,480	6,394	698	124	5	4	311
54	21	21	90	10	2	0	0	4
55	469	459	1,982	216	40	1	1	100
56	169	171	739	81	14	1	0	36
57	792	799	3,452	377	67	3	2	168
58	550	555	2,397	261	47	2	2	117
59	828	836	3,611	394	70	3	2	176
60	464	477	2,060	225	39	2	1	99
61	903	934	4,036	440	77	3	3	192
62	78	75	326	36	7	0	0	17
63	782	772	3,337	364	67	2	2	166
64	34	32	140	15	3	0	0	7
65	661	636	2,750	300	56	2	2	141
66	526	506	2,185	238	45	2	1	112
67	145	140	605	66	12	0	0	31
68	678	652	2,817	307	58	2	2	144
69	41	40	172	19	4	0	0	9
70	111	107	461	50	9	0	0	24
71	1,642	1,589	6,868	749	140	5	5	349
72	192	194	839	92	16	1	1	41
73	69	71	307	33	6	0	0	15
74	98	102	440	48	8	0	0	21
75	814	842	3,638	397	69	3	2	173
76	229	236	1,021	111	19	1	1	49
77	1,580	1,603	6,928	756	134	5	5	336

Table B-2: Wildlife Inventory

Sub-watershed	Deer	Raccoon	Muskrat	Beaver	Goose	Mallard	Wood Duck	Wild Turkey
78	504	508	2,196	240	43	2	1	107
79	54	55	238	26	5	0	0	12
80	407	413	1,785	195	35	1	1	87
81	586	591	2,556	279	50	2	2	125
82	88	89	383	42	7	0	0	19
83	36	36	158	17	3	0	0	8
84	1,746	1,762	7,612	830	149	6	5	371
85	780	787	3,399	371	66	2	2	166
86	613	613	2,649	289	52	2	2	130
87	101	97	418	46	9	0	0	21
88	1,168	1,148	4,959	541	99	4	3	248
89	744	731	3,161	345	63	2	2	158
90	353	352	1,521	166	30	1	1	75
91	803	801	3,459	377	68	3	2	171
92	1,316	1,313	5,673	619	112	4	4	280
93	1,304	1,300	5,619	613	111	4	4	277
94	418	416	1,799	196	36	1	1	89
95	165	165	713	78	14	1	0	35
96	917	922	3,983	434	78	3	3	195
97	144	144	622	68	12	0	0	31
98	589	590	2,550	278	50	2	2	125
99	968	976	4,219	460	82	3	3	206
100	2,164	2,179	9,419	1,028	184	7	6	461
101	1,343	1,349	5,830	636	114	4	4	286
102	521	519	2,245	245	44	2	1	111
103	1,119	1,133	4,894	534	95	4	3	238
104	560	564	2,435	266	48	2	2	119
105	592	590	2,549	278	50	2	2	126
106	1,293	1,317	5,691	621	110	4	4	275
107	492	513	2,217	242	42	2	1	105
108	497	487	2,105	230	42	2	1	106
109	406	421	1,822	199	35	1	1	86
110	73	75	323	35	6	0	0	16
111	666	702	3,033	331	57	2	2	142
112	545	595	2,571	280	46	2	2	116
113	747	718	3,104	339	64	2	2	159
114	1,116	1,074	4,640	506	95	3	3	237
115	704	677	2,927	319	60	2	2	150
116	2,067	2,001	8,648	943	176	6	6	440

Table B-2: Wildlife Inventory								
Sub-watershed	**Deer**	**Raccoon**	**Muskrat**	**Beaver**	**Goose**	**Mallard**	**Wood Duck**	**Wild Turkey**
117	1,182	1,197	5,174	564	101	4	3	251
118	609	586	2,531	276	52	2	2	130
119	1,371	1,329	5,742	626	117	4	4	292
120	1,465	1,491	6,444	703	125	5	4	312
121	756	769	3,324	363	64	2	2	161
122	1,161	1,181	5,106	557	99	4	3	247
123	1,673	1,697	7,332	800	142	5	5	356
124	1,342	1,366	5,902	644	114	4	4	286
125	1,185	1,212	5,240	572	101	4	3	252
Total	**84,171**	**84,553**	**365,400**	**39,862**	**7,165**	**266**	**239**	**17,908**

APPENDIX C:

Monthly Fecal Coliform Build-up Rates

Table C-1: Monthly Build-up Rates cfu/ac/day (January to June)

Land Use	Jan	Feb	Mar	April	May	Jun
Commercial/Industrial	5.31E+08	5.31E+08	5.31E+08	5.31E+08	5.31E+08	5.31E+08
Cropland	5.80E+07	1.60E+09	1.60E+09	3.30E+09	1.20E+09	2.80E+09
Forest	1.74E+07	1.74E+07	1.74E+07	1.74E+07	1.74E+07	1.74E+07
High Residential	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10
Medium Residential	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10
Low Residential	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10
Pasture	2.76E+09	6.91E+09	1.15E+10	7.24E+09	1.15E+10	1.18E+10

Table C-2: Monthly Build-up Rates cfu/ac/day (July to December)

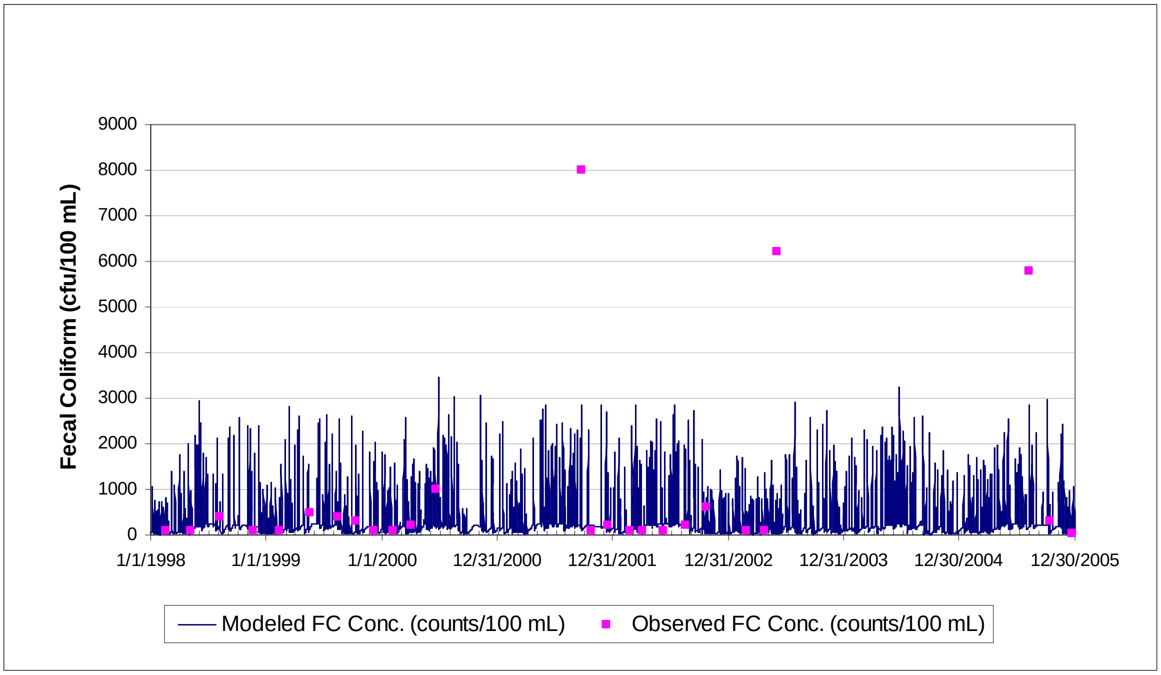
Land Use	Jul	Aug	Sep	Oct	Nov	Dec
Commercial/Industrial	5.31E+08	5.31E+08	5.31E+08	5.31E+08	5.31E+08	5.31E+08
Cropland	1.20E+09	2.80E+09	1.70E+09	3.10E+09	1.60E+09	5.80E+07
Forest	1.74E+07	1.74E+07	1.74E+07	1.74E+07	1.74E+07	1.74E+07
High Residential	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10
Medium Residential	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10
Low Residential	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10	1.19E+10
Pasture	1.15E+10	1.18E+10	1.18E+10	1.18E+10	1.15E+10	1.12E+10

APPENDIX D:

Water Quality Plots: Modeled and Observed Concentrations

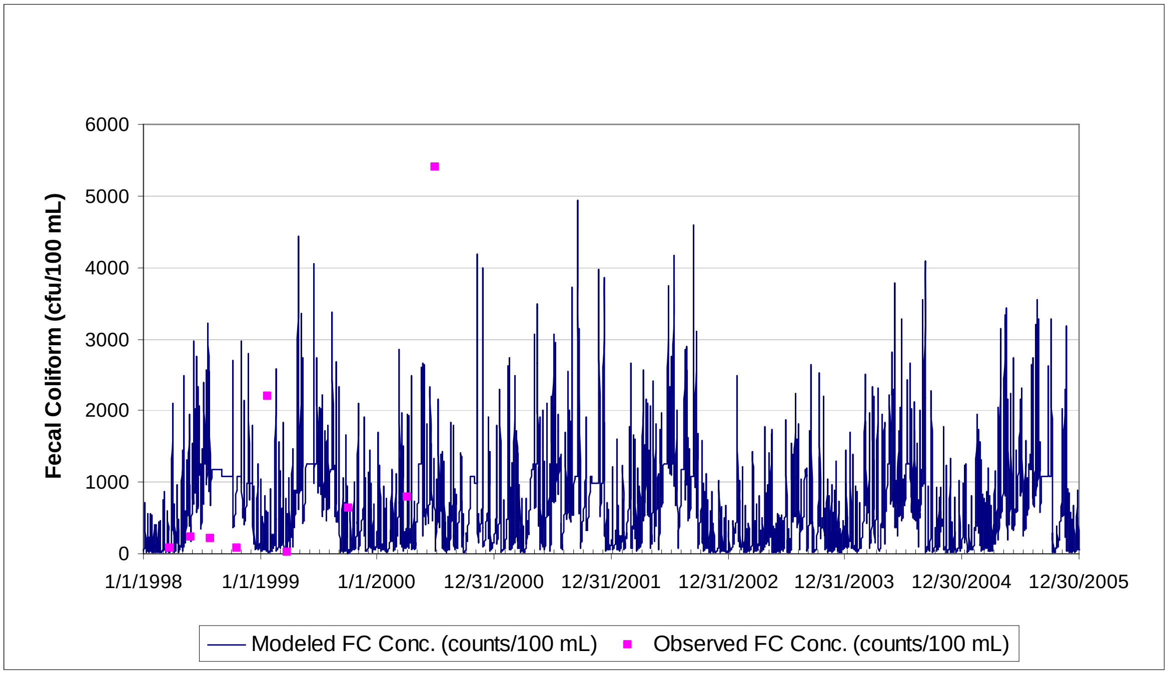
D.1 Blackberry Creek (Segment VAW-L52R-02)

Figure D-1: Fecal Coliform Concentrations at Blackberry Creek Station ABRY000.05 (Reach 60)



D.2 Byrds Branch (Segment VAC-L62R-04)

Figure D-2: Fecal Coliform Concentrations at Byrds Branch Station ABRY000.80 (Reach 9)



D.3 Dan River (Segment VAC-L60R-01)

Figure D-3: Fecal Coliform Concentrations at the Dan River Station 4ADAN015.30 (Reach 1)

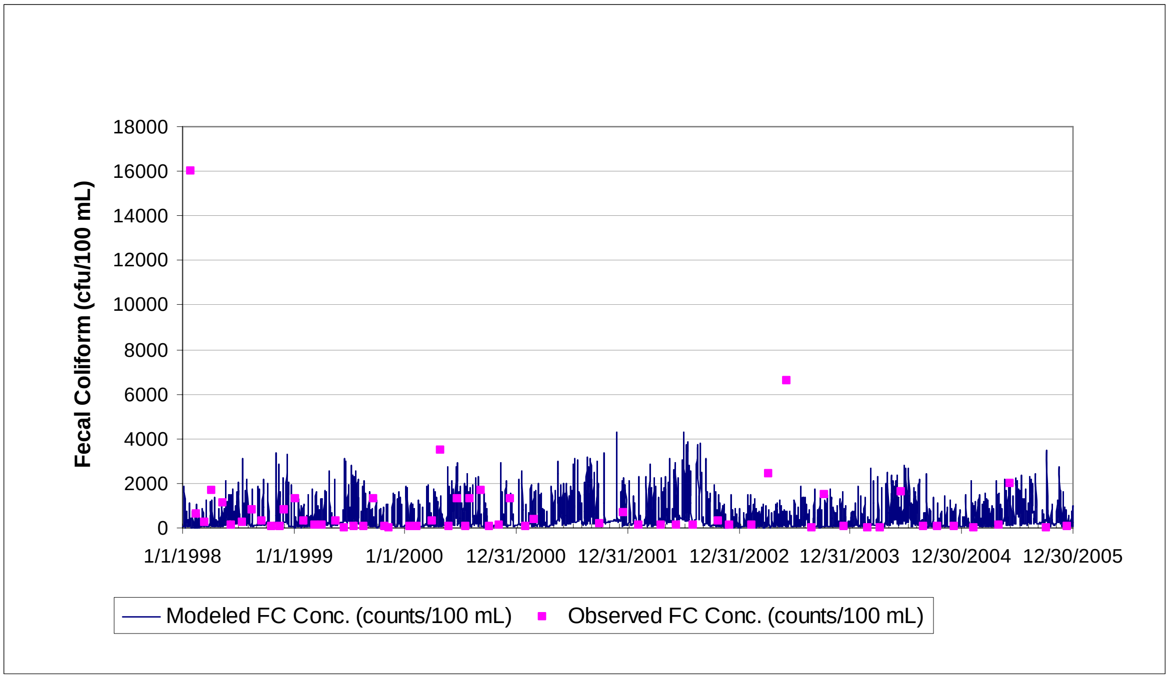
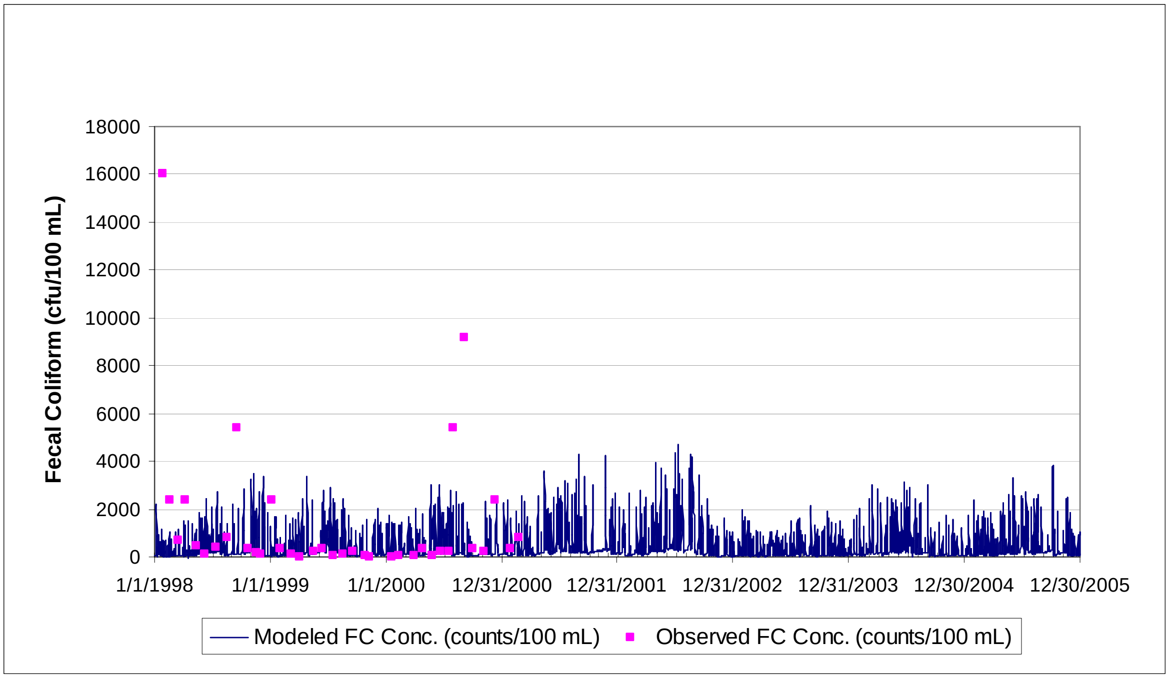
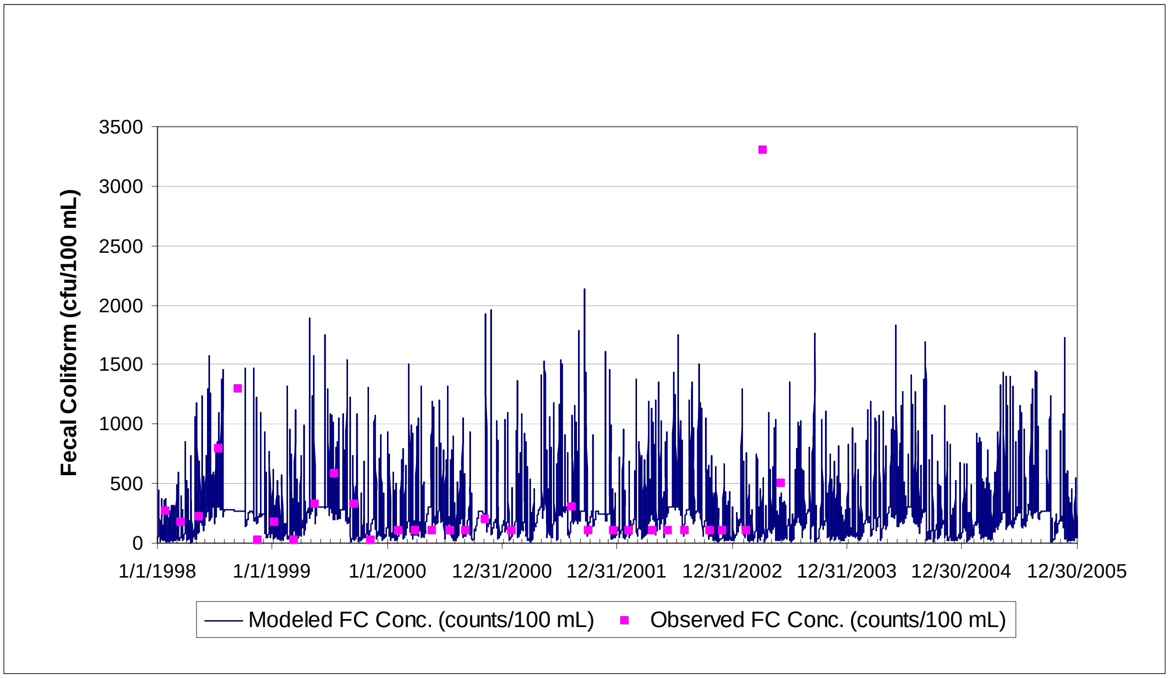


Figure D-4: Fecal Coliform Concentrations at the Dan River Station 4ADAN042.80 (Reach 15)



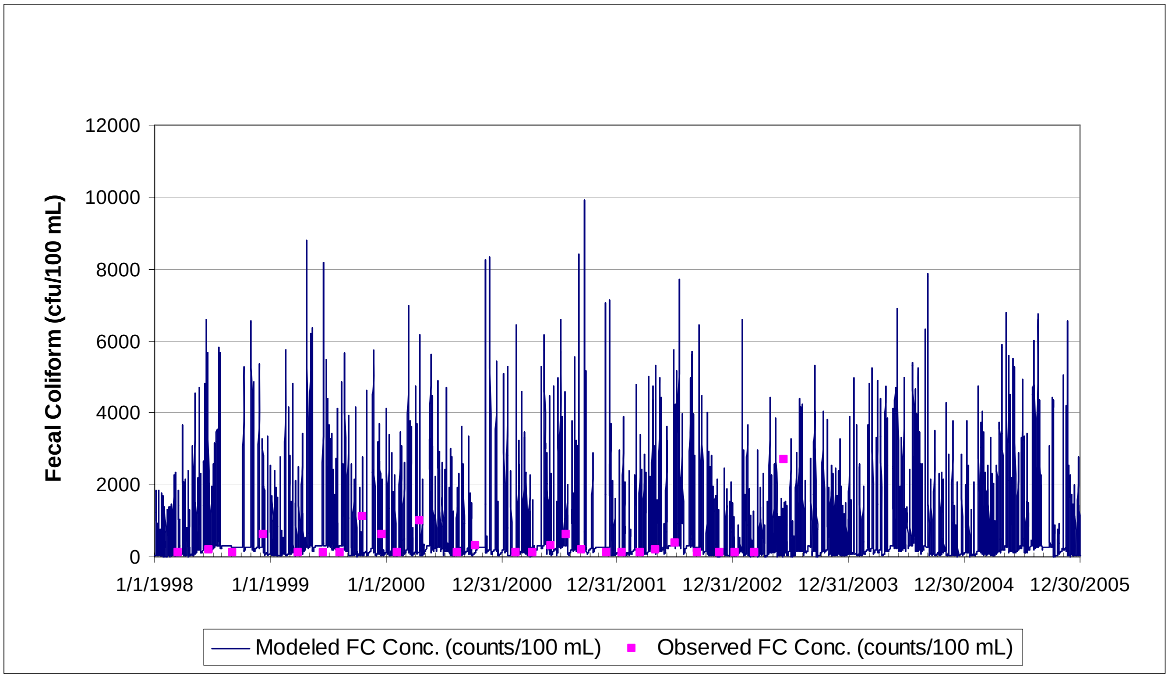
D.4 Double Creek (Segment VAC-L62R-03)

Figure D-5: Fecal Coliform Concentrations at Double Creek Station 4ADBC002.19 (Reach 11)



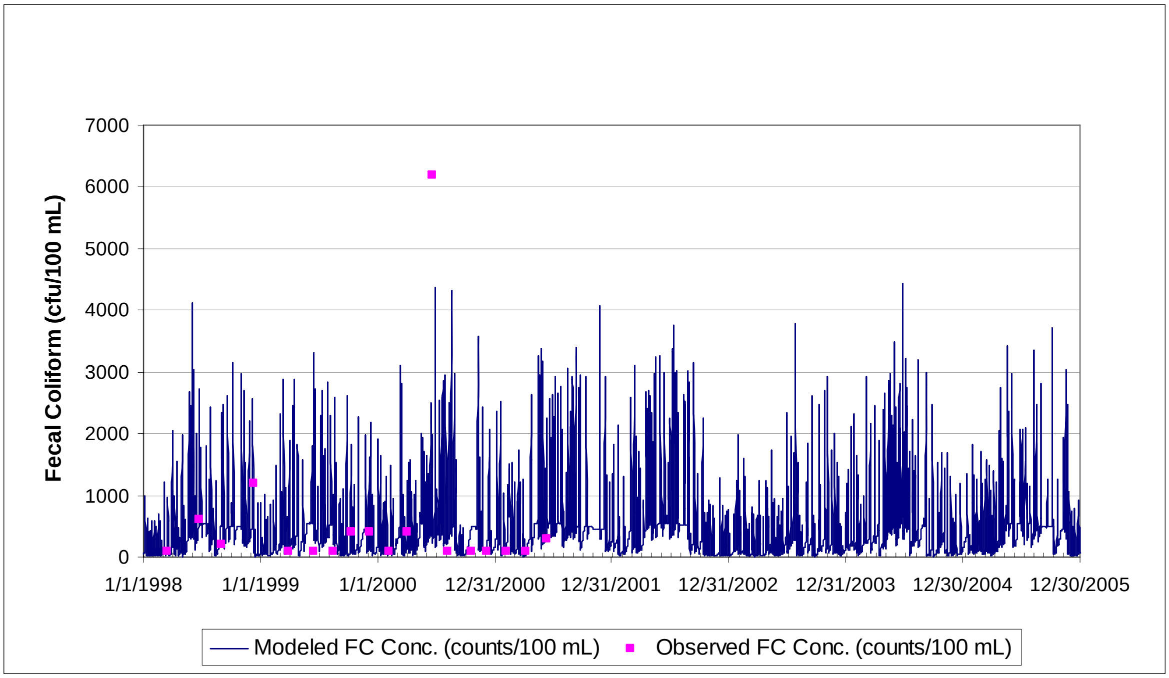
D.5 Fall Creek (Segment VAC-L61R-01)

Figure D-6: Fecal Coliform Concentrations at Fall Creek Station 4AFAL001.58 (Reach 22)



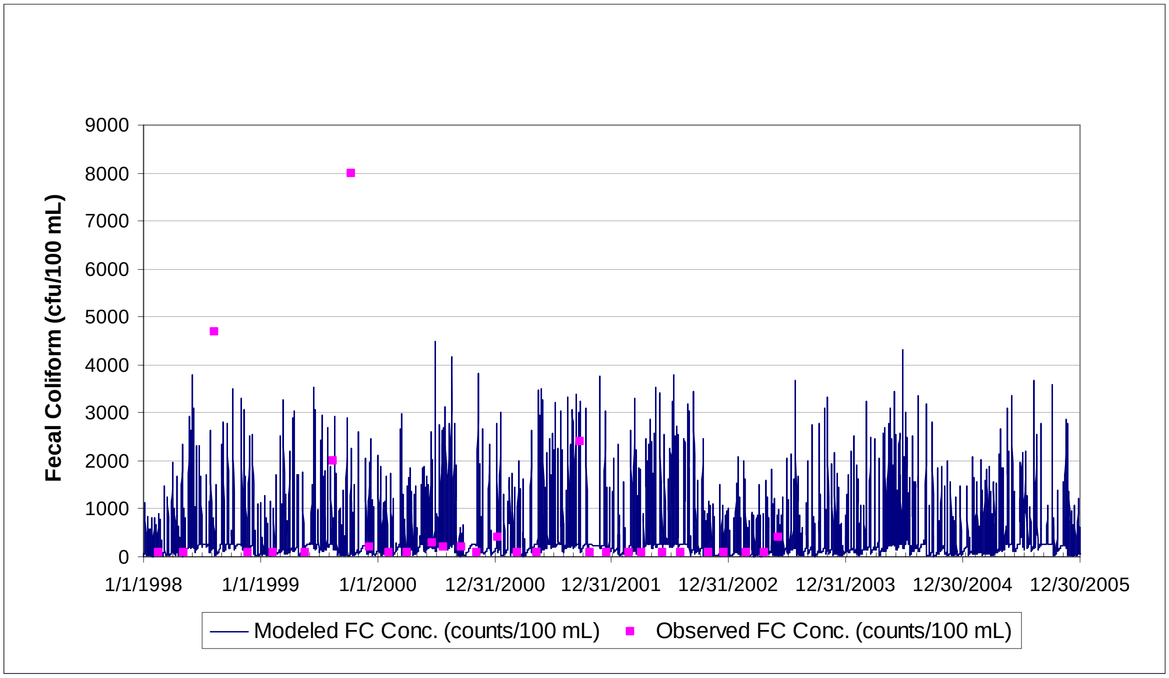
D.6 Leatherwood Creek (Segment VAW-L56R-01)

Figure D-7: Fecal Coliform Concentrations Leatherwood Creek Station 4ALWD002.54 (Reach 37)



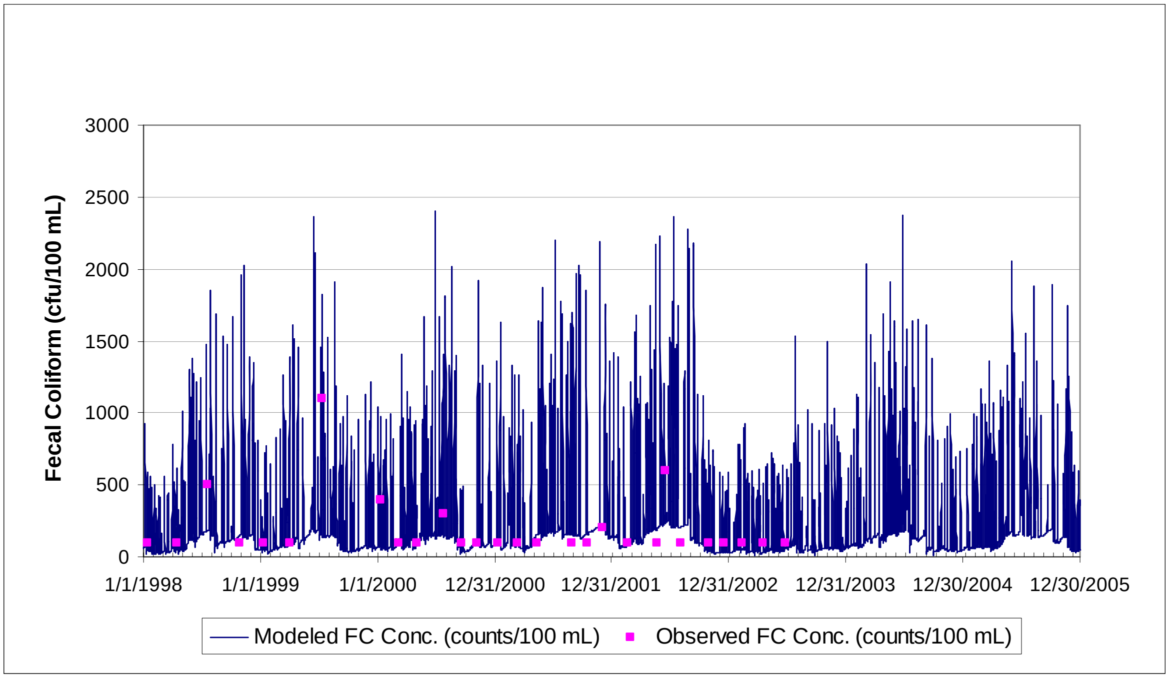
D.7 Marrowbone Creek (Segment VAW-L55R-01)

Figure D-8: Fecal Coliform Concentrations at Marrowbone Creek Station 4AMRR000.02 (Reach 61)



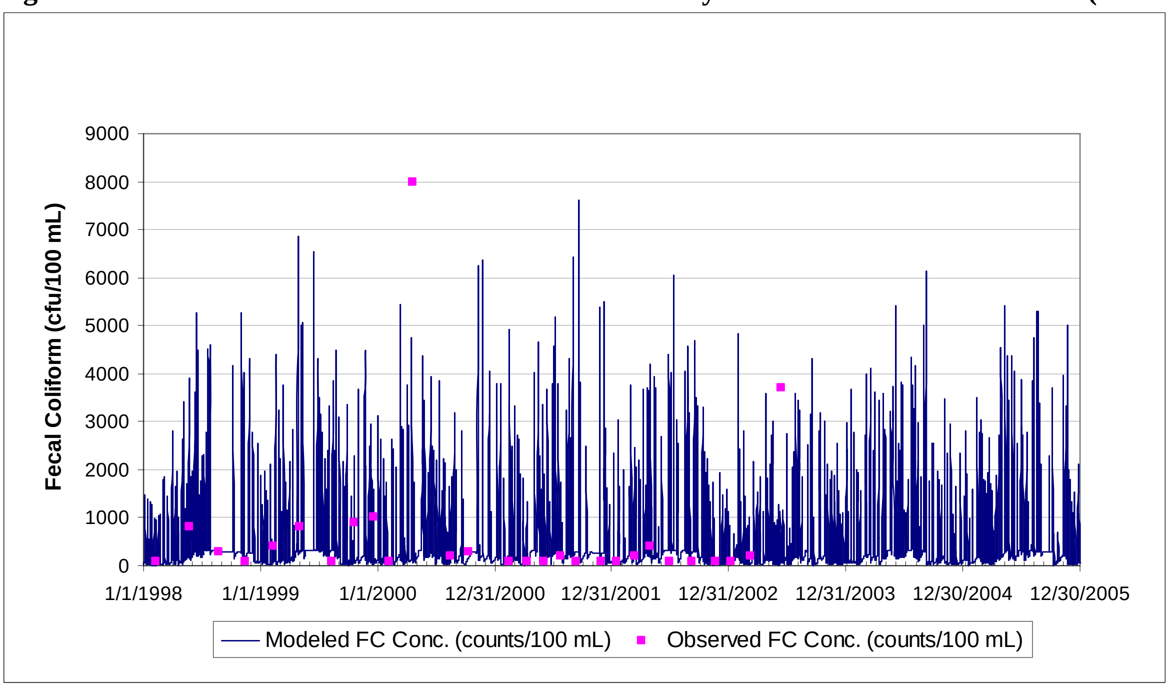
D.8 North Fork Mayo River (Segment VAW-L46R-01)

Figure D-9: Fecal Coliform Concentrations at the North Fork Mayo River Station 4ANMR002.60 (Reach 73)



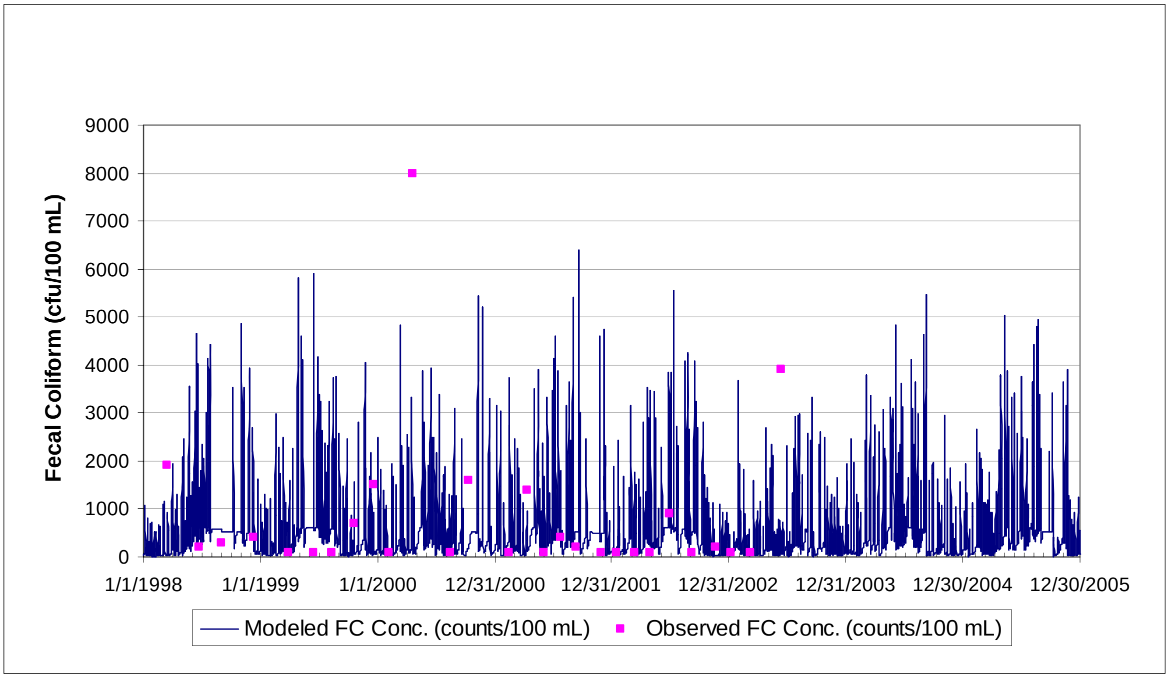
D.9 Sandy Creek (Segment VAC-L59R-01)

Figure D-10: Fecal Coliform Concentrations at the Sandy Creek Station 4ASCR007.06 (Reach 24)



D.10 Sandy River (Segment VAC-L58R-01)

Figure D-11: Fecal Coliform Concentrations at the Sandy River Station 4ASRV000.20 (Reach 26)



D.11 Smith River (Segments VAW-L53R-01 and VAW-L54R-01)

Figure D-12: Fecal Coliform Concentrations at the Smith River Station 4ASRE015.43 (Reach 36)

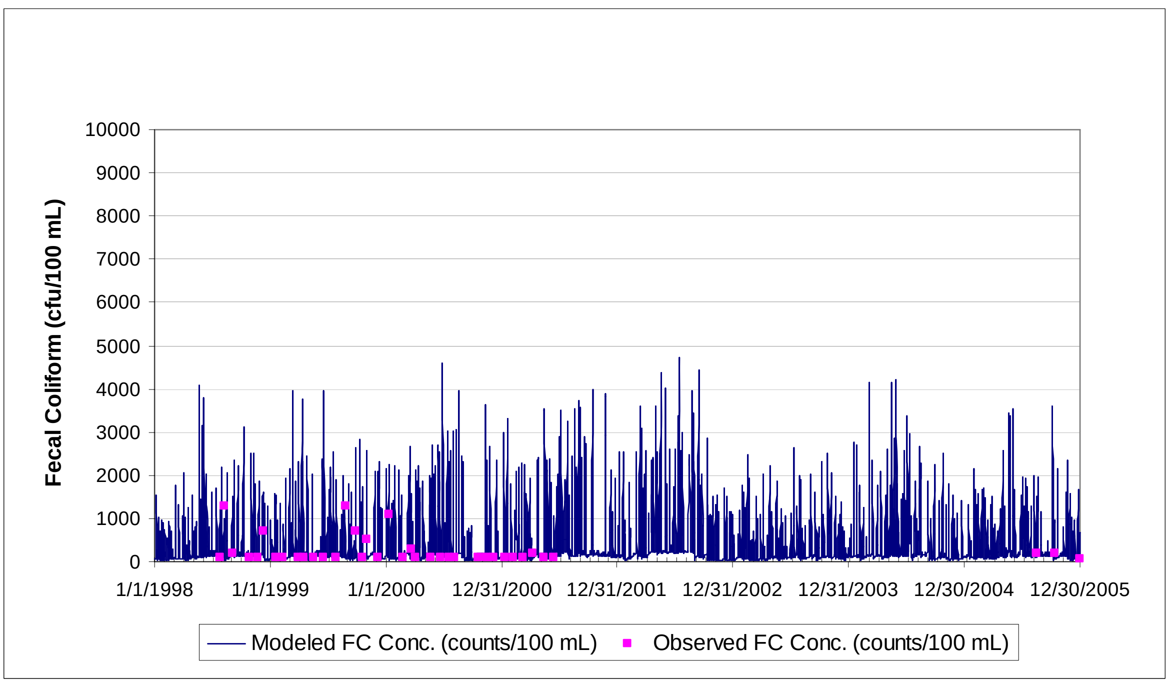


Figure D-13: Fecal Coliform Concentrations at the Smith River Station 4ASRE022.71 (Reach 41)

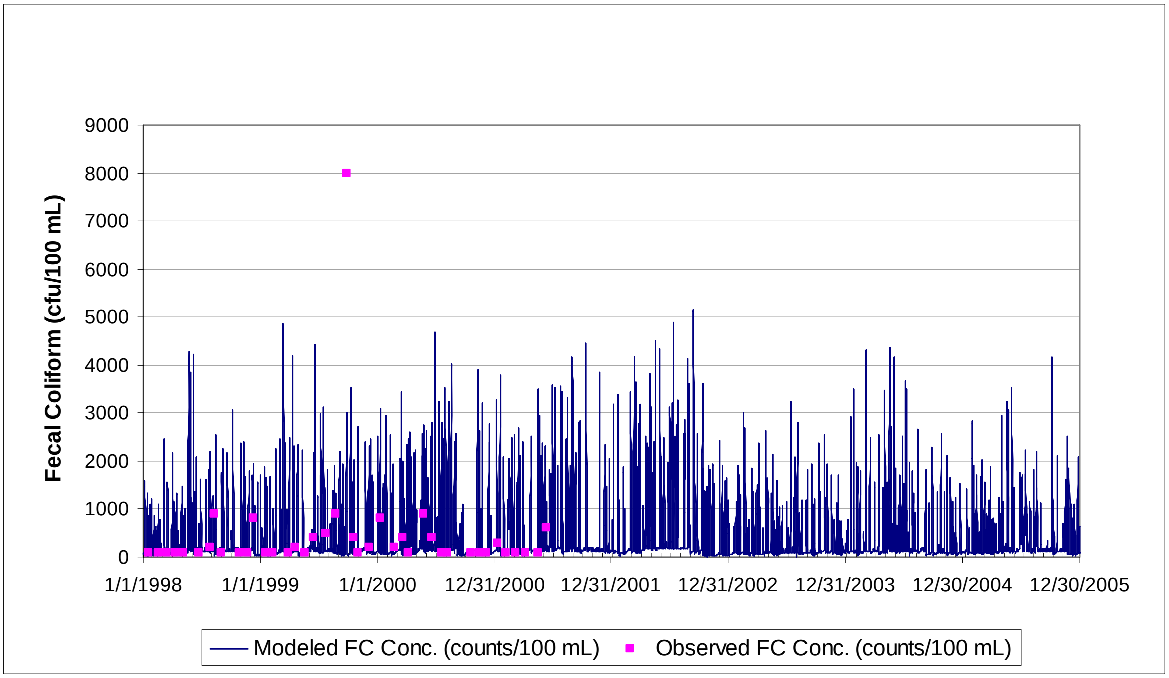
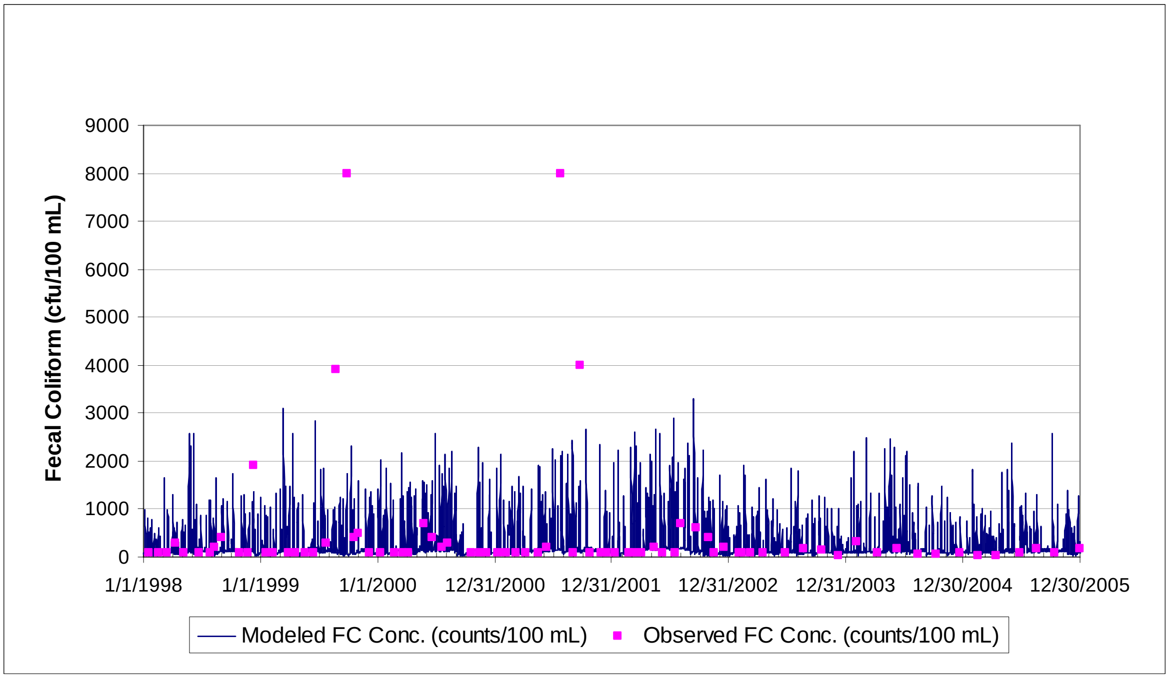
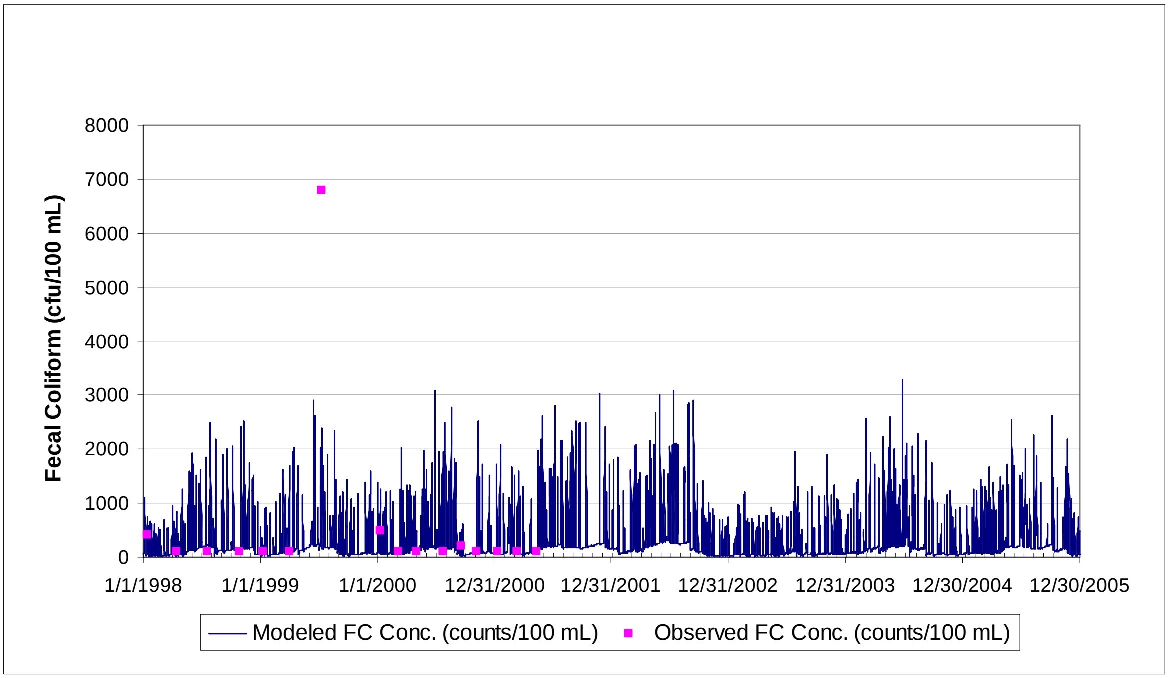


Figure D-14: Fecal Coliform Concentrations at the Smith River Station 4ASRE033.19 (Reach 44)



D.12 South Fork Mayo River (Segment VAW-L45R-01)

Figure D-15: Fecal Coliform Concentrations at the South Fork Mayo River Station 4ASMR004.14 (Reach 80)



APPENDIX E:

Monthly Fecal Coliform Direct Deposition Loads

Table E-1: Dan River (VAC-L60R-01) Monthly Direct Deposition Rates (cfu/ac/day)			
Month	Direct Cattle	Direct Septic	Direct Wildlife
1	1.09E+13	6.49E+09	7.68E+13
2	1.50E+13	5.86E+09	6.94E+13
3	2.22E+13	6.49E+09	7.68E+13
4	2.15E+13	6.27E+09	7.43E+13
5	2.79E+13	6.49E+09	7.68E+13
6	2.69E+13	6.27E+09	7.43E+13
7	2.79E+13	6.49E+09	7.68E+13
8	2.22E+13	6.49E+09	7.68E+13
9	1.60E+13	6.27E+09	7.43E+13
10	1.66E+13	6.49E+09	7.68E+13
11	1.06E+13	6.27E+09	7.43E+13
12	1.09E+13	6.49E+09	7.68E+13

Table E-2: Blackberry Creek (VAW-L52R-02) Monthly Direct Deposition Rates (cfu/ac/day)			
Month	Direct Cattle	Direct Septic	Direct Wildlife
1	8.41E+10	7.25E+06	6.61E+11
2	1.14E+11	6.55E+06	5.97E+11
3	1.69E+11	7.25E+06	6.61E+11
4	1.63E+11	7.02E+06	6.39E+11
5	2.11E+11	7.25E+06	6.61E+11
6	2.04E+11	7.02E+06	6.39E+11
7	2.11E+11	7.25E+06	6.61E+11
8	1.69E+11	7.25E+06	6.61E+11
9	1.22E+11	7.02E+06	6.39E+11
10	1.26E+11	7.25E+06	6.61E+11
11	8.14E+10	7.02E+06	6.39E+11
12	8.41E+10	7.25E+06	6.61E+11

Table E-3: Byrds Branch (VAC-L62R-04) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	2.85E+10	6.85E+05	1.21E+11
2	3.86E+10	6.19E+05	1.09E+11
3	5.70E+10	6.85E+05	1.21E+11
4	5.52E+10	6.63E+05	1.17E+11
5	7.13E+10	6.85E+05	1.21E+11
6	6.90E+10	6.63E+05	1.17E+11
7	7.13E+10	6.85E+05	1.21E+11
8	5.70E+10	6.85E+05	1.21E+11
9	4.14E+10	6.63E+05	1.17E+11
10	4.28E+10	6.85E+05	1.21E+11
11	2.76E+10	6.63E+05	1.17E+11
12	2.85E+10	6.85E+05	1.21E+11

Table E-4: Double Creek (VAC-L62R-03) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	1.28E+11	4.14E+06	6.04E+11
2	1.75E+11	3.74E+06	5.46E+11
3	2.60E+11	4.14E+06	6.04E+11
4	2.52E+11	4.01E+06	5.85E+11
5	3.27E+11	4.14E+06	6.04E+11
6	3.16E+11	4.01E+06	5.85E+11
7	3.27E+11	4.14E+06	6.04E+11
8	2.60E+11	4.14E+06	6.04E+11
9	1.88E+11	4.01E+06	5.85E+11
10	1.94E+11	4.14E+06	6.04E+11
11	1.24E+11	4.01E+06	5.85E+11
12	1.28E+11	4.14E+06	6.04E+11

Table E-5: Fall Creek (VAC-L61R-01) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	2.64E+11	1.01E+09	1.55E+12
2	3.64E+11	9.14E+08	1.40E+12
3	5.41E+11	1.01E+09	1.55E+12
4	5.23E+11	9.79E+08	1.50E+12
5	6.80E+11	1.01E+09	1.55E+12
6	6.58E+11	9.79E+08	1.50E+12
7	6.80E+11	1.01E+09	1.55E+12
8	5.41E+11	1.01E+09	1.55E+12
9	3.90E+11	9.79E+08	1.50E+12
10	4.03E+11	1.01E+09	1.55E+12
11	2.56E+11	9.79E+08	1.50E+12
12	2.64E+11	1.01E+09	1.55E+12

Table E-6: Leatherwood Creek (VAW-L56R-01) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	3.51E+11	4.27E+07	3.14E+12
2	4.77E+11	3.86E+07	2.84E+12
3	7.02E+11	4.27E+07	3.14E+12
4	6.80E+11	4.13E+07	3.05E+12
5	8.78E+11	4.27E+07	3.14E+12
6	8.50E+11	4.13E+07	3.05E+12
7	8.78E+11	4.27E+07	3.14E+12
8	7.02E+11	4.27E+07	3.14E+12
9	5.10E+11	4.13E+07	3.05E+12
10	5.27E+11	4.27E+07	3.14E+12
11	3.40E+11	4.13E+07	3.05E+12
12	3.51E+11	4.27E+07	3.14E+12

Table E-7: Marrowbone Creek (VAW-L55R-01) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	1.44E+11	1.83E+07	1.29E+12
2	1.95E+11	1.65E+07	1.17E+12
3	2.87E+11	1.83E+07	1.29E+12
4	2.78E+11	1.77E+07	1.25E+12
5	3.59E+11	1.83E+07	1.29E+12
6	3.48E+11	1.77E+07	1.25E+12
7	3.59E+11	1.83E+07	1.29E+12
8	2.87E+11	1.83E+07	1.29E+12
9	2.09E+11	1.77E+07	1.25E+12
10	2.16E+11	1.83E+07	1.29E+12
11	1.39E+11	1.77E+07	1.25E+12
12	1.44E+11	1.83E+07	1.29E+12

Table E-8: North Fork Mayo River (VAW-L46R-01) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	6.86E+11	3.24E+07	4.66E+12
2	9.38E+11	2.93E+07	4.22E+12
3	1.39E+12	3.24E+07	4.66E+12
4	1.34E+12	3.14E+07	4.51E+12
5	1.75E+12	3.24E+07	4.66E+12
6	1.69E+12	3.14E+07	4.51E+12
7	1.75E+12	3.24E+07	4.66E+12
8	1.39E+12	3.24E+07	4.66E+12
9	1.01E+12	3.14E+07	4.51E+12
10	1.04E+12	3.24E+07	4.66E+12
11	6.64E+11	3.14E+07	4.51E+12
12	6.86E+11	3.24E+07	4.66E+12

Table E-9: Smith River - Reach 36 (VAW-L54R-01) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	1.76E+11	9.30E+08	1.78E+12
2	2.39E+11	8.41E+08	1.61E+12
3	3.53E+11	9.30E+08	1.78E+12
4	3.42E+11	9.01E+08	1.73E+12
5	4.41E+11	9.30E+08	1.78E+12
6	4.27E+11	9.01E+08	1.73E+12
7	4.41E+11	9.30E+08	1.78E+12
8	3.53E+11	9.30E+08	1.78E+12
9	2.56E+11	9.01E+08	1.73E+12
10	2.64E+11	9.30E+08	1.78E+12
11	1.70E+11	9.01E+08	1.73E+12
12	1.76E+11	9.30E+08	1.78E+12

Table E-10: Smith River - Reach 42 (VAW-L53R-01) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	2.17E+12	7.57E+08	1.56E+13
2	2.99E+12	6.84E+08	1.41E+13
3	4.45E+12	7.57E+08	1.56E+13
4	4.31E+12	7.32E+08	1.50E+13
5	5.59E+12	7.57E+08	1.56E+13
6	5.41E+12	7.32E+08	1.50E+13
7	5.59E+12	7.57E+08	1.56E+13
8	4.45E+12	7.57E+08	1.56E+13
9	3.20E+12	7.32E+08	1.50E+13
10	3.31E+12	7.57E+08	1.56E+13
11	2.10E+12	7.32E+08	1.50E+13
12	2.17E+12	7.57E+08	1.56E+13

Table E-11: South Fork Mayo River (VAW-L45R-01) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	9.84E+11	9.78E+06	6.07E+12
2	1.35E+12	8.83E+06	5.48E+12
3	2.01E+12	9.78E+06	6.07E+12
4	1.94E+12	9.47E+06	5.88E+12
5	2.52E+12	9.78E+06	6.07E+12
6	2.44E+12	9.47E+06	5.88E+12
7	2.52E+12	9.78E+06	6.07E+12
8	2.01E+12	9.78E+06	6.07E+12
9	1.45E+12	9.47E+06	5.88E+12
10	1.50E+12	9.78E+06	6.07E+12
11	9.54E+11	9.47E+06	5.88E+12
12	9.84E+11	9.78E+06	6.07E+12

Table E-12: Sandy Creek (VAC-L59R-01) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	1.59E+11	1.43E+07	8.41E+11
2	2.19E+11	1.30E+07	7.60E+11
3	3.26E+11	1.43E+07	8.41E+11
4	3.16E+11	1.39E+07	8.14E+11
5	4.09E+11	1.43E+07	8.41E+11
6	3.96E+11	1.39E+07	8.14E+11
7	4.09E+11	1.43E+07	8.41E+11
8	3.26E+11	1.43E+07	8.41E+11
9	2.35E+11	1.39E+07	8.14E+11
10	2.42E+11	1.43E+07	8.41E+11
11	1.54E+11	1.39E+07	8.14E+11
12	1.59E+11	1.43E+07	8.41E+11

Table E-13: Sandy River (VAC-L58R-01) Monthly Direct Deposition Rates (cfu/ac/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	9.09E+11	7.34E+08	5.03E+12
2	1.25E+12	6.63E+08	4.56E+12
3	1.86E+12	7.34E+08	5.03E+12
4	1.80E+12	7.10E+08	4.87E+12
5	2.34E+12	7.34E+08	5.03E+12
6	2.26E+12	7.10E+08	4.87E+12
7	2.34E+12	7.34E+08	5.03E+12
8	1.86E+12	7.34E+08	5.03E+12
9	1.34E+12	7.10E+08	4.87E+12
10	1.38E+12	7.34E+08	5.03E+12
11	8.80E+11	7.10E+08	4.87E+12
12	9.09E+11	7.34E+08	5.03E+12

APPENDIX F:

Sensitivity Analysis

Sensitivity Analysis

The sensitivity analysis of the fecal coliform loadings and the waterbody response provides a better understanding of the watershed conditions that lead to the water quality standard violation and provides insight and direction in developing the TMDL allocation and implementation. Potential sources of fecal coliform include non-point (land-based) sources such as runoff from livestock grazing, manure and biosolids land application, residential waste from failed septic systems or straight pipes, and wildlife. Some of these sources are dry weather driven and others are wet weather driven.

The objective of the sensitivity analysis was to assess the impacts of variation of model calibration parameters on the simulation of flow and the violation of the fecal coliform standard in the nine impairments. For the January 1998 to December 2005 period, the model was run with 110 percent and 90 percent of calibrated values of the parameters. The scenarios that were analyzed include the following:

- 10 percent increase in LZSN; the lower zone nominal storage
- 10 percent decrease in LZSN
- 10 percent increase in INFILT; index to the infiltration capacity of the soil
- 10 percent decrease in INFILT
- 10 percent increase in AGWRC; the basic groundwater recession rate
- 10 percent decrease in AGWRC
- 10 percent increase in UZSN; the upper zone nominal storage
- 10 percent decrease in UZSN
- 10 percent increase in INTFW; the interflow/surface runoff partition parameter
- 10 percent decrease in INTFW
- 10 percent increase in IRC; the interflow recession parameter
- 10 percent decrease in IRC
- 10 percent increase in LZETP; the lower zone evapotranspiration (ET) parameter
- 10 percent decrease in LZETP

The modeled flows for different sensitivity runs were compared with observed flows at the gage and the coefficients of determination of the hydrologic sensitivity analysis are presented in **Table F-1**. Based on these tables it can be seen that the calibration parameters affect the coefficient of determination in the decreasing order of AGWRC, IRC, INFILT, LZSN, INTFW, UZSN and LZETP.

The sensitivity analysis was also performed for two water quality parameters, WSQOP and FSTDEC, by simulating the fecal coliform concentrations for 120 percent and 80 percent of their calibrated values. The rate of violation of the Monthly Geometric Mean Water Quality Standard was determined for each scenario and compared with the rate of violation under the water quality calibration run. The changes in the rate of violation are presented in **Table F-2**. The results of the sensitivity analysis show that at the calibrated values of WSQOP and FSTDEC there is no measurable effect on the violation of the water quality standards.

Table F-1: Sensitivity Analysis: Variation in Coefficient of Determination With Respect to Variation in Parameters For Simulation Period 1998-2005

Parameter	Coefficient of Determination	
	+10% change in parameter	-10% change in parameter
LZSN	0.645	0.656
INFILT	0.656	0.643
AGWRC	0.553	0.675
UZSN	0.655	0.652
INTFW	0.655	0.650
IRC	0.662	0.643
LZETP	0.653	0.653
Calibrated Parameters 0.650		

Table F-2: Sensitivity Analysis: Change in Violation Rate From 20% Change in Calibration Parameter Values

	WSQOP		FSTDEC	
Segment #	**20%**	**-20%**	**20%**	**-20%**
Dan River (VAC-L60R-01)	0.0%	0.0%	0.0%	0.0%
Blackberry Creek (VAW-L52R-02)	0.0%	0.0%	0.0%	0.0%
Byrds Branch (VAC-L62R-04)	0.0%	0.0%	0.0%	0.0%
Double Creek (VAC-L62R-03)	0.0%	0.0%	0.0%	0.0%
Fall Creek (VAC-L61R-01)	0.0%	0.0%	0.0%	0.0%
Leatherwood Creek (VAW-L56R-01)	0.0%	0.0%	0.0%	0.0%
Marrowbone Creek (VAW-L55R-01)	0.0%	0.0%	0.0%	0.0%
North Fork Mayo River (VAW-L46R-01)	0.0%	0.0%	0.0%	0.0%
Sandy Creek (VAC-L59R-01)	0.0%	0.0%	0.0%	0.0%
Sandy River (VAC-L58R-01)	0.0%	0.0%	0.0%	0.0%
Smith River (VAW-L54R-01)	0.0%	0.0%	0.0%	0.0%
Smith River (VAW-L53R-01)	0.0%	0.0%	0.0%	0.0%
South Fork Mayo River (VAW-L45R-01)	0.0%	0.0%	0.0%	0.0%